APPENDIX D-2

Structural Calculations of Double Sheet Coffer Dams

D-2 Structural Calculations of Double Sheet Coffer Dams

(1) Design Condition

The structural calculations of the double sheet coffer dam are performed with 「Design Manual of Double Sheet Coffer Dam May 2001」(herein after called 「Design Manual」). The study of the earthquake time is considered the 50 % of the earthquake coefficient which is the design value of the gate structure. (K=0.08×0.5=0.04)

(a) Allowable Stress

The allowance Stresses of each material are as follow's table.

Table C-2.1 Allowable Stree

Material	Allowable Stress (N/mm^2)		Remark
	Normal time	Earthquake time	
Sheet pile (S355GP)	180	270	
Tie Rod (SS400) D:less than 40mm	94	141	
D:more than40mm	86	129	
Weiling (SS400)	140	210	

(b) Safety factor

The safety factors of penetration depth etc. are more than values as follow's table. The foundation conditions are sand layers based on geological investigations.

Table C-2.2 Safety Factor

Items	Safety factor		Remarks
	Normal time	Earthquake time	
Shearing resistance of back filling in double sheet coffer dam	1.20	1.0	
Sliding	1.20	1.0	
Bearing capacity	1.20	1.0	
Penetration depth of sheet pile	1.50	1.2	Sand layer
Impervious effect	3.50	3.0	Sand layer

(d) Loading weight

The standard value, 10 (kN/m^2) of the loading weight is considered based on Guideline of temporary structure in road works by the Japan Road Association but the design values of the loading weight is reviewed accordingly, for examples, the works of large construction machine on double sheet coffer dam.

(e) Design grand level

The design grand level of the temporary works is decided by the design location of the regulators, survey results and the boring investigation data.

(f) Earth pressure

The earth pressures are calculated by the following equations based on Manual of steel double sheet pile method by the Ministry of Land, Infrastructure, Transport, and Tourism.

Active earth pressure : $Pa = Ka \cdot \Sigma(q + \gamma i \cdot hi) - 2C\sqrt{Ka}$

Passive earth pressure : $Pp = Kp \cdot \Sigma(q + \gamma i \cdot hi) - 2C\sqrt{Kp}$

Earth pressure at rest : $Po = Ko \cdot \Sigma(q + \gamma i \cdot hi)$

Where are,

Pa: Active earth pressure of each bottom layer (tf/m^2)

The case of Pa < 0 is Pa=0

Pp: Passive earth pressure of each bottom layer (tf/m^2)

Active earth pressure of each layer

Ka: $$Ka = \frac{\cos^2(\phi - \theta)}{\cos^2\theta\left\{1 + \sqrt{\dfrac{\sin\phi \cdot \sin(\phi - \theta)}{\cos\theta}}\right\}^2}$$

Active earth pressure of each layer

Kp: $$Kp = \frac{\cos^2(\phi - \theta)}{\cos^2\theta\left\{1 - \sqrt{\dfrac{\sin\phi \cdot \sin(\phi - \theta)}{\cos\theta}}\right\}^2}$$

Earth pressure at rest

Ko: Ko=1-sinΦ (sand)
=0.5 (clay)

γi: unit weight of each layer (kN/m^3)

C: cohesion of each layer (kN/m^2)

hi: thickness of each layer

q: loading (kN/m^2)

(g) Water pressure distribution

The water pressure distributions are divided into 4 types by the different from the foundation layers based on Manual of steel double sheet pile method by the Ministry of Land, Infrastructure, Transport, and Tourism.

Table c-2.3 Type of Foundation

No.	Type of foundation	Remarks
Type 1	Sand foundation	Dirout case
Type2	Clay foundation	
Type3	Foundation of alternate layer A (Upper sand +lower clay)	
Type4	Foundation of alternate layer B (Upper clay +lower sand)	

・Water pressure distribution at stress check of sheet pile

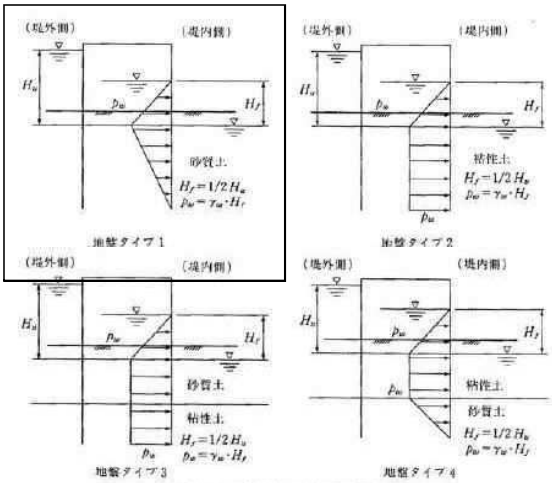

図7.1 矢板応力度照査用の水圧分布

・ Water pressure distribution at stability calculation of wall structure

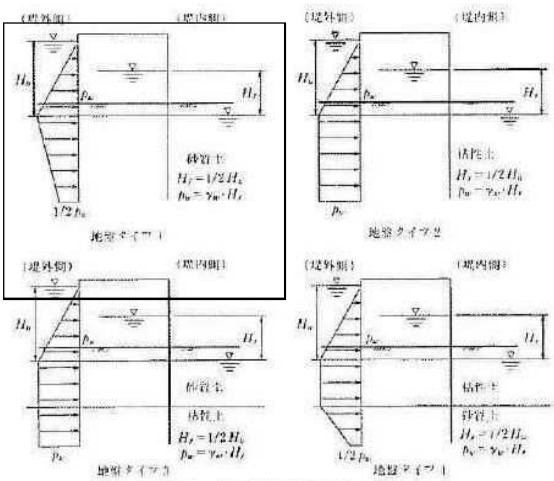

図7.2 壁体安定用計算用の水圧分布

(h) Coefficient of subgrade reaction at horizontal level

The bending moment of sheet pile is calculated by elasto-plasticity method based on Manual of steel double sheet pile method by the Ministry of Land, Infrastructure, Transport, and Tourism. The calculations of the coefficient of subgrade reaction at horizontal level are as follows:

Coefficient of subgrade reaction at horizontal level : $k_H = k_{HO}(B_H / 0.3)^{-3/4}$

$$k_{HO} = \alpha E_o / 0.3$$

Where is,

k_H : Coefficient of subgrade reaction at horizontal level (kN/m^3)

k_{HO} : Coefficient of subgrade reaction at horizontal level with value of plate bearing test by rigid body of 30 cm diameter

B_H : Horizontal loading width on foundation

α, E_o : Coefficient used with evaluation of modulus of deformation and subgrade reaction

Table C-2.4 Relation between E_o and α

Modulus of deformation by each test method Eo (kN/m^2)	α	
	Normal time	Earthquake time
Modulus of deformation in bore hole measurement	4	8
Modulus of deformation by unconfined compression test or tri-axial compression test	4	8
Modulus of deformation by equation of Eo = 2800N with N value of standard penetration test	1	2

(i) Water level

The temporary design values of the water level at each canal are as follows:

Table C-2.5 Discharge of Temporary Design

NDGR	Canal	Temporary design discharge
Ibrahimia Reg.	Ibrahimia	162 m^3/s
Bahr Yusef Reg	Bahr Yusef	185 m^3/s
Badraman	Badraman	6 m^3/s
	Diroutiah	10 m^3/s
Abo Gabal Reg.	Abo Gabal	2 m^3/s
	Irad Delgaw	6 m^3/s
Sahlyia Reg	Sahlyia	3.5 m^3/s

The maximum water level by the results of hydraulic calculation is as follows

Bahr Yusef canal: WL. 46.00 m

Ibrahimia canal: WL. 45.42 m (after bed excavation)

The crest elevation of the coffer dam is EL. 47.0 m with the results of the Bahr Yusef canal. This water level is as follows:

High water level at upstream : WL. 46.3 m < 47.0 m

and the high high water level is equal to the crest elevation.

Table C-2.6 Design Discharge and Water Level

NDGR	Canal	Maximum discharge Q_{max} (m^3/s)	Minimum discharge Q_{min} (m^3/s)	High high water level at upstream US. H.H.W.L (m)	High water level at upstream US. H.W.L (m)	Low water level at upstream US. L.W.L (m)	Low water level at downstream. L.W.L (m)
Ibrahimia Reg.	Ibrahimia	186	23.6	47.0	46.3	45.9	45.13
Bahr Yusef Reg	Bahr Yusef	227	33.1	47.0	46.3	45.9	45.82
Badraman	Badraman	9	1.2	47.0	46.3	45.9	45.9
	Diroutiah	12	1.7	47.0	46.3	45.9	45.9
Abo Gabal Reg.	Abo Gabal	7	0.9	47.0	46.3	45.9	45.9
	Irad Delgaw	9	1.3	47.0	46.3	45.9	45.9
Sahlyia Reg	Sahlyia	5	0.6	47.0	46.3	45.9	45.9

(2) Calculation results

1) Bahr Yusef Canal

2) Ibrahimia Canal

3) Abo Gabal Canal

4) Sahelyia Canal

Cover

(1)Bahr Yusef Canal

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1 Design condition

File name:Bahr Yusef 42,355a

1.1 Properties

(1)wall scale

final wall width : 8.000(m)
length of landside final sheet pile : 19.000(m)
length of riverside final sheet pile : 19.000(m)

(2)basic data

title : Bahr Yusef 2
comment :
wall type : Steel sheet pile
influence of water level : Yes consider
water unit weight Gamw : 10.00(kN/m³)
check earthquake case : Yes
check liquefaction case : No
check riverside sheet pile : Yes
tensile member installation position

No	position G.L.(m)
1	46.000
2	42.000

1.2 shape

(1)plane

wall extension

wall No	inter wl len.(m)	angle (deg)	object wall
1	60.500	----.---	
2	88.500	130.000	
3	60.500	90.000	OK

wall direction: Vertical

(2)side

top of filling soil : G.L. 47.000(m)
top of landside sheet pile : G.L. 47.000(m)
top of riverside sheet pile : G.L. 47.000(m)

(3)tensile member planar layout

tensile member adjusting installation method : Equally layout

wall 1

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	3.600	3.000	3	3.00	3
2	1.800	3.000	3	3.00	3

wall 2

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	3.600	3.000	3	3.00	2
2	1.800	3.000	3	3.00	2

wall 3

row	standard pitch (m)	start side adjust LS (m)	start side adjust number	end side adjust LE (m)	end side adjust number
1	1.800	3.000	3	3.00	2
2	1.800	3.000	3	3.00	2

1.3 Method

(1)check points

Check 4* C > Sum(Gam h) : No check
Check shielding effect : check sand ground
Check discharge : No
Check circle slope : No
Check, change of bearing capacity : No

(2)design method

shear deformation failure check points
search the position of min FS : No
ditto searching pitch : 1.00(m)
calculation of self-weight : Conforming design manual
consider external force above tensile member with the limit equivalent method : No consider
elasto-plastic analysis and calculation condition member force in liquefaction
coefficient of allowance when tensile member spring is calculated Alp. : 1.0
equivalent loading width for calculation BH : 10.0m
deformation coefficient in earthquake : 2.00 of ordinary time (input)
wall tip bearing condition : Free
calculation pitch : 0.20(m)
check elastic zone in elasto-plastic calculation :No
required elastic zone rate as above : 50.0%
design of residual water level
residual water level setting(riverside water level - landside water level)* ratio: 0.500

1.4 Strata data

(1)soil character of filling soil

filled soil	soil unit weight wet kN/m3	submrg kN/m3	satur. kN/m3	inter fric angle (deg)	cohesion Co kN/m2	increment k kN/m3
Sandy soil	18.0	9.0	19.0	30.0	0.0	0.0

(2)River side section(current ground level G.L. 39.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
1	3.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
2	2.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
3	7.000	Sandy	7.0	18.0	9.0	19.0	25.0	10.0	0.0	19600
4	5.000	Sandy	33.0	18.0	9.0	19.0	30.0	10.0	0.0	92400

(3)Embankment body section(current ground level G.L. 38.500m)

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
1	3.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
2	2.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
3	7.000	Sandy	7.0	18.0	9.0	19.0	25.0	10.0	0.0	19600
4	5.000	Sandy	33.0	18.0	9.0	19.0	30.0	10.0	0.0	92400

(4) Land side section(current ground level G.L. 38.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m³		Co kN/m2	Increment k kN/m3	
1	3.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
2	2.000	Sandy	6.0	18.0	9.0	19.0	25.0	10.0	0.0	16800
3	7.000	Sandy	7.0	18.0	9.0	19.0	25.0	10.0	0.0	19600
4	5.000	Sandy	33.0	18.0	9.0	19.0	30.0	10.0	0.0	92400

1.5 members

(1) wall data

effective rate of sheet pile
moment of inertia (stress deformation calculation) : 0.45
modulus of section : 0.60

landside
steel sheet pile in use : PU28+1
material in use : SY295
non-effective thickness of sheet pile front : 0.000(m)
ground evaluation when embedment is checked : Sandy ground

riverside
steel sheet pile in use : PU28+1
material in use : SY295
non-effective thickness of sheet pile front : 0.000(m)
ground evaluation when embedment is checked : Sandy ground

(2) tensile member, wailing data

tensile member

No	position G.L.(m)	tns mbr spring tns	tns mbr H-pitch m	tns mbr dia mm	tns mbr mat	tns mbr number	tns mbr	tns spring	wailing material
							direct iput	sprg cost. kN/m/m	
1	46.000	Use	3.600	25.0	7	1	No	----------	SS400
2	42.000	Use	1.800	75.0	7	1	No	----------	SS400

waling member
wailing member : H-steel
wailing check equation : TL/10

1.5 Study case data

(1) check case [deal Normal time]

check case name : iŽž
internal setting

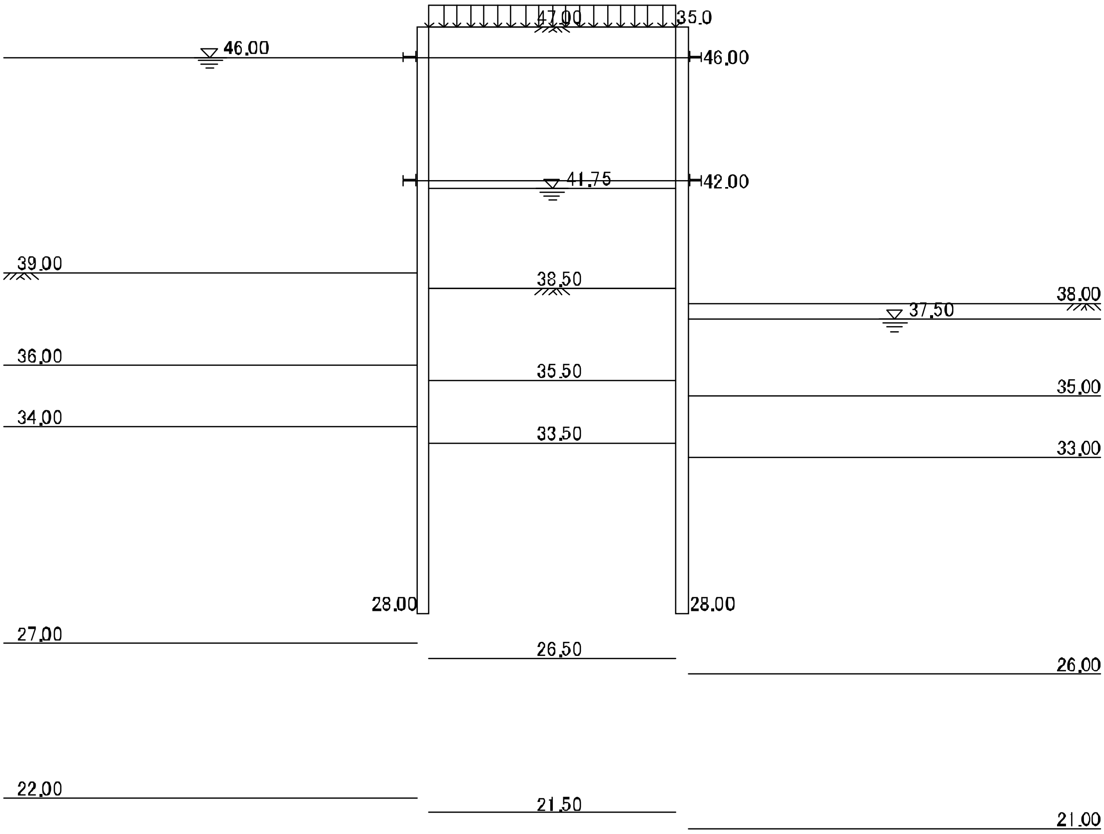
e-prss	soil spring	allowable
Normal time	Normal time	Normal time

water level condition
* stability calculation and check of landside sheet pile
riverside water level : G.L. 46.000(m)
landside water level : G.L. 37.500(m)
* check of riverside sheet pile
wall residual water level : G.L. 41.500(m)
riverside water level : G.L. 40.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	35.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



(2)check case [deal Earthquake time]
check case name : ’n kŽž
internal setting

e-prss	soil spring	allowable
Earthquake time	Earthquake time	Earthquake time

design seismicity
* design seismicity : 0.04
* seismic assumption : River standard method
resistant moment above shear deformation check level : Normal time
water level condition
* stability calculation and check of landside sheet pile
riverside water level : G.L. 46.000(m)
landside water level : G.L. 37.500(m)
* check of riverside sheet pile
wall residual water level : G.L. 41.500(m)
riverside water level : G.L. 40.000(m)

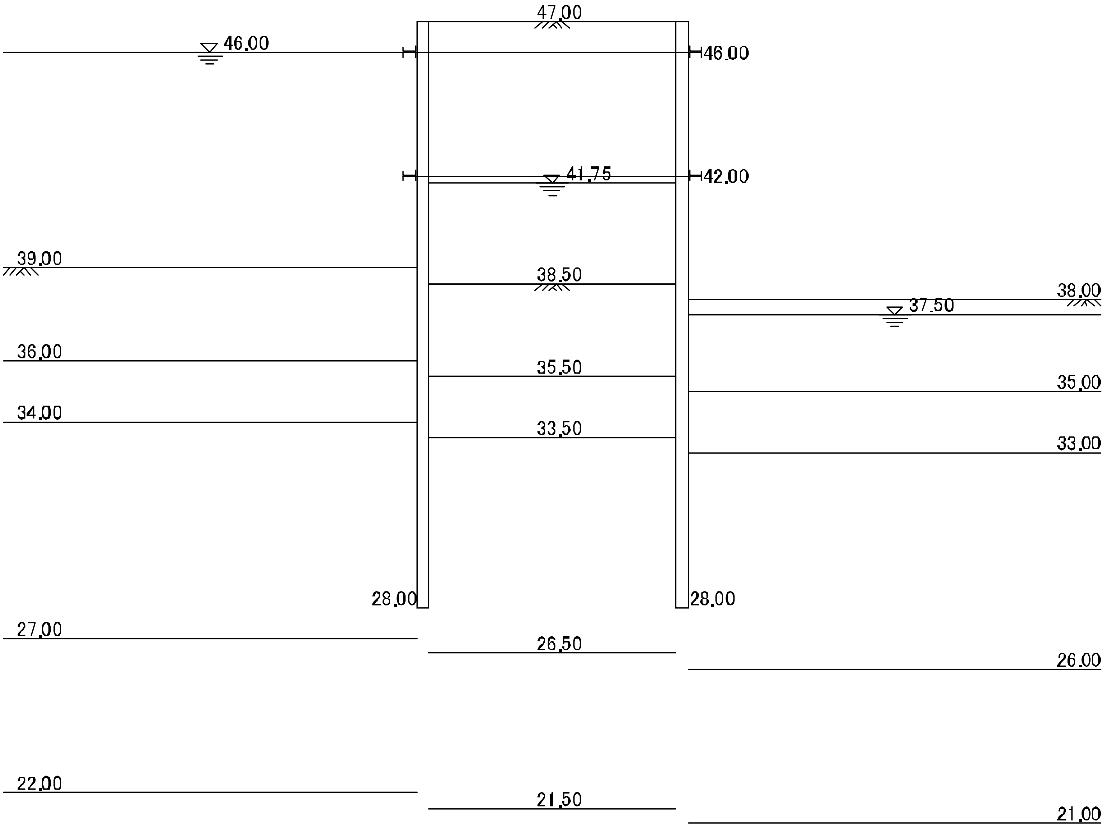
surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)

riverside sheet pile

* vertical force (stress calculation) : 0.00(kN m)



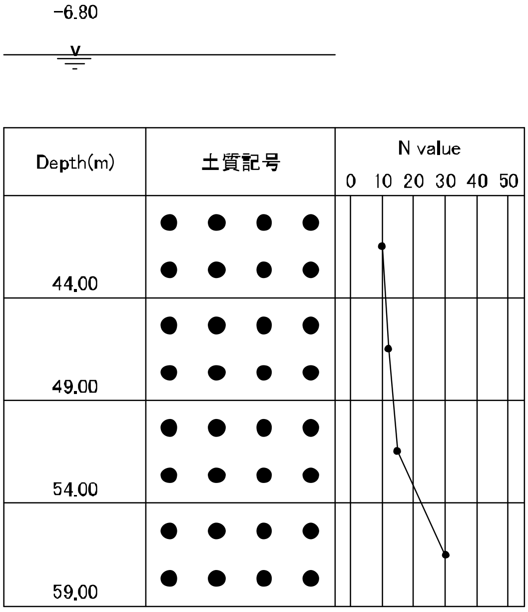
1.7 circular failure

Not calculate circular failure

1.8 discharge data

not check discharge

1.9 Drillhole log



FORUM8

1. 10 Steel data

steel sheet pile

No	steel name	w (mm)	h (mm)	W (kg/ m2)	A (cm2/ m)	I (cm4/ m)	Z (cm3/ m)
1	IIŒ^	400	100	48.0	153.00	8740	874
2	IIIŒ^	400	125	60.0	191.00	16800	1340
3	IIIŒ^	400	130	60.0	191.00	17400	1340
4	IVŒ^	400	170	76.1	242.50	38600	2270
5	VLŒ^	500	200	105.0	267.60	63000	3150
6	IVwŒ^	600	210	177.0	225.50	56700	2700
7	PU28	600	227	101.8	216.00	64460	2840
8	PU28+1	600	228	106.2	226.00	68380	3000

Wailing(H steel)

No	steel name	h (mm)	B (mm)	,″w (mm)	,″,† (mm)	A (m2)	w (kg/ m)	Zx (cm3)
1	H |100 ~100 ~ 6 ~ 8	100	100	6.0	8	21.59	16.9	76
2	H |125 ~125 ~ 6 ~ 9	125	125	6.5	9	30.00	23.6	134
3	H |150 ~150 ~ 7 ~10	150	150	7.0	10	39.65	31.1	216
4	H |175 ~175 ~ 7 ~11	175	175	7.5	11	51.42	40.4	331
5	H |200 ~200 ~ 8 ~12	200	200	8.0	12	63.53	49.9	472
6	H |250 ~250 ~ 9 ~14	250	250	9.0	14	91.43	71.8	860
7	H |300 ~300 ~10 ~15	300	300	10.0	15	118.40	93.0	1350
8	H |350 ~350 ~12 ~19	350	350	12.0	19	171.90	135.0	2280
9	H |400 ~400 ~13 ~21	400	400	13.0	21	218.70	172.0	3330
10	H |400 ~400 ~18 ~28	414	405	18.0	28	295.40	232.0	4480
11	H |400 ~400 ~20 ~35	428	407	20.0	35	360.70	283.0	5570
12	H |400 ~400 ~30 ~50	458	417	30.0	50	528.60	415.0	8170
13	H |400 ~400 ~45 ~70	498	432	45.0	70	770.10	605.0	12000
14	H |150 ~100 ~ 6 ~ 9	148	100	6.0	9	26.35	20.7	135
15	H |200 ~150 ~ 6 ~ 9	194	150	6.0	9	38.11	29.9	271
16	H |250 ~175 ~ 7 ~11	244	175	7.0	11	55.49	43.6	495
17	H |300 ~200 ~ 8 ~12	294	200	8.0	12	71.05	55.8	756
18	H |350 ~250 ~ 9 ~14	340	250	9.0	14	99.53	78.1	1250
19	H |400 ~300 ~10 ~16	390	300	10.0	16	133.20	105.0	1940
20	H |450 ~300 ~11 ~18	440	300	11.0	18	153.90	121.0	2490
21	H |500 ~300 ~11 ~18	488	300	11.0	18	159.20	125.0	2820
22	H |600 ~300 ~12 ~20	588	300	12.0	20	187.20	147.0	3890
23	H |700 ~300 ~13 ~24	700	300	13.0	24	231.50	182.0	5640
24	H |800 ~300 ~14 ~26	800	300	14.0	26	263.50	207.0	7160
25	H |900 ~300 ~15 ~23	890	299	15.0	23	266.90	210.0	7610
26	H |900 ~300 ~16 ~28	900	300	16.0	28	305.80	240.0	8990
27	H |150 ~ 75 ~ 5 ~ 7	150	75	5.0	7	17.85	14.0	89
28	H |175 ~ 90 ~ 5 ~ 8	175	90	5.0	8	22.90	18.0	138
29	H |200 ~100 ~ 5 ~ 8	200	100	5.5	8	26.67	20.9	181
30	H |250 ~125 ~ 6 ~ 9	250	125	6.0	9	36.97	29.0	317
31	H |300 ~150 ~ 6 ~ 9	300	150	6.5	9	46.78	36.7	481
32	H |350 ~175 ~ 7 ~11	350	175	7.0	11	62.91	49.4	771
33	H |400 ~200 ~ 8 ~13	400	200	8.0	13	83.37	65.4	1170
34	H |450 ~200 ~ 9 ~14	450	200	9.0	14	95.43	74.9	1460
35	H |500 ~200 ~10 ~16	500	200	10.0	16	112.20	88.2	1870
36	H |600 ~200 ~11 ~17	600	200	11.0	17	131.70	103.0	2520
37	H |200 ~200 ~ 8 ~12 E	200	200	8.0	12	51.53	55.0	366
38	H |250 ~250 ~ 9 ~14 E	250	250	9.0	14	78.18	80.0	708
39	H |300 ~300 ~10 ~15 E	300	300	10.0	15	104.80	100.0	1150
40	H |350 ~350 ~12 ~19 E	350	350	12.0	19	154.90	150.0	2000
41	H |400 ~400 ~13 ~21 E	400	400	13.0	21	197.70	200.0	2950

Note:Use one set of two sheets for stress check, and doubly consider in process.

1.11 material data

steel sheet pile material

Young's modulus : 2.00* 10^5 N/mm2

unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SY295		SY390	
	normal	earthq.	normal	earthq.
allw bending str	216	324	235	353
allw shear str	99	150	110	165

Material of steel pipe pile

Young's modulus : 2.00* 10^5 N/mm2

Unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SKY400		SY490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	278
allw shear str	80	120	106	160

material of wailing member

Young's modulus : 2.00* 10^5 N/mm2

allowable stress (unit: N/mm2)	SS400		SM490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	280

material of tensile member

Young's modulus : 2.00* 10^5 N/mm2

No	type	allw M stress (unit: N/mm2)	
		normal	earthq.
1	SS400 i ⁻40mm j	94	141
2	SS400 i „40mm j	86	129
3	SS490 i ⁻40mm j	110	165
4	SS490 i „40mm j	102	153
5	,′£–Í |490	125	195
6	,′£–Í |590	155	235
7	,′£–Í |690	176	264

1.12 standard value

(1)factor of safety

check items	requrie FS	
	normal	earthq.
check shear deform failure check slide check bear cap of found grnd check circular slope	1.20 1.20 1.20 1.20	1.00 1.00 1.00 1.00
chk embedment (sand grnd) chk embedment (clay grnd)	1.50 1.20	1.20 1.20
chk shielding (sand grnd) chk shielding (clay grnd)	3.25 3.00	------ ------

(2)design method for liquefaction

1)seismicity for evaluating liquefaction

region	strong	middle	weak
earthq.	0.18	0.15	0.12

2)soil layer classification according to FL

FL range	class
<= 1.00 1.00<= and <=1.30 >= 1.30	liquefied semi-liquefied non-liquefied

3)classification

internally fixed

classifi-cation	increment vibration	active passive
liquefied semi-liq non-liq	consider not not	not not ordinary

4)minimum embedment length to non-liquefied layer at tip: 1.000(m)

5)evaluation method of embedment length : suppose both front and back side of wall satisfied

2 Abbreviation Table

No	Abbreviation	Standard nomenclature
1	actv	active
2	agl	angle
3	bear cap. fac	bearing capacity factor
4	bf	before
5	bt	between
6	cntrt	concentrated
7	co. coord.	coordinate
8	coeff	coefficient
9	coh	cohesion, cohesive
10	comb	combination
11	coord	coordinate
12	crs area	cross section area
13	cs	case
14	dfr	deformation
15	dia	diameter
16	earthq.	earthquake
17	ecc	eccentricity
18	effsrchg	effective surcharge
19	el	elastic
20	embd L	embedment length
21	e-prss	earth pressure
22	exv	excavation
23	frc	force
24	freq compo	frequency component
25	fric	friction
26	Fs	safety factor
27	H	horizontal
28	inc	increment
29	inrt	inertia force
30	inter	internal, inner
31	ld	load
32	LEM	limit equilibrium method
33	liq	liquefaction
34	lv	level
35	ly	layer
36	lyr thck	layer thickness
37	mat	material
38	max	maximum
39	mbr	member
40	min	minimum
41	mt	moment
42	mthd	method
43	nd	node

No	Abbreviation	Standard nomenclature
44	non-liq	non-liquefaction
45	num	number
46	pl	plastic
47	prss	pressure
48	pssv	passive
49	rct	reaction (force)
50	rdc fcr	reduction factor
51	relstiff	relative stiffness
52	rfrm	reinforcement force, deterrent force
53	rsd	residual
54	rslt frc	resultant force
55	rsst	resistance
56	satur	saturation
57	sd	side
58	semi-liq	semi-liquefaction
59	stbl	stability
60	stffns	stiffness, deformation modulus(coeff.)
61	stnd	standard
62	str	stress
63	submrg	submerge, under water
64	Sum	summation
65	tns	tension, tensile
66	w/	with consideration
67	wl	wall
68	wt	weight
69	WT	water, water line, water level
70	wtr prss	water pressure

3　Result table

3.1 table of stability calculation result

Results of wall width B= 8.000(m), L of sheet pile landside LR= 19.000(m), riverside LL= 19.000(m)

(1)check result on shear deformation failure

*)check case: íŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m/m)	rsst moment Mr(kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	2117.14	7645.46	3.61 >= 1.20
Layer boundary surface	33.500	5.000	2350.88	5146.83	2.19 >= 1.20
Layer boundary surface	35.500	3.000	1726.04	4256.39	2.47 >= 1.20
Current ground level	38.500	0.000	703.13	2983.06	4.24 >= 1.20

*)check case: 'n kŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m/m)	rsst moment Mr(kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	3543.77	6587.56	1.86 >= 1.00
Layer boundary surface	33.500	5.000	2993.13	4783.96	1.60 >= 1.00
Layer boundary surface	35.500	3.000	2183.03	3957.98	1.81 >= 1.00
Current ground level	38.500	0.000	948.94	2811.89	2.96 >= 1.00

(2)check result for slide

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	H-frc sum Fd(kN/m)	rsst sum Fr(kN/m)	Factor of safety F
íŽž	28.000	10.500	1069.93	2555.54	2.39 >= 1.20
'n kŽž	28.000	10.500	1181.20	2348.75	1.99 >= 1.00

(3)check result on bearing capacity of foundational ground

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
íŽž	28.000	10.500	7708.78	1467.50	5.25>=1.20
'n kŽž	28.000	10.500	4898.36	1373.60	3.57>=1.00

* check result on embedment

(1)check result based on the limit equilibrium method

*)landside sheet pile

total length= 19.000m(G.L. 28.000m)

check case	required length (m)	final length (m)	active moment (kN.m/m)	passive moment (kN.m/m)	Factor of safety F
íŽž	17.160	19.000	8991.98	15638.55	1.74 >= 1.50
'n kŽž	14.930	19.000	8539.36	14847.00	1.74 >= 1.20

*)riverside sheet pile

total length= 19.000 m(G.L. 28.000m)

check case	required length (m)	final length (m)	active moment (kN.m/m)	passive moment (kN.m/m)	Factor of safety F
íŽž	14.450	19.000	7811.12	16798.52	2.15 >= 1.50
'n kŽž	12.430	19.000	7371.04	15943.66	2.16 >= 1.20

(2)check result on water shielding effect

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
íŽž	29.000	8.000	3.63>=3.25

(3) check about 4c > Sum(Gam h)

Not check about 4c > Sum(Gam h)

3.2 table of member force check result

(1)bending, shear, displacement results

*)landside sheet pile

Total length = 19.000m(G.L. 28.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
˂Žž	270.78	42.000	-243.35	42.000	40.16	37.200
ʼn kŽž	-274.93	38.400	-198.55	42.000	-41.14	47.000

*)riverside sheet pile

Total length = 19.000m(G.L. 28.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
˂Žž	-183.37	42.000	165.70	42.000	-15.67	37.000
ʼn kŽž	-120.54	42.000	132.03	42.000	-9.41	38.200

(2)result of tensile member reaction

*)landside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
ˊ7̌.ˇ/.	0.00	-380.88
ʼn kŽž	0.00	-282.18

*)riverside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
˂Žž	21.85	281.38
ʼn k7̌.ˇ/.	3.34	212.32

(3)table of check result on length of elastic state

Not check for elastic state

3.3 table of member force calculation result (wall, tensile member, wailing)

(1) wall

section type: Steel sheet pile

unit(N/mm²)

	Landside sheet pile		River side sheet pile	
Steel name Steel name	PU28+1 SY295		PU28+1 SY295	
Examined case	Bending stress	Shear stress	Bending stress	Shear stress
ıŽž 'n kŽ½	150.4<= 216.0 152.7<= 324.0	10.8<= 99.0 8.8<= 150.0	101.9<= 216.0 67.0<= 324.0	7.3<= 99.0 5.8<= 150.0

(2) tensile member

1) upper tensile member

diameter : Phi 25(mm)
material : ,'f. ť |690
installing pitch : 3.600(m)
number in use : 1
unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ıŽž 'n kŽ½	0.0<= 176.0 0.0<= 264.0	160.3<= 176.0 24.5<= 264.0

2) lower tensile member

diameter : Phi 75(mm)
material : ,'f. ť |690
installing pitch : 1.800(m)
number in use : 1
unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ıŽž 'n kŽž	155.2<= 176.0 115.0<= 264.0	114.6<= 176.0 86.5<= 264.0

(3) wailing member

1) upper wiling member

steel material : H |150 ~150 ~ 7 ~10
material in use : SS400
unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ıŽž 'n kŽž	0.0<= 140.0 0.0<= 210.0	65.6<= 140.0 10.0<= 210.0

2) lower wailing member

steel material : H |200 ~200 ~ 8 ~12
material in use : SS400
unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
'Ž½ 'n kŽž	130.7<= 140.0 96.8<= 210.0	96.6<= 140.0 72.9<= 210.0

4 Check case (nomal time)

4.1 calculation of external forces

4.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1) water pressure table (riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 42.000	4.000	0.00 40.00
2	42.000 41.750	0.250	40.00 42.50
3	41.750 39.000	2.750	42.50 70.00
4	39.000 37.500	1.500	70.00 85.00
5	37.500 36.000	1.500	85.00 78.29
6	36.000 34.000	2.000	78.29 69.34
7	34.000 28.000	6.000	69.34 42.50

(2) active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam.h) + q)- 2c*Sqrt(Ka)

$$Ka = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 + Sqrt\{\sin(Phi) * \sin(Phi - Theta) / \cos(Theta)\}]^2}$$

where, assume Theta=0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	0.406	-12.74 -7.26	0.00 0.00
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	0.406	-7.26 -1.78	0.00 0.00
3	36.000 35.512	0.488	9.0	25.00	10.0 10.0	27.00 31.39	0.406	-1.78 0.00	0.00 0.00
4	35.512 34.000	1.512	9.0	25.00	10.0 10.0	31.39 45.00	0.406	0.00 5.52	0.00 5.52
5	34.000 27.000	7.000	9.0	25.00	10.0 10.0	45.00 108.00	0.406	5.52 31.09	5.52 31.09
6	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	0.333	24.45 39.45	24.45 39.45

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 - Sqrt\{\sin(Phi) * \sin(Phi - Theta) / \cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	25.00	10.0 10.0	0.00 9.00	2.464	31.39 53.57
2	37.500 35.000	2.500	9.0	25.00	10.0 10.0	9.00 31.50	2.464	53.57 109.01
3	35.000 33.000	2.000	9.0	25.00	10.0 10.0	31.50 49.50	2.464	109.01 153.36
4	33.000 26.000	7.000	9.0	25.00	10.0 10.0	49.50 112.50	2.464	153.36 308.58
5	26.000 21.000	5.000	9.0	30.00	10.0 10.0	112.50 157.50	3.000	372.14 507.14

(4)active earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	0.333	11.67 17.67	11.67 17.67
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	0.333	17.67 41.67	17.67 41.67
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	0.333	41.67 43.17	41.67 43.17
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	0.333	43.17 52.92	43.17 52.92
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	158.75 167.75	0.406	51.69 55.34	51.69 55.34
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	167.75 185.75	0.406	55.34 62.65	55.34 62.65
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	185.75 203.75	0.406	62.65 69.95	62.65 69.95
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	203.75 266.75	0.406	69.95 95.52	69.95 95.52
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	266.75 311.75	0.333	77.37 92.37	77.37 92.37

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	3.000	105.00 159.00
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	3.000	159.00 375.00
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	3.000	375.00 388.50
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	3.000	388.50 476.25
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	158.75 167.75	2.464	422.54 444.72
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	167.75 185.75	2.464	444.72 489.07
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	185.75 203.75	2.464	489.07 533.42
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	203.75 266.75	2.464	533.42 688.64
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	266.75 311.75	3.000	834.89 969.89

(6)passive earth pressure intensity table (out of embankment: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	2.464	31.39 64.66
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	2.464	64.66 97.92
3	36.000 34.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	2.464	97.92 142.27
4	34.000 27.000	7.000	9.0	25.00	10.0 10.0	45.00 108.00	2.464	142.27 297.50
5	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	3.000	358.64 493.64

4.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 41.750(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.750 38.500	3.250	0.00 32.50
2	38.500 37.500	1.000	32.50 42.50
3	37.500 35.500	2.000	42.50 33.55
4	35.500 33.500	2.000	33.55 24.61
5	33.500 28.000	5.500	24.61 0.00

(2) active earth pressure intensity table (embankment section: working external force)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	0.333	11.67 17.67	11.67 17.67
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	0.333	17.67 41.67	17.67 41.67
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	0.333	41.67 43.17	41.67 43.17
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	0.333	43.17 52.92	43.17 52.92
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	158.75 167.75	0.406	51.69 55.34	51.69 55.34
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	167.75 185.75	0.406	55.34 62.65	55.34 62.65
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	185.75 203.75	0.406	62.65 69.95	62.65 69.95
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	203.75 266.75	0.406	69.95 95.52	69.95 95.52
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	266.75 311.75	0.333	77.37 92.37	77.37 92.37

(3) passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	25.00	10.0 10.0	0.00 9.00	2.464	31.39 53.57
2	37.500 35.000	2.500	9.0	25.00	10.0 10.0	9.00 31.50	2.464	53.57 109.01
3	35.000 33.000	2.000	9.0	25.00	10.0 10.0	31.50 49.50	2.464	109.01 153.36
4	33.000 26.000	7.000	9.0	25.00	10.0 10.0	49.50 112.50	2.464	153.36 308.58
5	26.000 21.000	5.000	9.0	30.00	10.0 10.0	112.50 157.50	3.000	372.14 507.14

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

po= Ko(Sum(Gam h)+ q)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ko	active e-prss po (kN m2)
1	38.000 37.500	0.500	18.0	0.00 9.00	0.577	0.00 5.20
2	37.500 35.000	2.500	9.0	9.00 31.50	0.577	5.20 18.19
3	35.000 33.000	2.000	9.0	31.50 49.50	0.577	18.19 28.58
4	33.000 26.000	7.000	9.0	49.50 112.50	0.577	28.58 64.96
5	26.000 21.000	5.000	9.0	112.50 157.50	0.500	56.25 78.75

Note: is a layer without earth pressure in calculation.

4.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1)water pressure intensity table (embankment section)

R.W.L. 41.500(m)

L.W.L. 40.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.500 40.000	1.500	0.00 15.00
2	40.000 38.500	1.500	15.00 13.13
3	38.500 37.500	1.000	13.13 11.88
4	37.500 35.500	2.000	11.88 9.38
5	35.500 33.500	2.000	9.38 6.88
6	33.500 28.000	5.500	6.88 0.00

(2)active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	35.00 125.00	0.333	11.67 41.67	11.67 41.67
2	42.000 41.500	0.500	18.0	30.00	0.0 0.0	125.00 134.00	0.333	41.67 44.67	41.67 44.67
3	41.500 40.000	1.500	9.0	30.00	0.0 0.0	134.00 147.50	0.333	44.67 49.17	44.67 49.17
4	40.000 38.500	1.500	9.0	30.00	0.0 0.0	147.50 161.00	0.333	49.17 53.67	49.17 53.67
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	161.00 170.00	0.406	52.60 56.25	52.60 56.25
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	170.00 188.00	0.406	56.25 63.56	56.25 63.56
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	188.00 206.00	0.406	63.56 70.87	63.56 70.87
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	206.00 269.00	0.406	70.87 96.43	70.87 96.43
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	269.00 314.00	0.333	78.12 93.12	78.12 93.12

(3)passive earth pressure intensity table(out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	2.464	31.39 64.66
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	2.464	64.66 97.92
3	36.000 34.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	2.464	97.92 142.27
4	34.000 27.000	7.000	9.0	25.00	10.0 10.0	45.00 108.00	2.464	142.27 297.50
5	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	3.000	358.64 493.64

Note:is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	39.000 37.500	1.500	9.0	0.00 13.50	0.577	0.00 7.79
2	37.500 36.000	1.500	9.0	13.50 27.00	0.577	7.79 15.59
3	36.000 34.000	2.000	9.0	27.00 45.00	0.577	15.59 25.98
4	34.000 27.000	7.000	9.0	45.00 108.00	0.577	25.98 62.36
5	27.000 22.000	5.000	9.0	108.00 153.00	0.500	54.00 76.50

Note: is a layer without earth pressure in calculation.

4.2 Stability analysis

4.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.20)

Md: shear deformation moment on check plane(kN* m/m)

Mr: shear resistant moment on check plane(kN* m/m)

$$Mr = Mro * \left(1 + \frac{d}{H} \right) + Msp$$

$$Mro = \int_{0}^{yo} (pRP - pRA)\, y\, dy$$

where,

Mro: basic shear resistant moment of filling soil

d : depth from current ground surface to check level

H : wall height(from top of wall to ground level in embankment range)

pRP: passive earth pressure above check level with a distance y(kN/m2)

pRA: active earth pressure above check level with a distance y(kN/m2)

y : a distance from the location of pRP,pRA working(m)

yo : cross point coordinates of the failure plane in filling soil

Msp: resistant moment caused by two rows sheet piles

smaller resistance either landside or riverside and make double to evaluate

Msp= 2* (smaller value either Msp1 or Msp2)

Msp1: resistant moment derived from sheet pile

Msp1= Sig.a* Zsp

Sig.a: allowable stress of sheet pile in use(N/mm2)

Zsp : section modulus considering joint(splice) of sheet pile in use(mm^3/ m)

Msp2: resistant moment allowed by embedment deeper than check level.

Msp2= Ppu* hpu

Ppu: passive resultant force from check elevation to sheet pile tip

hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	2117.14	7645.46	3.61>=1.20
Layer boundary surface	33.500	5.000	2350.88	5146.83	2.19>=1.20
Layer boundary surface	35.500	3.000	1726.04	4256.39	2.47>=1.20
Current ground level	38.500	0.000	703.13	2983.06	4.24>=1.20

(2)check level(Embedment tip: G.L. 28.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2117.14
resistant moment	Mr(kN.m/m)	7645.46
factor of safety	Mr/ Md	3.61>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	7651.77
active earth-prss moment	Ma	258.05
pssv earth-prss moment	- Mp	5792.68
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	2117.14

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	15.333	1226.67
2	42.000 41.750	0.250	40.00 42.50	10.31	13.874	143.07
3	41.750 39.000	2.750	42.50 70.00	154.69	12.263	1896.93
4	39.000 37.500	1.500	70.00 85.00	116.25	10.226	1188.75
5	37.500 36.000	1.500	85.00 78.29	122.47	8.760	1072.85
6	36.000 34.000	2.000	78.29 69.34	147.63	7.020	1036.40
7	34.000 28.000	6.000	69.34 42.50	335.53	3.240	1087.11
Sum				966.88		7651.77

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	10.250	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	8.750	0.00
3	36.000 35.512	0.488	0.00 0.00	0.00	7.756	0.00
4	35.512 34.000	1.512	0.00 5.52	4.17	6.504	27.15
5	34.000 28.000	6.000	5.52 27.44	98.88	2.335	230.90
Sum				103.06		258.05

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	31.39 53.57	21.24	9.728	206.63
2	37.500 35.000	2.500	53.57 109.01	203.22	8.108	1647.69
3	35.000 33.000	2.000	109.01 153.36	262.36	5.944	1559.40
4	33.000 28.000	5.000	153.36 264.23	1043.98	2.279	2378.95
Sum				1530.80		5792.68

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

FORUM8

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	7645.46 0.00 388.80 0.00
rsst moment Mr(kN.m/m)	7645.46

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 3420.34* (1+ 1.235)= 7645.46(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	31.625 28.000	3.625	574.99 655.38	76.80 90.04	498.19 565.34	1927.65	1.774	3420.34
Sum						1927.65		3420.34

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	31.625	28.000	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan^{-1} (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(388.80, 0.00)= 0.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m^3/m - - - - - - - - * 10^{-6} m^3/m * 10^3 kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 33.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2350.88
resistant moment	Mr(kN.m/m)	5146.83
factor of safety	Mr/ Md	2.19>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	3100.82
active earth-prss moment	Ma	4.96
pssv earth-prss moment	- Mp	754.90
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	2350.88

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	9.833	786.67
2	42.000 41.750	0.250	40.00 42.50	10.31	8.374	86.35
3	41.750 39.000	2.750	42.50 70.00	154.69	6.763	1046.15
4	39.000 37.500	1.500	70.00 85.00	116.25	4.726	549.38
5	37.500 36.000	1.500	85.00 78.29	122.47	3.260	399.28
6	36.000 34.000	2.000	78.29 69.34	147.63	1.520	224.43
7	34.000 33.500	0.500	69.34 67.11	34.11	0.251	8.57
Sum				665.46		3100.82

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	4.750	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	3.250	0.00
3	36.000 35.512	0.488	0.00 0.00	0.00	2.256	0.00
4	35.512 34.000	1.512	0.00 5.52	4.17	1.004	4.19
5	34.000 33.500	0.500	5.52 7.35	3.22	0.238	0.77
Sum				7.39		4.96

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	38.000 37.500	0.500	31.39 53.57	21.24	4.228	89.81
2	37.500 35.000	2.500	53.57 109.01	203.22	2.608	529.98
3	35.000 33.500	1.500	109.01 142.27	188.46	0.717	135.11
Sum				412.92		754.90

d. other load moment

* Sum(Pc)= 0.00(kN m/m)
* Sum(Mc)= 0.00(kN m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	4369.23 777.60 388.80 3549.33
rsst moment Mr(kN m/m)	5146.83

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2751.00* (1+ 0.588)= 4369.23(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP- pRA (kN/m2)	H frc Pr (kN/m)	arm L y (m)	moment Mro kN m/m
1	37.125 35.500	1.625	453.03 489.07	56.71 62.65	396.32 426.42	668.47	2.803	1873.46
2	35.500 33.500	2.000	489.07 533.42	62.65 69.95	426.42 463.46	889.88	0.986	877.53
Sum						1558.36		2751.00

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis- angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	37.125 35.500	35.500 33.500	1.625 2.000	25.00 25.00	0.00 0.00	32.50 32.50	2.551 3.139	57.50 57.50	1.035 1.274	3.586 4.414
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(388.80, 3549.33)= 777.60(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	33.500 28.000	5.500	153.36 275.32	1178.87	3.011	3549.33
Sum				1178.87		3549.33

(4) check level(Layer boundary surface: G.L. 35.500m)

1) check result

item	value
deformation moment MH(kN.m/m)	1726.04
resistant moment Mr(kN.m/m)	4256.39
factor of safety Mr/ MH	2.47>=1.20

2) deformation moment(MH)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc	1910.08 0.00 184.03 0.00
deformation moment MH(kN.m/m)	1726.04

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	7.833	626.67
2	42.000 41.750	0.250	40.00 42.50	10.31	6.374	65.73
3	41.750 39.000	2.750	42.50 70.00	154.69	4.763	736.77
4	39.000 37.500	1.500	70.00 85.00	116.25	2.726	316.88
5	37.500 36.000	1.500	85.00 78.29	122.47	1.260	154.34
6	36.000 35.500	0.500	78.29 76.05	38.59	0.251	9.69
Sum				522.30		1910.08

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	2.750	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	1.250	0.00
3	36.000 35.512	0.488	0.00 0.00	0.00	0.256	0.00
4	35.512 35.500	0.012	0.00 0.04	0.00	0.004	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	31.39 53.57	21.24	2.228	47.33
2	37.500 35.500	2.000	53.57 97.92	151.49	0.902	136.70
Sum				172.73		184.03

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	3478.79 777.60 388.80 6184.21
rsst moment Mr(kN.m/m)	4256.39

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2571.28* (1+ 0.353)= 3478.79(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	39.097 38.500	0.597	460.13 476.25	51.13 52.92	409.01 423.33	248.45	3.297	819.10
2	38.500 37.500	1.000	422.54 444.72	51.69 55.34	370.85 389.37	380.11	2.496	948.74
3	37.500 35.500	2.000	444.72 489.07	55.34 62.65	389.37 426.42	815.79	0.985	803.44
Sum						1444.36		2571.28

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth top GL(m)	depth bottom GL(m)	thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure angle xip	passive failure width Bp (m)	active failure angle xia	active failure width Ba (m)	failure W Bp+Ba (m)
1	39.097	38.500	0.597	30.00	0.00	30.00	1.034	60.00	0.345	1.379
2	38.500	37.500	1.000	25.00	0.00	32.50	1.570	57.50	0.637	2.207
3	37.500	35.500	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$\cot(xip)=\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}(-\dfrac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$

xip= 90.0- $\tan^{-1}$ (cot(xip))

* active failure plane

Ba= cot(xia)* h

$\cot(xia)=-\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}(-\dfrac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)})$

xia= 90.0- $\tan^{-1}$ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(388.80, 6184.21)= 777.60(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	216.0	216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	35.500 34.000	1.500	109.01 142.27	188.46	0.783	147.58
2	34.000 28.000	6.000	142.27 275.32	1252.77	4.819	6036.63
Sum				1441.23		6184.21

(5)check level(Current ground level: G.L. 38.500m)

1)check result

item		value
deformation moment	MH(kN.m/m)	703.13
resistant moment	Mr(kN.m/m)	2983.06
factor of safety	Mr/ MH	4.24>=1.20

2)deformation moment(MH)calculation

deformation moment in detail		moment
water pressure moment	Mw	703.13
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	0.00
other load moment	Mc	0.00
deformation moment	MH(kN.m/m)	703.13

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	4.833	386.67
2	42.000 41.750	0.250	40.00 42.50	10.31	3.374	34.79
3	41.750 39.000	2.750	42.50 70.00	154.69	1.763	272.71
4	39.000 38.500	0.500	70.00 75.00	36.25	0.247	8.96
Sum				281.25		703.13

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.500	0.500	0.00 0.00	0.00	0.250	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	2205.46 777.60 388.80 10898.64
rsst moment Mr(kN.m/m)	2983.06

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2205.46* (1+ 0.000)= 2205.46(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.964 41.750	0.214	376.94 388.50	41.88 43.17	335.06 345.33	72.80	3.356	244.36
2	41.750 38.500	3.250	388.50 476.25	43.17 52.92	345.33 423.33	1249.08	1.570	1961.10
Sum						1321.89		2205.46

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+Ba (m)
1	41.964	41.750	0.214	30.00	0.00	30.00	0.371	60.00	0.124	0.494
2	41.750	38.500	3.250	30.00	0.00	30.00	5.629	60.00	1.876	7.506
Interval Sum(Bp) + Ba										8.000

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xip= 90.0- tan^{-1} (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(388.80, 10898.64)= 777.60(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	216.0	216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.500 37.500	1.000	42.48 64.66	53.57	0.534	28.63
2	37.500 36.000	1.500	64.66 97.92	121.93	1.801	219.62
3	36.000 34.000	2.000	97.92 142.27	240.19	3.562	855.45
4	34.000 28.000	6.000	142.27 275.32	1252.77	7.819	9794.95
Sum				1668.46		10898.64

4.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.20)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	28.000	10.500	1069.93	2555.54	2.39>=1.20

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item	value
sum of H force Fd(kN/m)	1069.93
sum of rsst Fr(kN/m)	2555.54
factor of safety Fr/ Fd	2.39>=1.20

2)sum of horizontal force(Fd)

horizontal force in detail	H force
water pressure Fw active earth pressure Fa other load Fc	966.88 103.06 0.00
sum of H force Fd(kN/m)	1069.93

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail	H force
ground H resistance Fs passive earth pressure Fp	1024.74 1530.80
sum of resistance Fr(kN/m)	2555.54

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 8.000+ 2026.00* tan(25.00) Deg.

= 1024.74(kN/m)

b.soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (218.25+ 35.00)* 8.000= 2026.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	42.000	4.000	18.0	72.00
3	42.000	41.750	0.250	18.0	4.50
4	41.750	38.500	3.250	9.0	29.25
5	38.500	37.500	1.000	9.0	9.00
6	37.500	35.500	2.000	9.0	18.00
7	35.500	33.500	2.000	9.0	18.00
8	33.500	28.000	5.500	9.0	49.50
Sum			19.000		218.25

c.passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

4.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 8.000, height H= 8.500(m) using the next equation.

$$\frac{Qu}{V - Gam2 * Df * Be} >= FS$$

$$Qu = Be\{ k * c * Nc + k * Gam2 * Df * (Nq - 1) + \frac{1}{2} * Gam1 * Be * NGam \}$$

where,

FS : required factor of safety(1.20)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B- 2e

B: wall width

e: eccentricity(e= Mb/ V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/ V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	28.000	10.500	7708.78	1467.50	5.25>=1.20

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	2026.00
	distance from ground to check level	Df	10.500
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	5.910
	v-compo sum V- Gam2.Df.Be (kN/m)		1467.50
Qu	moment on check level	Mb	2117.14
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	1.045
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		7708.78
factor of safety			5.25>=1.20

2)summery of external force

external force detail		moment Mb(kN.m/m)	H-force Hb(kN/m)
water pressure	Mw(Fw)	7651.77	966.88
active earth pressure	Ma(Fa)	258.05	103.06
passive earth pressure-	Mp(Fp)	5792.68	1530.80
other load	Mc(Fc)	0.00	0.00
external force sum		2117.14	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b.active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

3) weight of filling soil(V)

refer to 'b. weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 2026.00(kN/m)

4) eccentricity distance(e) calculation

e = Mb/ V

= 2117.14/ 2026.00

= 1.045(m)

Be= B- 2e

= 8.000- 2.0* 1.045

= 5.910(m)

5) calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 2026.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\ 2 = \frac{Sum(Gam\ i\ hi)}{Sum(hi)}$$

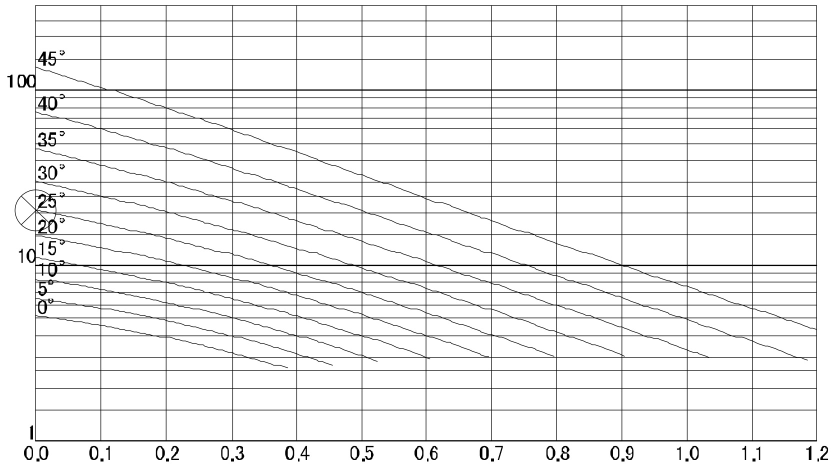
= 9.00(kN/m3)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	38.500	37.500	1.000	9.0	9.00
2	37.500	35.500	2.000	9.0	18.00
3	35.500	33.500	2.000	9.0	18.00
4	33.500	28.000	5.500	9.0	49.50
Sum			10.500		94.50

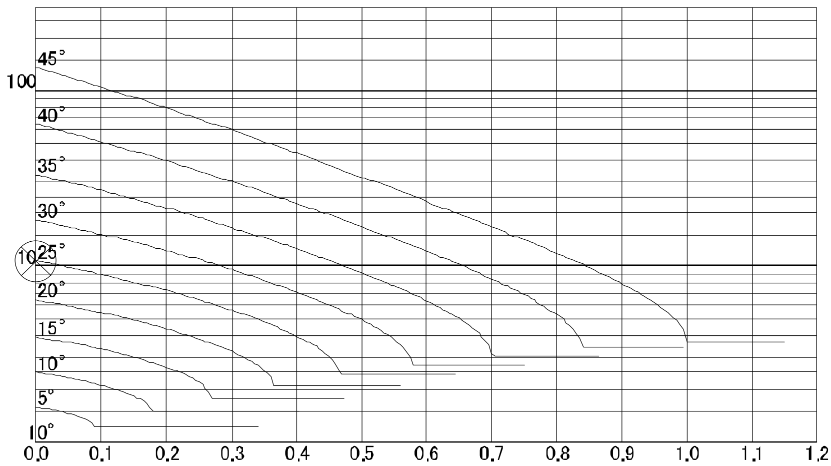
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mb/ Hb)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

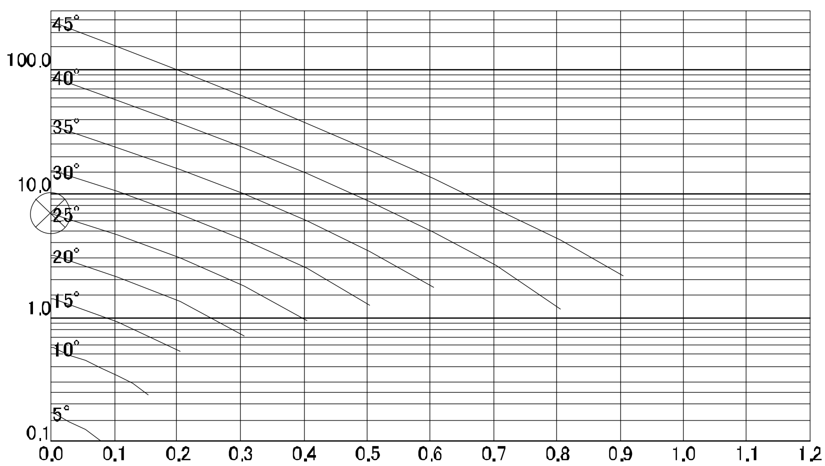
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



4.3 landside sheet pile

4.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.750(m)
L.WL : 37.500(m)

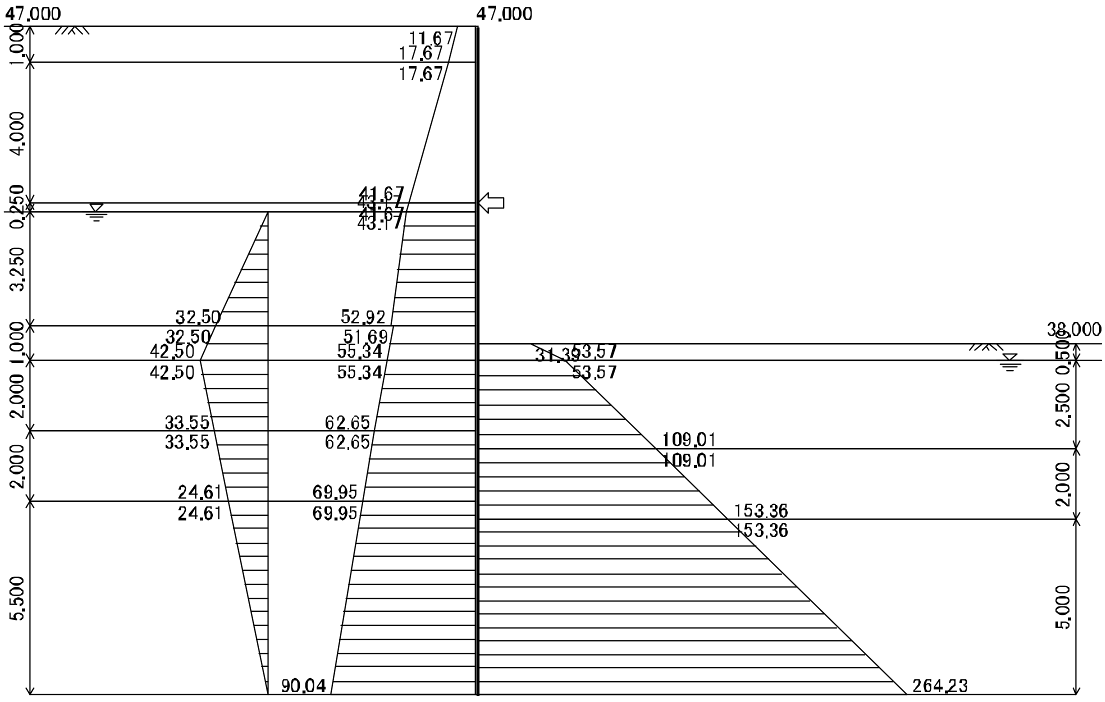
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	29.840	28.000
active sd	Ma+Mw+Mac(kN m/m)	6504.29	8991.98
passive sd	Mp+Mpc(kN m/m)	9758.68	15638.55
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.500>=1.50	1.739>=1.50



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(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.750	0.250	41.67 43.17	10.60	0.126	1.33
2	41.750 38.500	3.250	43.17 52.92	156.14	1.930	301.34
3	38.500 37.500	1.000	51.69 55.34	53.51	4.006	214.36
4	37.500 35.500	2.000	55.34 62.65	117.99	5.521	651.37
5	35.500 33.500	2.000	62.65 69.95	132.60	7.518	996.93
6	33.500 28.000	5.500	69.95 90.04	439.98	11.365	5000.47
Sum				910.83		7165.81

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.750 38.500	3.250	0.00 32.50	52.81	2.417	127.63
2	38.500 37.500	1.000	32.50 42.50	37.50	4.022	150.83
3	37.500 35.500	2.000	42.50 33.55	76.05	5.461	415.31
4	35.500 33.500	2.000	33.55 24.61	58.16	7.449	433.20
5	33.500 28.000	5.500	24.61 0.00	67.66	10.333	699.20
Sum				292.19		1826.17

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	31.39 53.57	21.24	4.272	90.73
2	37.500 35.000	2.500	53.57 109.01	203.22	5.892	1197.39
3	35.000 33.000	2.000	109.01 153.36	262.36	8.056	2113.70
4	33.000 28.000	5.000	153.36 264.23	1043.98	11.721	12236.73
Sum				1530.80		15638.55

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

4.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	270.78	G.L. 42.000
max shear force Smax(kN/m)	-243.35	G.L. 42.000
upper tension mbr rct R1(kN/m)	0.00	G.L. 46.000
lower tension mbr rct R2(kN/m)	-380.88	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	11.67 17.67	0.00 0.00	---- ----	---- ----	11.67 17.67	---- ----
2	46.000 42.000	17.67 41.67	0.00 0.00	---- ----	---- ----	17.67 41.67	---- ----
3	42.000 41.750	41.67 43.17	0.00 0.00	---- ----	---- ----	41.67 43.17	---- ----
4	41.750 38.500	43.17 52.92	0.00 32.50	---- ----	---- ----	43.17 85.42	---- ----
5	38.500 38.000	51.69 53.51	32.50 37.50	---- ----	---- ----	84.19 91.01	---- ----
6	38.000 37.500	53.51 55.34	37.50 42.50	31.39 53.57	0.00 5.20	91.01 92.64	31.39 48.37
7	37.500 35.500	55.34 62.65	42.50 33.55	53.57 97.92	5.20 15.59	92.64 80.61	48.37 82.33
8	35.500 35.000	62.65 64.47	33.55 31.32	97.92 109.01	15.59 18.19	80.61 77.60	82.33 90.82
9	35.000 33.500	64.47 69.95	31.32 24.61	109.01 142.27	18.19 25.98	77.60 68.58	90.82 116.29
10	33.500 33.000	69.95 71.78	24.61 22.37	142.27 153.36	25.98 28.58	68.58 65.57	116.29 124.78
11	33.000 28.000	71.78 90.04	22.37 0.00	153.36 264.23	28.58 54.56	65.57 35.48	124.78 209.67

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	38.000	37.500	0.500	16800	4037
2	37.500	35.000	2.500	16800	4037
3	35.000	33.000	2.000	16800	4037
4	33.000	26.000	7.000	19600	4710
5	26.000	21.000	5.000	92400	22202

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.*(2*number*A*E)}{(L*s)}$$

where,

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Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000] m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	11.67	1.20	--------	--------	--------	--------
2	46.800	On excavation plane	12.87	12.87	2.57	--------	--------	--------	--------
3	46.600	On excavation plane	14.07	14.07	2.81	--------	--------	--------	--------
4	46.400	On excavation plane	15.27	15.27	3.05	--------	--------	--------	--------
5	46.200	On excavation plane	16.47	16.47	3.29	--------	--------	--------	--------
6	46.000	Tensile member	17.67	17.67	3.53	--------	--------	--------	6818
7	45.800	On excavation plane	18.87	18.87	3.77	--------	--------	--------	--------
8	45.600	On excavation plane	20.07	20.07	4.01	--------	--------	--------	--------
9	45.400	On excavation plane	21.27	21.27	4.25	--------	--------	--------	--------
10	45.200	On excavation plane	22.47	22.47	4.49	--------	--------	--------	--------
11	45.000	On excavation plane	23.67	23.67	4.73	--------	--------	--------	--------
12	44.800	On excavation plane	24.87	24.87	4.97	--------	--------	--------	--------
13	44.600	On excavation plane	26.07	26.07	5.21	--------	--------	--------	--------
14	44.400	On excavation plane	27.27	27.27	5.45	--------	--------	--------	--------
15	44.200	On excavation plane	28.47	28.47	5.69	--------	--------	--------	--------
16	44.000	On excavation plane	29.67	29.67	5.93	--------	--------	--------	--------
17	43.800	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
18	43.600	On excavation plane	32.07	32.07	6.41	--------	--------	--------	--------
19	43.400	On excavation plane	33.27	33.27	6.65	--------	--------	--------	--------
20	43.200	On excavation plane	34.47	34.47	6.89	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN m
			above nd kN m2	below nd kN m2	cntrt ld kN m2	above nd kN m2	below nd kN m2	cntrt ld kN m2	
21	43.000	On excavation plane	35.67	35.67	7.13	--------	--------	--------	--------
22	42.800	On excavation plane	36.87	36.87	7.37	--------	--------	--------	--------
23	42.600	On excavation plane	38.07	38.07	7.61	--------	--------	--------	--------
24	42.400	On excavation plane	39.27	39.27	7.85	--------	--------	--------	--------
25	42.200	On excavation plane	40.47	40.47	8.09	--------	--------	--------	--------
26	42.000	Tensile member	41.67	41.67	8.33	--------	--------	--------	122718
27	41.800	On excavation plane	42.87	42.87	5.33	--------	--------	--------	--------
28	41.750	On excavation plane	43.17	43.17	4.35	--------	--------	--------	--------
29	41.600	On excavation plane	45.12	45.12	7.92	--------	--------	--------	--------
30	41.400	On excavation plane	47.72	47.72	9.54	--------	--------	--------	--------
31	41.200	On excavation plane	50.32	50.32	10.06	--------	--------	--------	--------
32	41.000	On excavation plane	52.92	52.92	10.58	--------	--------	--------	--------
33	40.800	On excavation plane	55.52	55.52	11.10	--------	--------	--------	--------
34	40.600	On excavation plane	58.12	58.12	11.62	--------	--------	--------	--------
35	40.400	On excavation plane	60.72	60.72	12.14	--------	--------	--------	--------
36	40.200	On excavation plane	63.32	63.32	12.66	--------	--------	--------	--------
37	40.000	On excavation plane	65.92	65.92	13.18	--------	--------	--------	--------
38	39.800	On excavation plane	68.52	68.52	13.70	--------	--------	--------	--------
39	39.600	On excavation plane	71.12	71.12	14.22	--------	--------	--------	--------
40	39.400	On excavation plane	73.72	73.72	14.74	--------	--------	--------	--------
41	39.200	On excavation plane	76.32	76.32	15.26	--------	--------	--------	--------
42	39.000	On excavation plane	78.92	78.92	15.78	--------	--------	--------	--------
43	38.800	On excavation plane	81.52	81.52	16.30	--------	--------	--------	--------
44	38.600	On excavation plane	84.12	84.12	12.57	--------	--------	--------	--------
45	38.500	On excavation plane	85.42	84.19	8.48	--------	--------	--------	--------
46	38.400	On excavation plane	85.55	85.55	12.88	--------	--------	--------	--------
47	38.200	On excavation plane	88.28	88.28	17.66	--------	--------	--------	--------
48	38.000	Pa plas.	91.01	91.01	18.15	0.00	31.39	3.31	--------
49	37.800	Pa plas.	91.67	91.67	18.33	38.19	38.19	7.64	--------
50	37.600	Pa plas.	92.32	92.32	13.84	44.98	44.98	6.62	--------
51	37.500	Pa plas.	92.64	92.64	9.25	48.37	48.37	4.82	--------
52	37.400	Pa plas.	92.04	92.04	13.78	50.07	50.07	7.57	--------
53	37.200	Pa plas.	90.84	90.84	18.17	53.47	53.47	10.69	--------
54	37.000	Pa plas.	89.64	89.64	17.93	56.86	56.86	11.37	--------
55	36.800	Pa plas.	88.43	88.43	17.69	60.26	60.26	12.05	--------
56	36.600	Pa plas.	87.23	87.23	17.45	63.65	63.65	12.73	--------
57	36.400	Pa plas.	86.03	86.03	17.21	67.05	67.05	13.41	--------
58	36.200	Pa plas.	84.82	84.82	16.96	70.44	70.44	14.09	--------
59	36.000	Pa plas.	83.62	83.62	16.72	73.84	73.84	14.77	--------
60	35.800	Pa plas.	82.42	82.42	16.48	77.24	77.24	15.45	--------
61	35.600	Pa plas.	81.21	81.21	12.20	80.63	80.63	12.03	--------
62	35.500	Pa plas.	80.61	80.61	8.06	82.33	82.33	8.23	--------
63	35.400	Pa plas.	80.01	80.01	11.98	84.03	84.03	12.67	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
64	35.200	Pa plas.	78.80	78.80	15.76	87.42	87.42	17.48	--------
65	35.000	Pa plas.	77.60	77.60	15.52	90.82	90.82	18.16	--------
66	34.800	Pa plas.	76.40	76.40	15.28	94.22	94.22	18.84	--------
67	34.600	Pa plas.	75.19	75.19	15.04	97.61	97.61	19.52	--------
68	34.400	Pa plas.	73.99	73.99	14.80	101.01	101.01	20.20	--------
69	34.200	Pa plas.	72.79	72.79	14.56	104.40	104.40	20.88	--------
70	34.000	Pa plas.	71.58	71.58	14.32	107.80	107.80	21.56	--------
71	33.800	Pas ela.	70.38	70.38	14.08	111.19	111.19	--------	807
72	33.600	Pas ela.	69.18	69.18	10.40	114.59	114.59	--------	606
73	33.500	Pas ela.	68.58	68.58	6.86	116.29	116.29	--------	404
74	33.400	Pas ela.	67.97	67.97	10.17	117.99	117.99	--------	606
75	33.200	Pas ela.	66.77	66.77	13.35	121.38	121.38	--------	807
76	33.000	Pas ela.	65.57	65.57	13.11	124.78	124.78	--------	875
77	32.800	Pas ela.	64.36	64.36	12.87	128.17	128.17	--------	942
78	32.600	Pas ela.	63.16	63.16	12.63	131.57	131.57	--------	942
79	32.400	Pas ela.	61.96	61.96	12.39	134.96	134.96	--------	942
80	32.200	Pas ela.	60.75	60.75	12.15	138.36	138.36	--------	942
81	32.000	Pas ela.	59.55	59.55	11.91	141.76	141.76	--------	942
82	31.800	Pas ela.	58.35	58.35	11.67	145.15	145.15	--------	942
83	31.600	Pas ela.	57.14	57.14	11.43	148.55	148.55	--------	942
84	31.400	Pas ela.	55.94	55.94	11.19	151.94	151.94	--------	942
85	31.200	Pas ela.	54.74	54.74	10.95	155.34	155.34	--------	942
86	31.000	Pas ela.	53.53	53.53	10.71	158.73	158.73	--------	942
87	30.800	Pas ela.	52.33	52.33	10.47	162.13	162.13	--------	942
88	30.600	Pas ela.	51.12	51.12	10.22	165.53	165.53	--------	942
89	30.400	Pas ela.	49.92	49.92	9.98	168.92	168.92	--------	942
90	30.200	Pas ela.	48.72	48.72	9.74	172.32	172.32	--------	942
91	30.000	Pas ela.	47.51	47.51	9.50	175.71	175.71	--------	942
92	29.800	Pas ela.	46.31	46.31	9.26	179.11	179.11	--------	942
93	29.600	Pas ela.	45.11	45.11	9.02	182.50	182.50	--------	942
94	29.400	Pas ela.	43.90	43.90	8.78	185.90	185.90	--------	942
95	29.200	Pas ela.	42.70	42.70	8.54	189.30	189.30	--------	942
96	29.000	Pas ela.	41.50	41.50	8.30	192.69	192.69	--------	942
97	28.800	Pas ela.	40.29	40.29	8.06	196.09	196.09	--------	942
98	28.600	Pas ela.	39.09	39.09	7.82	199.48	199.48	--------	942
99	28.400	Pas ela.	37.89	37.89	7.58	202.88	202.88	--------	942
100	28.200	Pas ela.	36.68	36.68	7.34	206.28	206.28	--------	942
101	28.000	Pas ela.	35.48	0.00	3.58	209.67	0.00	--------	471
Sum					1051.19			304.11	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= 40.16mm(G.L. 37.200m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	----	-15.25	----	----
2	46.800	on exv	----	-14.81	----	----
3	46.600	on exv	----	-14.38	----	----
4	46.400	on exv	----	-13.94	----	----
5	46.200	on exv	----	-13.51	----	----
6	46.000	on exv	6818	-13.07	----	Note: 0.00
7	45.800	on exv	----	-12.62	----	----
8	45.600	on exv	----	-12.17	----	----
9	45.400	on exv	----	-11.71	----	----
10	45.200	on exv	----	-11.24	----	----
11	45.000	on exv	----	-10.75	----	----
12	44.800	on exv	----	-10.24	----	----
13	44.600	on exv	----	-9.70	----	----
14	44.400	on exv	----	-9.14	----	----
15	44.200	on exv	----	-8.54	----	----
16	44.000	on exv	----	-7.89	----	----
17	43.800	on exv	----	-7.19	----	----
18	43.600	on exv	----	-6.43	----	----
19	43.400	on exv	----	-5.60	----	----
20	43.200	on exv	----	-4.69	----	----
21	43.000	on exv	----	-3.70	----	----
22	42.800	on exv	----	-2.59	----	----
23	42.600	on exv	----	-1.38	----	----
24	42.400	on exv	----	-0.03	----	----
25	42.200	on exv	----	1.46	----	----
26	42.000	on exv	122718	3.10	----	Note: -380.88
27	41.800	on exv	----	4.92	----	----
28	41.750	on exv	----	5.40	----	----
29	41.600	on exv	----	6.88	----	----
30	41.400	on exv	----	8.95	----	----
31	41.200	on exv	----	11.11	----	----
32	41.000	on exv	----	13.33	----	----
33	40.800	on exv	----	15.58	----	----
34	40.600	on exv	----	17.83	----	----
35	40.400	on exv	----	20.06	----	----
36	40.200	on exv	----	22.24	----	----
37	40.000	on exv	----	24.37	----	----
38	39.800	on exv	----	26.41	----	----
39	39.600	on exv	----	28.36	----	----
40	39.400	on exv	----	30.19	----	----
41	39.200	on exv	----	31.89	----	----
42	39.000	on exv	----	33.44	----	----
43	38.800	on exv	----	34.85	----	----
44	38.600	on exv	----	36.10	----	----
45	38.500	on exv	----	36.66	----	----
46	38.400	on exv	----	37.18	----	----
47	38.200	on exv	----	38.10	----	----
48	38.000	pssv pl	----	38.84	8.20	----
49	37.800	pssv pl	----	39.41	9.46	----
50	37.600	pssv pl	----	39.82	10.93	----
51	37.500	pssv pl	----	39.97	11.93	----
52	37.400	pssv pl	----	40.07	12.51	----
53	37.200	pssv pl	----	40.16	13.24	----
54	37.000	pssv pl	----	40.10	14.09	----
55	36.800	pssv pl	----	39.89	14.93	----
56	36.600	pssv pl	----	39.55	15.77	----
57	36.400	pssv pl	----	39.09	16.61	----
58	36.200	pssv pl	----	38.51	17.45	----
59	36.000	pssv pl	----	37.82	18.29	----
60	35.800	pssv pl	----	37.04	19.13	----
61	35.600	pssv pl	----	36.18	19.87	----
62	35.500	pssv pl	----	35.72	20.40	----
63	35.400	pssv pl	----	35.24	20.92	----
64	35.200	pssv pl	----	34.24	21.66	----
65	35.000	pssv pl	----	33.19	22.50	----
66	34.800	pssv pl	----	32.09	23.34	----
67	34.600	pssv pl	----	30.97	24.18	----
68	34.400	pssv pl	----	29.82	25.02	----
69	34.200	pssv pl	----	28.66	25.86	----
70	34.000	pssv pl	----	27.50	26.70	----
71	33.800	pssv el	807	26.35	27.55	-21.27
72	33.600	pssv el	606	25.20	28.28	-15.26
73	33.500	pssv el	404	24.64	28.81	-9.95
74	33.400	pssv el	606	24.08	29.33	-14.58
75	33.200	pssv el	807	22.97	30.07	-18.54
76	33.000	pssv el	875	21.89	28.53	-19.15
77	32.800	pssv el	942	20.84	27.22	-19.63
78	32.600	pssv el	942	19.83	27.94	-18.67
79	32.400	pssv el	942	18.84	28.66	-17.75
80	32.200	pssv el	942	17.90	29.38	-16.86
81	32.000	pssv el	942	16.99	30.10	-16.00
82	31.800	pssv el	942	16.11	30.82	-15.18
83	31.600	pssv el	942	15.27	31.54	-14.39
84	31.400	pssv el	942	14.47	32.26	-13.63
85	31.200	pssv el	942	13.70	32.98	-12.90
86	31.000	pssv el	942	12.96	33.71	-12.20

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
87	30.800	pssv el	942	12.24	34.43	-11.53
88	30.600	pssv el	942	11.56	35.15	-10.89
89	30.400	pssv el	942	10.89	35.87	-10.26
90	30.200	pssv el	942	10.25	36.59	-9.66
91	30.000	pssv el	942	9.63	37.31	-9.07
92	29.800	pssv el	942	9.02	38.03	-8.50
93	29.600	pssv el	942	8.43	38.75	-7.94
94	29.400	pssv el	942	7.85	39.47	-7.39
95	29.200	pssv el	942	7.27	40.19	-6.85
96	29.000	pssv el	942	6.71	40.92	-6.32
97	28.800	pssv el	942	6.14	41.64	-5.79
98	28.600	pssv el	942	5.59	42.36	-5.26
99	28.400	pssv el	942	5.03	43.08	-4.74
100	28.200	pssv el	942	4.47	43.80	-4.21
101	28.000	pssv el	471	3.92	44.34	-1.85
Sum						-747.09

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= 270.78kN m/m(G.L. 42.000m)
max shear force Smax= -243.35kN/m (G.L. 42.000m)
max displacement Del.xmax= 40.16mm (G.L. 37.200m)

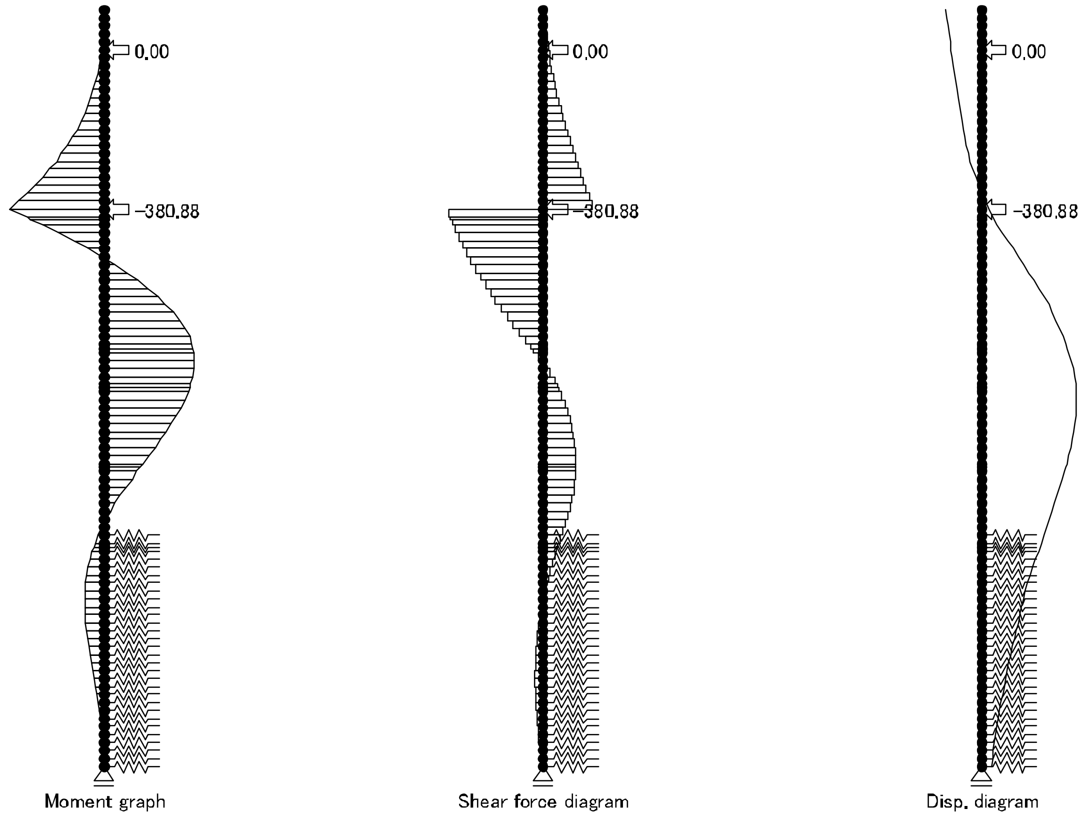
node No	Y co GL(m)	moment kN m/m top	moment kN m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	1.20	-15.25	------------
2	46.800	0.24	0.24	1.20	3.77	-14.81	------------
3	46.600	0.99	0.99	3.77	6.58	-14.38	------------
4	46.400	2.31	2.31	6.58	9.64	-13.94	------------
5	46.200	4.24	4.24	9.64	12.93	-13.51	------------
6	46.000	6.82	6.82	12.93	16.46	-13.07	* 0.00
7	45.800	10.12	10.12	16.46	20.24	-12.62	------------
8	45.600	14.16	14.16	20.24	24.25	-12.17	------------
9	45.400	19.01	19.01	24.25	28.50	-11.71	------------
10	45.200	24.71	24.71	28.50	33.00	-11.24	------------
11	45.000	31.31	31.31	33.00	37.73	-10.75	------------
12	44.800	38.86	38.86	37.73	42.70	-10.24	------------
13	44.600	47.40	47.40	42.70	47.92	-9.70	------------
14	44.400	56.98	56.98	47.92	53.37	-9.14	------------
15	44.200	67.66	67.66	53.37	59.06	-8.54	------------
16	44.000	79.47	79.47	59.06	65.00	-7.89	------------
17	43.800	92.47	92.47	65.00	71.17	-7.19	------------
18	43.600	106.70	106.70	71.17	77.58	-6.43	------------
19	43.400	122.22	122.22	77.58	84.24	-5.60	------------
20	43.200	139.07	139.07	84.24	91.13	-4.69	------------
21	43.000	157.29	157.29	91.13	98.26	-3.70	------------
22	42.800	176.95	176.95	98.26	105.64	-2.59	------------
23	42.600	198.07	198.07	105.64	113.25	-1.38	------------
24	42.400	220.72	220.72	113.25	121.10	-0.03	------------
25	42.200	244.94	244.94	121.10	129.20	1.46	------------
26	42.000	270.78	270.78	129.20	-243.35	3.10	* -380.88
27	41.800	222.11	222.11	-243.35	-238.02	4.92	------------
28	41.750	210.21	210.21	-238.02	-233.67	5.40	------------
29	41.600	175.16	175.16	-233.67	-225.75	6.88	------------
30	41.400	130.01	130.01	-225.75	-216.21	8.95	------------
31	41.200	86.77	86.77	-216.21	-206.14	11.11	------------
32	41.000	45.54	45.54	-206.14	-195.56	13.33	------------
33	40.800	6.43	6.43	-195.56	-184.46	15.58	------------
34	40.600	-30.46	-30.46	-184.46	-172.83	17.83	------------
35	40.400	-65.03	-65.03	-172.83	-160.69	20.06	------------
36	40.200	-97.17	-97.17	-160.69	-148.03	22.24	------------
37	40.000	-126.77	-126.77	-148.03	-134.84	24.37	------------
38	39.800	-153.74	-153.74	-134.84	-121.14	26.41	------------
39	39.600	-177.97	-177.97	-121.14	-106.92	28.36	------------
40	39.400	-199.35	-199.35	-106.92	-92.17	30.19	------------
41	39.200	-217.79	-217.79	-92.17	-76.91	31.89	------------
42	39.000	-233.17	-233.17	-76.91	-61.13	33.44	------------
43	38.800	-245.39	-245.39	-61.13	-44.82	34.85	------------
44	38.600	-254.36	-254.36	-44.82	-32.25	36.10	------------
45	38.500	-257.58	-257.58	-32.25	-23.77	36.66	------------
46	38.400	-259.96	-259.96	-23.77	-10.89	37.18	------------
47	38.200	-262.14	-262.14	-10.89	6.77	38.10	------------
48	38.000	-260.78	-260.78	6.77	21.61	38.84	------------
49	37.800	-256.46	-256.46	21.61	32.31	39.41	------------
50	37.600	-250.00	-250.00	32.31	39.52	39.82	------------
51	37.500	-246.05	-246.05	39.52	43.96	39.97	------------
52	37.400	-241.65	-241.65	43.96	50.17	40.07	------------
53	37.200	-231.62	-231.62	50.17	57.64	40.16	------------

node No	Y co GL(m)	moment kN.m/m top	bottom	shear force kN/m top	bottom	disp Del.x mm	reaction Q kN/m
54	37.000	-220.09	-220.09	57.64	64.20	40.10	------------
55	36.800	-207.25	-207.25	64.20	69.83	39.89	------------
56	36.600	-193.28	-193.28	69.83	74.55	39.55	------------
57	36.400	-178.37	-178.37	74.55	78.34	39.09	------------
58	36.200	-162.70	-162.70	78.34	81.22	38.51	------------
59	36.000	-146.46	-146.46	81.22	83.18	37.82	------------
60	35.800	-129.82	-129.82	83.18	84.21	37.04	------------
61	35.600	-112.98	-112.98	84.21	84.39	36.18	------------
62	35.500	-104.54	-104.54	84.39	84.21	35.72	------------
63	35.400	-96.12	-96.12	84.21	83.52	35.24	------------
64	35.200	-79.42	-79.42	83.52	81.80	34.24	------------
65	35.000	-63.06	-63.06	81.80	79.16	33.19	------------
66	34.800	-47.23	-47.23	79.16	75.59	32.09	------------
67	34.600	-32.11	-32.11	75.59	71.11	30.97	------------
68	34.400	-17.89	-17.89	71.11	65.71	29.82	------------
69	34.200	-4.74	-4.74	65.71	59.38	28.66	------------
70	34.000	7.13	7.13	59.38	52.14	27.50	------------
71	33.800	17.56	17.56	52.14	44.95	26.35	-21.27
72	33.600	26.55	26.55	44.95	40.08	25.20	-15.26
73	33.500	30.56	30.56	40.08	37.00	24.64	-9.95
74	33.400	34.26	34.26	37.00	32.59	24.08	-14.58
75	33.200	40.78	40.78	32.59	27.40	22.97	-18.54
76	33.000	46.26	46.26	27.40	21.37	21.89	-19.15
77	32.800	50.53	50.53	21.37	14.61	20.84	-19.63
78	32.600	53.45	53.45	14.61	8.57	19.83	-18.67
79	32.400	55.17	55.17	8.57	3.21	18.84	-17.75
80	32.200	55.81	55.81	3.21	-1.50	17.90	-16.86
81	32.000	55.51	55.51	-1.50	-5.59	16.99	-16.00
82	31.800	54.39	54.39	-5.59	-9.09	16.11	-15.18
83	31.600	52.57	52.57	-9.09	-12.05	15.27	-14.39
84	31.400	50.16	50.16	-12.05	-14.49	14.47	-13.63
85	31.200	47.26	47.26	-14.49	-16.45	13.70	-12.90
86	31.000	43.97	43.97	-16.45	-17.95	12.96	-12.20
87	30.800	40.39	40.39	-17.95	-19.01	12.24	-11.53
88	30.600	36.58	36.58	-19.01	-19.67	11.56	-10.89
89	30.400	32.65	32.65	-19.67	-19.95	10.89	-10.26
90	30.200	28.66	28.66	-19.95	-19.86	10.25	-9.66
91	30.000	24.69	24.69	-19.86	-19.43	9.63	-9.07
92	29.800	20.80	20.80	-19.43	-18.67	9.02	-8.50
93	29.600	17.07	17.07	-18.67	-17.58	8.43	-7.94
94	29.400	13.55	13.55	-17.58	-16.19	7.85	-7.39
95	29.200	10.31	10.31	-16.19	-14.50	7.27	-6.85
96	29.000	7.41	7.41	-14.50	-12.52	6.71	-6.32
97	28.800	4.91	4.91	-12.52	-10.25	6.14	-5.79
98	28.600	2.86	2.86	-10.25	-7.70	5.59	-5.26
99	28.400	1.32	1.32	-7.70	-4.86	5.03	-4.74
100	28.200	0.35	0.35	-4.86	-1.73	4.47	-4.21
101	28.000	0.00	----------	-1.73	----------	3.92	-1.85

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= 270.78kN m/m (G.L. 42.000m)
max shear force Smax= -243.35kN/m (G.L. 42.000m)
max displacement Del.xmax= 40.16mm (G.L. 37.200m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	270.78	0.00	243.35

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	150	216	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	11	99	OK

4.3.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
0.00	3.600	0.00

3) stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* \cdot A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
0	176	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
380.88	1.800	685.59

3) stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* \cdot A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
155	176	OK

4.3.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$$M = \frac{P^{*}L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
0.00	3.600	0.00

3)stress

$$Sig. = \frac{M^{*}10^{6}}{Z^{*}10^{3}} \quad <= Sig.a$$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
0	140	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P^{*}L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
685.59	1.800	123.41

3)stress

$$Sig. = \frac{M^{*}10^{6}}{Z^{*}10^{3}} \quad <= Sig.a$$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
131	140	OK

4.4 riverside sheet pile

4.4.1 Calculation of embedment length

(1)result summery

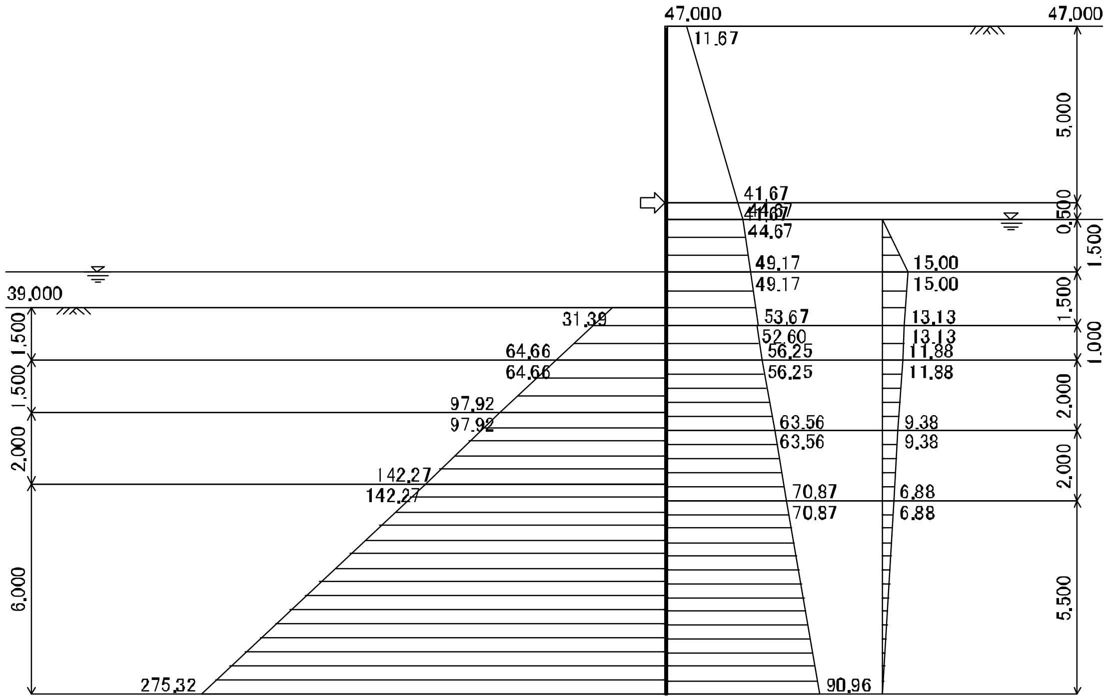
steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.500(m)
L.WL : 40.000(m)

Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,
Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	32.550	28.000
active sd	Ma+Mw+Mac(kN.m/m)	3083.92	7811.12
passive sd	Mp+Mpc(kN.m/m)	4627.78	16798.52
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.501>=1.50	2.151>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.500	0.500	41.67 44.67	21.58	0.253	5.46
2	41.500 40.000	1.500	44.67 49.17	70.38	1.262	88.81
3	40.000 38.500	1.500	49.17 53.67	77.13	2.761	212.94
4	38.500 37.500	1.000	52.60 56.25	54.43	4.006	218.02
5	37.500 35.500	2.000	56.25 63.56	119.81	5.520	661.42
6	35.500 33.500	2.000	63.56 70.87	134.43	7.518	1010.63
7	33.500 28.000	5.500	70.87 90.96	445.01	11.364	5056.98
Sum				922.76		7254.24

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.500 40.000	1.500	0.00 15.00	11.25	1.500	16.88
2	40.000 38.500	1.500	15.00 13.13	21.09	2.733	57.66
3	38.500 37.500	1.000	13.13 11.88	12.50	3.992	49.90
4	37.500 35.500	2.000	11.88 9.38	21.25	5.461	116.04
5	35.500 33.500	2.000	9.38 6.88	16.25	7.449	121.04
6	33.500 28.000	5.500	6.88 0.00	18.91	10.333	195.36
Sum				101.25		556.88

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 37.500	1.500	31.39 64.66	72.04	3.837	276.38
2	37.500 36.000	1.500	64.66 97.92	121.93	5.301	646.38
3	36.000 34.000	2.000	97.92 142.27	240.19	7.062	1696.11
4	34.000 28.000	6.000	142.27 275.32	1252.77	11.319	14179.65
Sum				1686.93		16798.52

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

4.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-183.37	G.L. 42.000
max shear force Smax(kN/m)	165.70	G.L. 42.000
upper tension mbr rct R1(kN/m)	21.85	G.L. 46.000
lower tension mbr rct R2(kN/m)	281.38	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 42.000	11.67 41.67	0.00 0.00	---- ----	---- ----	11.67 41.67	---- ----
2	42.000 41.500	41.67 44.67	0.00 0.00	---- ----	---- ----	41.67 44.67	---- ----
3	41.500 40.000	44.67 49.17	0.00 15.00	---- ----	---- ----	44.67 64.17	---- ----
4	40.000 39.000	49.17 52.17	15.00 13.75	---- ----	---- ----	64.17 65.92	---- ----
5	39.000 38.500	52.17 53.67	13.75 13.13	31.39 42.48	0.00 2.60	65.92 64.19	31.39 39.88
6	38.500 37.500	52.60 56.25	13.13 11.88	42.48 64.66	2.60 7.79	63.13 60.33	39.88 56.86
7	37.500 36.000	56.25 61.73	11.88 10.00	64.66 97.92	7.79 15.59	60.33 56.14	56.86 82.33
8	36.000 35.500	61.73 63.56	10.00 9.38	97.92 109.01	15.59 18.19	56.14 54.75	82.33 90.82
9	35.500 34.000	63.56 69.04	9.38 7.50	109.01 142.27	18.19 25.98	54.75 50.56	90.82 116.29
10	34.000 33.500	69.04 70.87	7.50 6.88	142.27 153.36	25.98 28.58	50.56 49.16	116.29 124.78
11	33.500 28.000	70.87 90.96	6.88 0.00	153.36 275.32	28.58 57.16	49.16 33.79	124.78 218.16

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	39.000	37.500	1.500	16800	4037
2	37.500	36.000	1.500	16800	4037
3	36.000	34.000	2.000	16800	4037
4	34.000	27.000	7.000	19600	4710
5	27.000	22.000	5.000	92400	22202

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp. * (2 * number * A * E)}{(L * s)}$$

where,

FORUM8

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000] m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	11.67	1.20	--------	--------	--------	--------
2	46.800	On excavation plane	12.87	12.87	2.57	--------	--------	--------	--------
3	46.600	On excavation plane	14.07	14.07	2.81	--------	--------	--------	--------
4	46.400	On excavation plane	15.27	15.27	3.05	--------	--------	--------	--------
5	46.200	On excavation plane	16.47	16.47	3.29	--------	--------	--------	--------
6	46.000	Tensile member	17.67	17.67	3.53	--------	--------	--------	6818
7	45.800	On excavation plane	18.87	18.87	3.77	--------	--------	--------	--------
8	45.600	On excavation plane	20.07	20.07	4.01	--------	--------	--------	--------
9	45.400	On excavation plane	21.27	21.27	4.25	--------	--------	--------	--------
10	45.200	On excavation plane	22.47	22.47	4.49	--------	--------	--------	--------
11	45.000	On excavation plane	23.67	23.67	4.73	--------	--------	--------	--------
12	44.800	On excavation plane	24.87	24.87	4.97	--------	--------	--------	--------
13	44.600	On excavation plane	26.07	26.07	5.21	--------	--------	--------	--------
14	44.400	On excavation plane	27.27	27.27	5.45	--------	--------	--------	--------
15	44.200	On excavation plane	28.47	28.47	5.69	--------	--------	--------	--------
16	44.000	On excavation plane	29.67	29.67	5.93	--------	--------	--------	--------
17	43.800	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
18	43.600	On excavation plane	32.07	32.07	6.41	--------	--------	--------	--------
19	43.400	On excavation plane	33.27	33.27	6.65	--------	--------	--------	--------
20	43.200	On excavation plane	34.47	34.47	6.89	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
21	43.000	On excavation plane	35.67	35.67	7.13	--------	--------	--------	--------
22	42.800	On excavation plane	36.87	36.87	7.37	--------	--------	--------	--------
23	42.600	On excavation plane	38.07	38.07	7.61	--------	--------	--------	--------
24	42.400	On excavation plane	39.27	39.27	7.85	--------	--------	--------	--------
25	42.200	On excavation plane	40.47	40.47	8.09	--------	--------	--------	--------
26	42.000	Tensile member	41.67	41.67	8.33	--------	--------	--------	122718
27	41.800	On excavation plane	42.87	42.87	8.57	--------	--------	--------	--------
28	41.600	On excavation plane	44.07	44.07	6.59	--------	--------	--------	--------
29	41.500	On excavation plane	44.67	44.67	4.48	--------	--------	--------	--------
30	41.400	On excavation plane	45.97	45.97	6.94	--------	--------	--------	--------
31	41.200	On excavation plane	48.57	48.57	9.71	--------	--------	--------	--------
32	41.000	On excavation plane	51.17	51.17	10.23	--------	--------	--------	--------
33	40.800	On excavation plane	53.77	53.77	10.75	--------	--------	--------	--------
34	40.600	On excavation plane	56.37	56.37	11.27	--------	--------	--------	--------
35	40.400	On excavation plane	58.97	58.97	11.79	--------	--------	--------	--------
36	40.200	On excavation plane	61.57	61.57	12.31	--------	--------	--------	--------
37	40.000	On excavation plane	64.17	64.17	12.78	--------	--------	--------	--------
38	39.800	On excavation plane	64.52	64.52	12.90	--------	--------	--------	--------
39	39.600	On excavation plane	64.87	64.87	12.97	--------	--------	--------	--------
40	39.400	On excavation plane	65.22	65.22	13.04	--------	--------	--------	--------
41	39.200	On excavation plane	65.57	65.57	13.11	--------	--------	--------	--------
42	39.000	Pa plas.	65.92	65.92	13.16	0.00	31.39	3.22	--------
43	38.800	Pa plas.	65.23	65.23	13.05	34.79	34.79	6.96	--------
44	38.600	Pa plas.	64.54	64.54	9.69	38.19	38.19	5.66	--------
45	38.500	Pa plas.	64.19	63.13	6.37	39.88	39.88	3.99	--------
46	38.400	Pa plas.	62.85	62.85	9.42	41.58	41.58	6.30	--------
47	38.200	Pa plas.	62.29	62.29	12.46	44.98	44.98	9.00	--------
48	38.000	Pa plas.	61.73	61.73	12.35	48.37	48.37	9.67	--------
49	37.800	Pa plas.	61.17	61.17	12.23	51.77	51.77	10.35	--------
50	37.600	Pa plas.	60.61	60.61	9.10	55.16	55.16	8.21	--------
51	37.500	Pa plas.	60.33	60.33	6.03	56.86	56.86	5.69	--------
52	37.400	Pa plas.	60.06	60.06	9.00	58.56	58.56	8.85	--------
53	37.200	Pa plas.	59.50	59.50	11.90	61.96	61.96	12.39	--------
54	37.000	Pas ela.	58.94	58.94	11.79	65.35	65.35	--------	807
55	36.800	Pas ela.	58.38	58.38	11.68	68.75	68.75	--------	807
56	36.600	Pas ela.	57.82	57.82	11.56	72.14	72.14	--------	807
57	36.400	Pas ela.	57.26	57.26	11.45	75.54	75.54	--------	807
58	36.200	Pas ela.	56.70	56.70	11.34	78.93	78.93	--------	807
59	36.000	Pas ela.	56.14	56.14	11.23	82.33	82.33	--------	807
60	35.800	Pas ela.	55.59	55.59	11.12	85.73	85.73	--------	807
61	35.600	Pas ela.	55.03	55.03	8.26	89.12	89.12	--------	606
62	35.500	Pas ela.	54.75	54.75	5.47	90.82	90.82	--------	404
63	35.400	Pas ela.	54.47	54.47	8.16	92.52	92.52	--------	606

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
64	35.200	Pas ela.	53.91	53.91	10.78	95.91	95.91	--------	807
65	35.000	Pas ela.	53.35	53.35	10.67	99.31	99.31	--------	807
66	34.800	Pas ela.	52.79	52.79	10.56	102.70	102.70	--------	807
67	34.600	Pas ela.	52.23	52.23	10.45	106.10	106.10	--------	807
68	34.400	Pas ela.	51.67	51.67	10.33	109.50	109.50	--------	807
69	34.200	Pas ela.	51.12	51.12	10.22	112.89	112.89	--------	807
70	34.000	Pas ela.	50.56	50.56	10.11	116.29	116.29	--------	875
71	33.800	Pas ela.	50.00	50.00	10.00	119.68	119.68	--------	942
72	33.600	Pas ela.	49.44	49.44	7.43	123.08	123.08	--------	706
73	33.500	Pas ela.	49.16	49.16	4.92	124.78	124.78	--------	471
74	33.400	Pas ela.	48.88	48.88	7.32	126.47	126.47	--------	706
75	33.200	Pas ela.	48.32	48.32	9.66	129.87	129.87	--------	942
76	33.000	Pas ela.	47.76	47.76	9.55	133.27	133.27	--------	942
77	32.800	Pas ela.	47.20	47.20	9.44	136.66	136.66	--------	942
78	32.600	Pas ela.	46.65	46.65	9.33	140.06	140.06	--------	942
79	32.400	Pas ela.	46.09	46.09	9.22	143.45	143.45	--------	942
80	32.200	Pas ela.	45.53	45.53	9.11	146.85	146.85	--------	942
81	32.000	Pas ela.	44.97	44.97	8.99	150.25	150.25	--------	942
82	31.800	Pas ela.	44.41	44.41	8.88	153.64	153.64	--------	942
83	31.600	Pas ela.	43.85	43.85	8.77	157.04	157.04	--------	942
84	31.400	Pas ela.	43.29	43.29	8.66	160.43	160.43	--------	942
85	31.200	Pas ela.	42.73	42.73	8.55	163.83	163.83	--------	942
86	31.000	Pas ela.	42.18	42.18	8.44	167.22	167.22	--------	942
87	30.800	Pas ela.	41.62	41.62	8.32	170.62	170.62	--------	942
88	30.600	Pas ela.	41.06	41.06	8.21	174.02	174.02	--------	942
89	30.400	Pas ela.	40.50	40.50	8.10	177.41	177.41	--------	942
90	30.200	Pas ela.	39.94	39.94	7.99	180.81	180.81	--------	942
91	30.000	Pas ela.	39.38	39.38	7.88	184.20	184.20	--------	942
92	29.800	Pas ela.	38.82	38.82	7.76	187.60	187.60	--------	942
93	29.600	Pas ela.	38.26	38.26	7.65	190.99	190.99	--------	942
94	29.400	Pas ela.	37.71	37.71	7.54	194.39	194.39	--------	942
95	29.200	Pas ela.	37.15	37.15	7.43	197.79	197.79	--------	942
96	29.000	Pas ela.	36.59	36.59	7.32	201.18	201.18	--------	942
97	28.800	Pas ela.	36.03	36.03	7.21	204.58	204.58	--------	942
98	28.600	Pas ela.	35.47	35.47	7.09	207.97	207.97	--------	942
99	28.400	Pas ela.	34.91	34.91	6.98	211.37	211.37	--------	942
100	28.200	Pas ela.	34.35	34.35	6.87	214.76	214.76	--------	942
101	28.000	Pas ela.	33.79	0.00	3.39	218.16	0.00	--------	471
Sum					842.96			90.29	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= -15.67mm(G.L. 37.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-4.35	- - - -	- - - -
2	46.800	on exv	- - - -	-4.12	- - - -	- - - -
3	46.600	on exv	- - - -	-3.89	- - - -	- - - -
4	46.400	on exv	- - - -	-3.66	- - - -	- - - -
5	46.200	on exv	- - - -	-3.43	- - - -	- - - -
6	46.000	on exv	6818	-3.21	- - - -	Note: 21.85
7	45.800	on exv	- - - -	-2.98	- - - -	- - - -
8	45.600	on exv	- - - -	-2.77	- - - -	- - - -
9	45.400	on exv	- - - -	-2.55	- - - -	- - - -
10	45.200	on exv	- - - -	-2.34	- - - -	- - - -
11	45.000	on exv	- - - -	-2.14	- - - -	- - - -
12	44.800	on exv	- - - -	-1.94	- - - -	- - - -
13	44.600	on exv	- - - -	-1.75	- - - -	- - - -
14	44.400	on exv	- - - -	-1.57	- - - -	- - - -
15	44.200	on exv	- - - -	-1.41	- - - -	- - - -
16	44.000	on exv	- - - -	-1.26	- - - -	- - - -
17	43.800	on exv	- - - -	-1.14	- - - -	- - - -
18	43.600	on exv	- - - -	-1.05	- - - -	- - - -
19	43.400	on exv	- - - -	-0.99	- - - -	- - - -
20	43.200	on exv	- - - -	-0.97	- - - -	- - - -
21	43.000	on exv	- - - -	-1.01	- - - -	- - - -
22	42.800	on exv	- - - -	-1.10	- - - -	- - - -
23	42.600	on exv	- - - -	-1.27	- - - -	- - - -
24	42.400	on exv	- - - -	-1.51	- - - -	- - - -
25	42.200	on exv	- - - -	-1.85	- - - -	- - - -
26	42.000	on exv	122718	-2.29	- - - -	Note: 281.38
27	41.800	on exv	- - - -	-2.85	- - - -	- - - -
28	41.600	on exv	- - - -	-3.50	- - - -	- - - -
29	41.500	on exv	- - - -	-3.86	- - - -	- - - -
30	41.400	on exv	- - - -	-4.24	- - - -	- - - -
31	41.200	on exv	- - - -	-5.02	- - - -	- - - -
32	41.000	on exv	- - - -	-5.85	- - - -	- - - -
33	40.800	on exv	- - - -	-6.71	- - - -	- - - -
34	40.600	on exv	- - - -	-7.57	- - - -	- - - -
35	40.400	on exv	- - - -	-8.42	- - - -	- - - -
36	40.200	on exv	- - - -	-9.26	- - - -	- - - -
37	40.000	on exv	- - - -	-10.06	- - - -	- - - -
38	39.800	on exv	- - - -	-10.83	- - - -	- - - -
39	39.600	on exv	- - - -	-11.55	- - - -	- - - -
40	39.400	on exv	- - - -	-12.21	- - - -	- - - -
41	39.200	on exv	- - - -	-12.82	- - - -	- - - -
42	39.000	pssv pl	- - - -	-13.37	7.99	- - - -
43	38.800	pssv pl	- - - -	-13.85	8.62	- - - -
44	38.600	pssv pl	- - - -	-14.28	9.35	- - - -
45	38.500	pssv pl	- - - -	-14.46	9.88	- - - -
46	38.400	pssv pl	- - - -	-14.64	10.41	- - - -
47	38.200	pssv pl	- - - -	-14.94	11.14	- - - -
48	38.000	pssv pl	- - - -	-15.19	11.98	- - - -
49	37.800	pssv pl	- - - -	-15.38	12.82	- - - -
50	37.600	pssv pl	- - - -	-15.52	13.56	- - - -
51	37.500	pssv pl	- - - -	-15.57	14.09	- - - -
52	37.400	pssv pl	- - - -	-15.61	14.61	- - - -
53	37.200	pssv pl	- - - -	-15.66	15.35	- - - -
54	37.000	pssv el	807	-15.67	16.19	12.65
55	36.800	pssv el	807	-15.64	17.03	12.63
56	36.600	pssv el	807	-15.58	17.87	12.58
57	36.400	pssv el	807	-15.48	18.71	12.50
58	36.200	pssv el	807	-15.36	19.55	12.40
59	36.000	pssv el	807	-15.21	20.40	12.28
60	35.800	pssv el	807	-15.04	21.24	12.14
61	35.600	pssv el	606	-14.85	21.97	8.99
62	35.500	pssv el	404	-14.75	22.50	5.95
63	35.400	pssv el	606	-14.64	23.02	8.87
64	35.200	pssv el	807	-14.42	23.76	11.64
65	35.000	pssv el	807	-14.19	24.60	11.45
66	34.800	pssv el	807	-13.94	25.44	11.25
67	34.600	pssv el	807	-13.69	26.28	11.05
68	34.400	pssv el	807	-13.42	27.12	10.84
69	34.200	pssv el	807	-13.16	27.97	10.62
70	34.000	pssv el	875	-12.89	26.59	11.28
71	33.800	pssv el	942	-12.62	25.41	11.89
72	33.600	pssv el	706	-12.35	26.04	8.73
73	33.500	pssv el	471	-12.22	26.49	5.75
74	33.400	pssv el	706	-12.09	26.95	8.54
75	33.200	pssv el	942	-11.82	27.58	11.14
76	33.000	pssv el	942	-11.56	28.30	10.89
77	32.800	pssv el	942	-11.31	29.02	10.65
78	32.600	pssv el	942	-11.06	29.74	10.41
79	32.400	pssv el	942	-10.81	30.46	10.18
80	32.200	pssv el	942	-10.57	31.18	9.96
81	32.000	pssv el	942	-10.34	31.90	9.74
82	31.800	pssv el	942	-10.11	32.62	9.53
83	31.600	pssv el	942	-9.89	33.34	9.32
84	31.400	pssv el	942	-9.68	34.07	9.11
85	31.200	pssv el	942	-9.47	34.79	8.92
86	31.000	pssv el	942	-9.26	35.51	8.72

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
87	30.800	pssv el	942	-9.06	36.23	8.54
88	30.600	pssv el	942	-8.87	36.95	8.35
89	30.400	pssv el	942	-8.68	37.67	8.17
90	30.200	pssv el	942	-8.49	38.39	7.99
91	30.000	pssv el	942	-8.30	39.11	7.82
92	29.800	pssv el	942	-8.12	39.83	7.65
93	29.600	pssv el	942	-7.94	40.56	7.48
94	29.400	pssv el	942	-7.76	41.28	7.31
95	29.200	pssv el	942	-7.59	42.00	7.15
96	29.000	pssv el	942	-7.41	42.72	6.98
97	28.800	pssv el	942	-7.24	43.44	6.82
98	28.600	pssv el	942	-7.07	44.16	6.66
99	28.400	pssv el	942	-6.89	44.88	6.49
100	28.200	pssv el	942	-6.72	45.60	6.33
101	28.000	pssv el	471	-6.55	46.14	3.08
Sum						752.66

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)
max bending moment Mmax= -183.37kN m/m(G.L. 42.000m)
max shear force Smax= 165.70kN/m (G.L. 42.000m)
max displacement Del.xmax= -15.67mm (G.L. 37.000m)

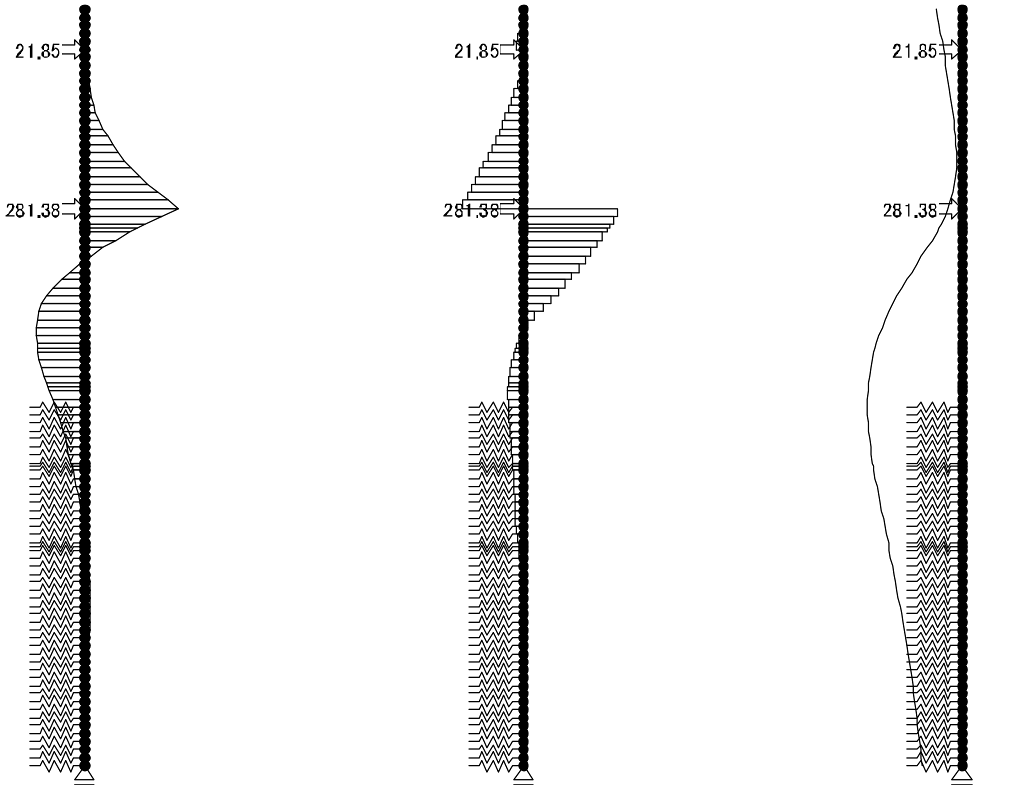
node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-1.20	-4.35	------------
2	46.800	-0.24	-0.24	-1.20	-3.77	-4.12	------------
3	46.600	-0.99	-0.99	-3.77	-6.58	-3.89	------------
4	46.400	-2.31	-2.31	-6.58	-9.64	-3.66	------------
5	46.200	-4.24	-4.24	-9.64	-12.93	-3.43	------------
6	46.000	-6.82	-6.82	-12.93	5.39	-3.21	* 21.85
7	45.800	-5.75	-5.75	5.39	1.62	-2.98	------------
8	45.600	-5.42	-5.42	1.62	-2.40	-2.77	------------
9	45.400	-5.90	-5.90	-2.40	-6.65	-2.55	------------
10	45.200	-7.23	-7.23	-6.65	-11.14	-2.34	------------
11	45.000	-9.46	-9.46	-11.14	-15.88	-2.14	------------
12	44.800	-12.64	-12.64	-15.88	-20.85	-1.94	------------
13	44.600	-16.81	-16.81	-20.85	-26.06	-1.75	------------
14	44.400	-22.02	-22.02	-26.06	-31.52	-1.57	------------
15	44.200	-28.32	-28.32	-31.52	-37.21	-1.41	------------
16	44.000	-35.76	-35.76	-37.21	-43.14	-1.26	------------
17	43.800	-44.39	-44.39	-43.14	-49.32	-1.14	------------
18	43.600	-54.26	-54.26	-49.32	-55.73	-1.05	------------
19	43.400	-65.40	-65.40	-55.73	-62.38	-0.99	------------
20	43.200	-77.88	-77.88	-62.38	-69.28	-0.97	------------
21	43.000	-91.73	-91.73	-69.28	-76.41	-1.01	------------
22	42.800	-107.02	-107.02	-76.41	-83.78	-1.10	------------
23	42.600	-123.77	-123.77	-83.78	-91.40	-1.27	------------
24	42.400	-142.05	-142.05	-91.40	-99.25	-1.51	------------
25	42.200	-161.90	-161.90	-99.25	-107.34	-1.85	------------
26	42.000	-183.37	-183.37	-107.34	165.70	-2.29	* 281.38
27	41.800	-150.23	-150.23	165.70	157.13	-2.85	------------
28	41.600	-118.81	-118.81	157.13	150.54	-3.50	------------
29	41.500	-103.75	-103.75	150.54	146.07	-3.86	------------
30	41.400	-89.14	-89.14	146.07	139.12	-4.24	------------
31	41.200	-61.32	-61.32	139.12	129.41	-5.02	------------
32	41.000	-35.44	-35.44	129.41	119.18	-5.85	------------
33	40.800	-11.60	-11.60	119.18	108.42	-6.71	------------
34	40.600	10.08	10.08	108.42	97.15	-7.57	------------
35	40.400	29.51	29.51	97.15	85.36	-8.42	------------
36	40.200	46.58	46.58	85.36	73.04	-9.26	------------
37	40.000	61.19	61.19	73.04	60.26	-10.06	------------
38	39.800	73.24	73.24	60.26	47.36	-10.83	------------
39	39.600	82.72	82.72	47.36	34.39	-11.55	------------
40	39.400	89.59	89.59	34.39	21.34	-12.21	------------
41	39.200	93.86	93.86	21.34	8.23	-12.82	------------
42	39.000	95.51	95.51	8.23	-1.70	-13.37	------------
43	38.800	95.17	95.17	-1.70	-7.79	-13.85	------------
44	38.600	93.61	93.61	-7.79	-11.82	-14.28	------------
45	38.500	92.43	92.43	-11.82	-14.20	-14.46	------------
46	38.400	91.01	91.01	-14.20	-17.31	-14.64	------------
47	38.200	87.55	87.55	-17.31	-20.78	-14.94	------------
48	38.000	83.39	83.39	-20.78	-23.45	-15.19	------------
49	37.800	78.70	78.70	-23.45	-25.33	-15.38	------------
50	37.600	73.63	73.63	-25.33	-26.22	-15.52	------------
51	37.500	71.01	71.01	-26.22	-26.57	-15.57	------------
52	37.400	68.36	68.36	-26.57	-26.72	-15.61	------------
53	37.200	63.01	63.01	-26.72	-26.23	-15.66	------------

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
54	37.000	57.77	57.77	-26.23	-25.36	-15.67	12.65
55	36.800	52.69	52.69	-25.36	-24.41	-15.64	12.63
56	36.600	47.81	47.81	-24.41	-23.40	-15.58	12.58
57	36.400	43.13	43.13	-23.40	-22.35	-15.48	12.50
58	36.200	38.66	38.66	-22.35	-21.29	-15.36	12.40
59	36.000	34.41	34.41	-21.29	-20.24	-15.21	12.28
60	35.800	30.36	30.36	-20.24	-19.21	-15.04	12.14
61	35.600	26.52	26.52	-19.21	-18.48	-14.85	8.99
62	35.500	24.67	24.67	-18.48	-18.00	-14.75	5.95
63	35.400	22.87	22.87	-18.00	-17.30	-14.64	8.87
64	35.200	19.41	19.41	-17.30	-16.44	-14.42	11.64
65	35.000	16.12	16.12	-16.44	-15.66	-14.19	11.45
66	34.800	12.99	12.99	-15.66	-14.96	-13.94	11.25
67	34.600	10.00	10.00	-14.96	-14.36	-13.69	11.05
68	34.400	7.13	7.13	-14.36	-13.85	-13.42	10.84
69	34.200	4.36	4.36	-13.85	-13.45	-13.16	10.62
70	34.000	1.67	1.67	-13.45	-12.29	-12.89	11.28
71	33.800	-0.79	-0.79	-12.29	-10.40	-12.62	11.89
72	33.600	-2.87	-2.87	-10.40	-9.10	-12.35	8.73
73	33.500	-3.78	-3.78	-9.10	-8.26	-12.22	5.75
74	33.400	-4.61	-4.61	-8.26	-7.04	-12.09	8.54
75	33.200	-6.02	-6.02	-7.04	-5.57	-11.82	11.14
76	33.000	-7.13	-7.13	-5.57	-4.23	-11.56	10.89
77	32.800	-7.98	-7.98	-4.23	-3.02	-11.31	10.65
78	32.600	-8.58	-8.58	-3.02	-1.94	-11.06	10.41
79	32.400	-8.97	-8.97	-1.94	-0.97	-10.81	10.18
80	32.200	-9.17	-9.17	-0.97	-0.12	-10.57	9.96
81	32.000	-9.19	-9.19	-0.12	0.63	-10.34	9.74
82	31.800	-9.06	-9.06	0.63	1.27	-10.11	9.53
83	31.600	-8.81	-8.81	1.27	1.82	-9.89	9.32
84	31.400	-8.45	-8.45	1.82	2.27	-9.68	9.11
85	31.200	-7.99	-7.99	2.27	2.64	-9.47	8.92
86	31.000	-7.46	-7.46	2.64	2.93	-9.26	8.72
87	30.800	-6.88	-6.88	2.93	3.14	-9.06	8.54
88	30.600	-6.25	-6.25	3.14	3.28	-8.87	8.35
89	30.400	-5.59	-5.59	3.28	3.35	-8.68	8.17
90	30.200	-4.92	-4.92	3.35	3.36	-8.49	7.99
91	30.000	-4.25	-4.25	3.36	3.30	-8.30	7.82
92	29.800	-3.59	-3.59	3.30	3.19	-8.12	7.65
93	29.600	-2.95	-2.95	3.19	3.01	-7.94	7.48
94	29.400	-2.35	-2.35	3.01	2.79	-7.76	7.31
95	29.200	-1.79	-1.79	2.79	2.50	-7.59	7.15
96	29.000	-1.29	-1.29	2.50	2.17	-7.41	6.98
97	28.800	-0.86	-0.86	2.17	1.78	-7.24	6.82
98	28.600	-0.50	-0.50	1.78	1.34	-7.07	6.66
99	28.400	-0.23	-0.23	1.34	0.85	-6.89	6.49
100	28.200	-0.06	-0.06	0.85	0.31	-6.72	6.33
101	28.000	0.00	----------	0.31	----------	-6.55	3.08

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -183.37kN m/m (G.L. 42.000m)
max shear force Smax= 165.70kN m (G.L. 42.000m)
max displacement Del.xmax= -15.67mm (G.L. 37.000m)



Moment graph Shear force diagram Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/m)

4.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	183.37	0.00	165.70

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \le Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	102	216	OK

(4) shear stress

$$Tau = \frac{S}{A} \le Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	7	99	OK

4.4.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,’£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
21.85	3.600	78.67

3) stress

$$Sig. = \frac{P^* 10^3}{n^* A} \quad \text{<=} Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
160	176	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,’£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
281.38	1.800	506.48

3) stress

$$Sig. = \frac{P^* 10^3}{n^* A} \quad \text{<=} Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
115	176	OK

4.4.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$M = \frac{P^* \cdot L}{10}$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
78.67	3.600	28.32

3)stress

$Sig. = \frac{M^*10^6}{Z^*10^3} \quad <= Sig.a$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
66	140	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$M = \frac{P^* \cdot L}{10}$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
506.48	1.800	91.17

3)stress

$Sig. = \frac{M^*10^6}{Z^*10^3} \quad <= Sig.a$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
97	140	OK

5 Check case (earhtquake time)

5.1 calculation of external forces

design seismicity during an earthquake : Kh= 0.04

design seismicity method: river standard equation

$$Kh' = \frac{Gam\ sat}{Gam\ sat - Gam\ w} * Kh$$

where,

Gam sat: soil saturated weight

Gam w : water unit weight

5.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1)water pressure table(riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 42.000	4.000	0.00 40.00
2	42.000 41.750	0.250	40.00 42.50
3	41.750 39.000	2.750	42.50 70.00
4	39.000 37.500	1.500	70.00 85.00
5	37.500 36.000	1.500	85.00 78.29
6	36.000 34.000	2.000	78.29 69.34
7	34.000 28.000	6.000	69.34 42.50

(2)active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h)+ q)- 2c*Sqrt(Ka)

$$Ka = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1+ Sqrt\{\sin(Phi) * \sin(Phi - Theta)/ \cos(Theta)\}]^2}$$

in case of clay, Kh= 0 in 10m below GL and active earth pressure is linearly estimated

Kh = 0 for clay in 10m below GL.

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
3	36.000 35.739	0.261	9.0	25.00	10.0 10.0	27.00 29.35	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
4	35.739 34.000	1.739	9.0	25.00	10.0 10.0	29.35 45.00	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 7.27
5	34.000 29.000	5.000	9.0	25.00	10.0 10.0	45.00 90.00	0.0844 0.0844	4.83 4.83	0.464 0.464	7.27 28.16
6	29.000 27.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.0844 0.0844	4.83 4.83	0.464 0.464	28.16 36.52
7	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	0.0844 0.0844	4.83 4.83	0.386 0.386	29.26 46.62

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp=\frac{\cos^2(Phi-Theta)}{\cos^2(Theta)*[1-Sqrt(\{sin(Phi)*sin(Phi-Theta)/cos(Theta)\}]^2}$$

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	25.00	10.0 10.0	0.00 9.00	0.0400 0.0400	2.29 2.29	2.400 2.400	30.98 52.59
2	37.500 35.000	2.500	9.0	25.00	10.0 10.0	9.00 31.50	0.0844 0.0844	4.83 4.83	2.327 2.327	51.45 103.80
3	35.000 33.000	2.000	9.0	25.00	10.0 10.0	31.50 49.50	0.0844 0.0844	4.83 4.83	2.327 2.327	103.80 145.68
4	33.000 26.000	7.000	9.0	25.00	10.0 10.0	49.50 112.50	0.0844 0.0844	4.83 4.83	2.327 2.327	145.68 292.26
5	26.000 21.000	5.000	9.0	30.00	10.0 10.0	112.50 157.50	0.0844 0.0844	4.83 4.83	2.850 2.850	354.38 482.62

(4)active earth pressure intensity table(embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	18.00 90.00	0.333	6.00 30.00	6.00 30.00
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	90.00 94.50	0.333	30.00 31.50	30.00 31.50
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	94.50 123.75	0.333	31.50 41.25	31.50 41.25
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	123.75 132.75	0.406	37.48 41.14	37.48 41.14
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	132.75 150.75	0.406	41.14 48.44	41.14 48.44
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	150.75 168.75	0.406	48.44 55.75	48.44 55.75
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	168.75 231.75	0.406	55.75 81.32	55.75 81.32
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	231.75 276.75	0.333	65.70 80.70	65.70 80.70

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	3.000	0.00 54.00
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	18.00 90.00	3.000	54.00 270.00
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	90.00 94.50	3.000	270.00 283.50
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	94.50 123.75	3.000	283.50 371.25
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	123.75 132.75	2.464	336.30 358.48
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	132.75 150.75	2.464	358.48 402.83
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	150.75 168.75	2.464	402.83 447.18
8	33.500 26.500	7.000	9.0	25.00	10.0 10.0	168.75 231.75	2.464	447.18 602.41
9	26.500 21.500	5.000	9.0	30.00	10.0 10.0	231.75 276.75	3.000	729.89 864.89

(6)passive earth pressure intensity table (out of embankment: passive resistant moment below)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	0.0844 0.0844	4.83 4.83	2.327 2.327	30.51 61.92
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 93.33
3	36.000 34.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	0.0844 0.0844	4.83 4.83	2.327 2.327	93.33 135.21
4	34.000 27.000	7.000	9.0	25.00	10.0 10.0	45.00 108.00	0.0844 0.0844	4.83 4.83	2.327 2.327	135.21 281.79
5	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 469.80

(7)seismicity for inertia force, H-force distribution table(embankment section: for inertia moment)

seismicity for inertia force is linearly distributed from GL to 10m depth, calculate with reducing seismicity. Regardless WT, design seismicity is considered using next equation. Basic design seismicity is applied with input design seismicity for the case of earthquake.

pe= Gam * B* Kh

where,

pe : inertia force intensity, H-force, for each layer (top and bottom)
Gam : wet weight of each layer
B : embankment width in use (8.000)m
Kh : design seismicity for each layer (top and bottom)

No	depth GL(m)	layer thick. h (m)	soil unit weight			seis-micity Kh	inertia H-compo pe=Gam.B.Kh
			wet Gamt	sub Gam'	sat Gamsat		
1	47.000 46.000	1.000	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
2	46.000 42.000	4.000	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
3	42.000 41.750	0.250	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
4	41.750 38.500	3.250	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
5	38.500 37.500	1.000	18.0	9.0	19.0	0.0400 0.0360	* 5.76 * 5.18
6	37.500 35.500	2.000	18.0	9.0	19.0	0.0360 0.0280	* 5.18 * 4.03
7	35.500 33.500	2.000	18.0	9.0	19.0	0.0280 0.0200	* 4.03 * 2.88
8	33.500 28.500	5.000	18.0	9.0	19.0	0.0200 0.0000	* 2.88 * 0.00
9	28.500 26.500	2.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
10	26.500 21.500	5.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00

Note:* character shows a section where linearly reduced seismicity.

5.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1)water pressure intensity table (embankment section)

R.W.L. 41.750(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.750 38.500	3.250	0.00 32.50
2	38.500 37.500	1.000	32.50 42.50
3	37.500 35.500	2.000	42.50 33.55
4	35.500 33.500	2.000	33.55 24.61
5	33.500 28.000	5.500	24.61 0.00

(2)active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 6.43
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	18.00 90.00	0.0400 0.0400	2.29 2.29	0.357 0.357	6.43 32.15
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	90.00 94.50	0.0400 0.0400	2.29 2.29	0.357 0.357	32.15 33.76
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	94.50 123.75	0.0844 0.0844	4.83 4.83	0.386 0.386	36.47 47.76
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	123.75 132.75	0.0844 0.0844	4.83 4.83	0.464 0.464	43.83 48.01
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	132.75 150.75	0.0844 0.0844	4.83 4.83	0.464 0.464	48.01 56.37
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	150.75 168.75	0.0844 0.0844	4.83 4.83	0.464 0.464	56.37 64.72
8	33.500 28.500	5.000	9.0	25.00	10.0 10.0	168.75 213.75	0.0844 0.0844	4.83 4.83	0.464 0.464	64.72 85.62
9	28.500 26.500	2.000	9.0	25.00	10.0 10.0	213.75 231.75	0.0844 0.0844	4.83 4.83	0.464 0.464	85.62 93.97
10	26.500 21.500	5.000	9.0	30.00	10.0 10.0	231.75 276.75	0.0844 0.0844	4.83 4.83	0.386 0.386	77.02 94.38

(3)passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	25.00	10.0 10.0	0.00 9.00	0.0400 0.0400	2.29 2.29	2.400 2.400	30.98 52.59
2	37.500 35.000	2.500	9.0	25.00	10.0 10.0	9.00 31.50	0.0844 0.0844	4.83 4.83	2.327 2.327	51.45 103.80
3	35.000 33.000	2.000	9.0	25.00	10.0 10.0	31.50 49.50	0.0844 0.0844	4.83 4.83	2.327 2.327	103.80 145.68
4	33.000 26.000	7.000	9.0	25.00	10.0 10.0	49.50 112.50	0.0844 0.0844	4.83 4.83	2.327 2.327	145.68 292.26
5	26.000 21.000	5.000	9.0	30.00	10.0 10.0	112.50 157.50	0.0844 0.0844	4.83 4.83	2.850 2.850	354.38 482.62

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	38.000 37.500	0.500	18.0	0.00 9.00	0.577	0.00 5.20
2	37.500 35.000	2.500	9.0	9.00 31.50	0.577	5.20 18.19
3	35.000 33.000	2.000	9.0	31.50 49.50	0.577	18.19 28.58
4	33.000 26.000	7.000	9.0	49.50 112.50	0.577	28.58 64.96
5	26.000 21.000	5.000	9.0	112.50 157.50	0.500	56.25 78.75

Note:is a layer without earth pressure in calculation.

5.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure table (embankment section)

H.W.L. 41.500(m)

L.W.L. 40.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.500 40.000	1.500	0.00 15.00
2	40.000 38.500	1.500	15.00 13.13
3	38.500 37.500	1.000	13.13 11.88
4	37.500 35.500	2.000	11.88 9.38
5	35.500 33.500	2.000	9.38 6.88
6	33.500 28.000	5.500	6.88 0.00

(2) active earth pressure magnitude table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	0.00 90.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 32.15
2	42.000 41.500	0.500	18.0	30.00	0.0 0.0	90.00 99.00	0.0400 0.0400	2.29 2.29	0.357 0.357	32.15 35.37
3	41.500 40.000	1.500	9.0	30.00	0.0 0.0	99.00 112.50	0.0844 0.0844	4.83 4.83	0.386 0.386	38.21 43.42
4	40.000 38.500	1.500	9.0	30.00	0.0 0.0	112.50 126.00	0.0844 0.0844	4.83 4.83	0.386 0.386	43.42 48.63
5	38.500 37.500	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	0.464 0.464	44.87 49.05
6	37.500 35.500	2.000	9.0	25.00	10.0 10.0	135.00 153.00	0.0844 0.0844	4.83 4.83	0.464 0.464	49.05 57.41
7	35.500 33.500	2.000	9.0	25.00	10.0 10.0	153.00 171.00	0.0844 0.0844	4.83 4.83	0.464 0.464	57.41 65.77
8	33.500 28.500	5.000	9.0	25.00	10.0 10.0	171.00 216.00	0.0844 0.0844	4.83 4.83	0.464 0.464	65.77 86.66
9	28.500 26.500	2.000	9.0	25.00	10.0 10.0	216.00 234.00	0.0844 0.0844	4.83 4.83	0.464 0.464	86.66 95.02
10	26.500 21.500	5.000	9.0	30.00	10.0 10.0	234.00 279.00	0.0844 0.0844	4.83 4.83	0.386 0.386	77.89 95.25

(3)passive earth pressure intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 37.500	1.500	9.0	25.00	10.0 10.0	0.00 13.50	0.0844 0.0844	4.83 4.83	2.327 2.327	30.51 61.92
2	37.500 36.000	1.500	9.0	25.00	10.0 10.0	13.50 27.00	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 93.33
3	36.000 34.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	0.0844 0.0844	4.83 4.83	2.327 2.327	93.33 135.21
4	34.000 27.000	7.000	9.0	25.00	10.0 10.0	45.00 108.00	0.0844 0.0844	4.83 4.83	2.327 2.327	135.21 281.79
5	27.000 22.000	5.000	9.0	30.00	10.0 10.0	108.00 153.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 469.80

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	39.000 37.500	1.500	9.0	0.00 13.50	0.577	0.00 7.79
2	37.500 36.000	1.500	9.0	13.50 27.00	0.577	7.79 15.59
3	36.000 34.000	2.000	9.0	27.00 45.00	0.577	15.59 25.98
4	34.000 27.000	7.000	9.0	45.00 108.00	0.577	25.98 62.36
5	27.000 22.000	5.000	9.0	108.00 153.00	0.500	54.00 76.50

Note: is a layer without earth pressure in calculation.

5.2 Stability analysis

5.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.00)

Md: shear deformation moment on check plane(kN* m/m)

Mr: shear resistant moment on check plane(kN* m/m)

$$Mr = Mro * \left(1 + \frac{d}{H} \right) + Msp$$

$$Mro = \int_{0}^{yo} (pRP - pRA) y\,dy$$

where,

- Mro: basic shear resistant moment of filling soil
- d : depth from current ground surface to check level
- H : wall height(from top of wall to ground level in embankment range)
- pRP: passive earth pressure above check level with a distance y(kN/m2)
- pRA: active earth pressure above check level with a distance y(kN/m2)
- y : a distance from the location of pRP, pRA working(m)
- yo : cross point coordinates of the failure plane in filling soil
- Msp: resistant moment caused by two rows sheet piles
  smaller resistance either landside or riverside and make double to evaluate
  Msp= 2* (smaller value either Msp1 or Msp2)
  - Msp1: resistant moment derived from sheet pile
    Msp1= Sig.a* Zsp
    Sig.a: allowable stress of sheet pile in use(N/mm2)
    Zsp : section modulus considering joint(splice) of sheet pile in use(mm^3/ m)
  - Msp2: resistant moment allowed by embedment deeper than check level.
    Msp2= Ppu* hpu
    Ppu: passive resultant force from check elevation to sheet pile tip
    hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	3543.77	6587.56	1.86>=1.00
Layer boundary surface	33.500	5.000	2993.13	4783.96	1.60>=1.00
Layer boundary surface	35.500	3.000	2183.03	3957.98	1.81>=1.00
Current ground level	38.500	0.000	948.94	2811.89	2.96>=1.00

(2)check level(Embedment tip: G.L. 28.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	3543.77
resistant moment	Mr(kN.m/m)	6587.56
factor of safety	Mr/ Md	1.86>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	7651.77
active earth-prss moment	Ma	322.78
pssv earth-prss moment	- Mp	5517.12
other load moment	Mc	0.00
inertia force moment	Me	928.56
dynamic hydraulic moment	Mwd	157.78
deformation moment	Md(kN.m/m)	3543.77

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	15.333	1226.67
2	42.000 41.750	0.250	40.00 42.50	10.31	13.874	143.07
3	41.750 39.000	2.750	42.50 70.00	154.69	12.263	1896.93
4	39.000 37.500	1.500	70.00 85.00	116.25	10.226	1188.75
5	37.500 36.000	1.500	85.00 78.29	122.47	8.760	1072.85
6	36.000 34.000	2.000	78.29 69.34	147.63	7.020	1036.40
7	34.000 28.000	6.000	69.34 42.50	335.53	3.240	1087.11
Sum				966.88		7651.77

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	10.250	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	8.750	0.00
3	36.000 35.739	0.261	0.00 0.00	0.00	7.869	0.00
4	35.739 34.000	1.739	0.00 7.27	6.32	6.580	41.56
5	34.000 29.000	5.000	7.27 28.16	88.56	3.009	266.44
6	29.000 28.000	1.000	28.16 32.34	30.25	0.488	14.78
Sum				125.13		322.78

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	30.98 52.59	20.89	9.728	203.25
2	37.500 35.000	2.500	51.45 103.80	194.06	8.109	1573.71
3	35.000 33.000	2.000	103.80 145.68	249.48	5.944	1482.91
4	33.000 28.000	5.000	145.68 250.38	990.15	2.280	2257.25
Sum				1454.58		5517.12

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 77.76(kN/m)

Me = Sum(Me) + Mew

= 928.56(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	5.76 5.76	5.76	18.500	106.56
2	46.000 42.000	4.000	5.76 5.76	23.04	16.000	368.64
3	42.000 41.750	0.250	5.76 5.76	1.44	13.875	19.98
4	41.750 38.500	3.250	5.76 5.76	18.72	12.125	226.98
5	38.500 37.500	1.000	5.76 5.18	5.47	10.009	54.77
6	37.500 35.500	2.000	5.18 4.03	9.22	8.542	78.72
7	35.500 33.500	2.000	4.03 2.88	6.91	6.556	45.31
8	33.500 28.500	5.000	2.88 0.00	7.20	3.833	27.60
9	28.500 28.000	0.500	0.00 0.00	0.00	0.250	0.00
Sum				77.76		928.56

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gamw: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 11.43(kN/m)

Mwd= 157.78(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN m	arm length L (m)	moment Mwd kN m/m
46.000	39.000	7.000	7.000	4.200	11.43	13.800	157.78

Note: Lwd is a distance from water level, resultant force works at G.L. 41.800(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure
Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	6587.56 0.00 583.20 0.00
rsst moment Mr(kN m/m)	6587.56

a.resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro* (1+ d/ H)= 2947.07* (1+ 1.235)= 6587.56(kN m/m)
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN m2)	active pRA (kN/m2)	side pRP-pRA (kN m2)	H-frc Pr (kN m)	arm L y (m)	moment Mro kN m/m
1	31.625 28.000	3.625	488.76 569.14	62.60 75.84	426.16 493.31	1666.53	1.768	2947.07
Sum						1666.53		2947.07

b.yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis- angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	31.625	28.000	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane
Bp= cot(xip)* h
$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$
xip= 90.0- tan^{-1} (cot(xip))
* active failure plane
Ba= cot(xia)* h
$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$
xia= 90.0- tan^{-1} (cot(xia))
* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level
Msp= 2* min(Msp1, Msp2)
= 2* min(583.20, 0.00)= 0.00(kN m/m)

d.resistant moment (Msp1) of sheet pile
It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 33.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2993.13
resistant moment	Mr(kN.m/m)	4783.96
factor of safety	Mr/ Md	1.60>=1.00

2)deformation moment(Md)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc inertia force moment Me dynamic hydraulic moment Mwd	3100.82 7.81 723.29 0.00 512.88 94.90
deformation moment Md(kN.m/m)	2993.13

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	9.833	786.67
2	42.000 41.750	0.250	40.00 42.50	10.31	8.374	86.35
3	41.750 39.000	2.750	42.50 70.00	154.69	6.763	1046.15
4	39.000 37.500	1.500	70.00 85.00	116.25	4.726	549.38
5	37.500 36.000	1.500	85.00 78.29	122.47	3.260	399.28
6	36.000 34.000	2.000	78.29 69.34	147.63	1.520	224.43
7	34.000 33.500	0.500	69.34 67.11	34.11	0.251	8.57
Sum				665.46		3100.82

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	4.750	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	3.250	0.00
3	36.000 35.739	0.261	0.00 0.00	0.00	2.369	0.00
4	35.739 34.000	1.739	0.00 7.27	6.32	1.080	6.82
5	34.000 33.500	0.500	7.27 9.36	4.16	0.240	1.00
Sum				10.47		7.81

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	30.98 52.59	20.89	4.228	88.34
2	37.500 35.000	2.500	51.45 103.80	194.06	2.609	506.39
3	35.000 33.500	1.500	103.80 135.21	179.26	0.717	128.55
Sum				394.21		723.29

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 70.56(kN/m)

Me = Sum(Me) + Mew

= 512.88(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

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* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	5.76 5.76	5.76	13.000	74.88
2	46.000 42.000	4.000	5.76 5.76	23.04	10.500	241.92
3	42.000 41.750	0.250	5.76 5.76	1.44	8.375	12.06
4	41.750 38.500	3.250	5.76 5.76	18.72	6.625	124.02
5	38.500 37.500	1.000	5.76 5.18	5.47	4.509	24.67
6	37.500 35.500	2.000	5.18 4.03	9.22	3.042	28.03
7	35.500 33.500	2.000	4.03 2.88	6.91	1.056	7.30
Sum				70.56		512.88

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gamw: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 11.43(kN/m)

Mwd= 94.90(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	39.000	7.000	7.000	4.200	11.43	8.300	94.90

Note: Lwd is a distance from water level, resultant force works at G.L. 41.800(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	3617.56 1166.40 583.20 3364.72
rsst moment Mr(kN.m/m)	4783.96

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2277.72* (1+ 0.588)= 3617.56(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	37.125 35.500	1.625	366.79 402.83	42.51 48.44	324.29 354.39	551.42	2.800	1544.25
2	35.500 33.500	2.000	402.83 447.18	48.44 55.75	354.39 391.43	745.82	0.983	733.47
Sum						1297.24		2277.72

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	37.125	35.500	1.625	25.00	0.00	32.50	2.551	57.50	1.035	3.586
2	35.500	33.500	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(583.20, 3364.72)= 1166.40(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	324.0	324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	33.500 28.000	5.500	145.68 260.85	1117.96	3.010	3364.72

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
Sum				1117.96		3364.72

(4)check level(Layer boundary surface: G.L. 35.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2183.03
resistant moment	Mr(kN.m/m)	3957.98
factor of safety	Mr/ Md	1.81>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	1910.08
active earth-prss moment	Ma	0.01
pssv earth-prss moment	- Mp	177.37
other load moment	Mc	0.00
inertia force moment	Me	378.29
dynamic hydraulic moment	Mwd	72.03
deformation moment	Md(kN.m/m)	2183.03

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	7.833	626.67
2	42.000 41.750	0.250	40.00 42.50	10.31	6.374	65.73
3	41.750 39.000	2.750	42.50 70.00	154.69	4.763	736.77
4	39.000 37.500	1.500	70.00 85.00	116.25	2.726	316.88
5	37.500 36.000	1.500	85.00 78.29	122.47	1.260	154.34
6	36.000 35.500	0.500	78.29 76.05	38.59	0.251	9.69
Sum				522.30		1910.08

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 37.500	1.500	0.00 0.00	0.00	2.750	0.00
2	37.500 36.000	1.500	0.00 0.00	0.00	1.250	0.00
3	36.000 35.739	0.261	0.00 0.00	0.00	0.369	0.00
4	35.739 35.500	0.239	0.00 1.00	0.12	0.080	0.01
Sum				0.12		0.01

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	30.98 52.59	20.89	2.228	46.56
2	37.500 35.500	2.000	51.45 93.33	144.78	0.904	130.82
Sum				165.67		177.37

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 63.65(kN/m)

Me = Sum(Me)+ Mew

= 378.29(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	5.76 5.76	5.76	11.000	63.36
2	46.000 42.000	4.000	5.76 5.76	23.04	8.500	195.84
3	42.000 41.750	0.250	5.76 5.76	1.44	6.375	9.18
4	41.750 38.500	3.250	5.76 5.76	18.72	4.625	86.58
5	38.500 37.500	1.000	5.76 5.18	5.47	2.509	13.73
6	37.500 35.500	2.000	5.18 4.03	9.22	1.042	9.60
Sum				63.65		378.29

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gamw: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure
Fwd= 11.43(kN/m)
Mwd= 72.03(kN.m/m)
* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	39.000	7.000	7.000	4.200	11.43	6.300	72.03

Note: Lwd is a distance from water level, resultant force works at G.L. 41.800(m).
Note: Arm length is a distance from check level to resultant force point.
* inside dynamic hydraulic pressure
Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	2791.58 1166.40 583.20 5864.08
rsst moment Mr(kN.m/m)	3957.98

a.resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro* (1+ d/ H)= 2063.34* (1+ 0.353)= 2791.58(kN.m/m)
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	39.097 38.500	0.597	355.13 371.25	39.46 41.25	315.67 330.00	192.73	3.296	635.30
2	38.500 37.500	1.000	336.30 358.48	37.48 41.14	298.82 317.34	308.08	2.495	768.66
3	37.500 35.500	2.000	358.48 402.83	41.14 48.44	317.34 354.39	671.73	0.982	659.38
Sum						1172.54		2063.34

b.yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure
is considered above. In the same way, take a cross point of riverside and consider active
Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top
height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	39.097	38.500	0.597	30.00	0.00	30.00	1.034	60.00	0.345	1.379
2	38.500	37.500	1.000	25.00	0.00	32.50	1.570	57.50	0.637	2.207
3	37.500	35.500	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										7.999

* passive failure plane
Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xip= 90.0- tan⁻1 (cot(xip))
* active failure plane
Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xia= 90.0- tan⁻1 (cot(xia))
* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)
= 2* min(583.20, 5864.08) = 1166.40(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp. Z allowable stress Sig. a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig. a* Alp. Z	kN* m/m	583.20	583.20

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	35.500 34.000	1.500	103.80 135.21	179.26	0.783	140.33
2	34.000 28.000	6.000	135.21 260.85	1188.18	4.817	5723.75
Sum				1367.44		5864.08

(5) check level(Current ground level: G.L. 38.500m)

1) check result

item	value
deformation moment MH(kN.m/m)	948.94
resistant moment Mr(kN.m/m)	2811.89
factor of safety Mr/ MH	2.96>=1.00

2) deformation moment(MH)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc inertia force moment Me dynamic hydraulic moment Mwd	703.13 0.00 0.00 0.00 208.08 37.73
deformation moment MH(kN.m/m)	948.94

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H frc Pw (kN/m)	arm L y (m)	moment Mw (kN m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	4.833	386.67
2	42.000 41.750	0.250	40.00 42.50	10.31	3.374	34.79
3	41.750 39.000	2.750	42.50 70.00	154.69	1.763	272.71
4	39.000 38.500	0.500	70.00 75.00	36.25	0.247	8.96
Sum				281.25		703.13

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.500	0.500	0.00 0.00	0.00	0.250	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 48.96(kN/m)

Me = Sum(Me)+ Mew

= 208.08(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	5.76 5.76	5.76	8.000	46.08
2	46.000 42.000	4.000	5.76 5.76	23.04	5.500	126.72
3	42.000 41.750	0.250	5.76 5.76	1.44	3.375	4.86
4	41.750 38.500	3.250	5.76 5.76	18.72	1.625	30.42
Sum				48.96		208.08

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 11.43(kN/m)

Mwd= 37.73(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	39.000	7.000	7.000	4.200	11.43	3.300	37.73

Note: Lwd is a distance from water level, resultant force works at G.L. 41.800(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro*(1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1645.49 1166.40 583.20 10339.25
rsst moment Mr(kN.m/m)	2811.89

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro*(1+ d/ H)= 1645.49*(1+ 0.000)= 1645.49(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)*(2* p1+ p2)/(p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.964 41.750	0.214	271.94 283.50	30.22 31.50	241.73 252.00	52.83	3.356	177.31
2	41.750 38.500	3.250	283.50 371.25	31.50 41.25	252.00 330.00	945.75	1.552	1468.19
Sum						998.58		1645.49

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	41.964 41.750	41.750 38.500	0.214 3.250	30.00 30.00	0.00 0.00	30.00 30.00	0.371 5.629	60.00 60.00	0.124 1.876	0.494 7.506
Interval Sum(Bp) + Ba										8.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)
= 2* min(583.20, 10339.25)= 1166.40(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m³/m - - - - - - - - $* 10^{-6}$ m³/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	38.500 37.500	1.000	40.98 61.92	51.45	0.534	27.47
2	37.500 36.000	1.500	61.92 93.33	116.43	1.801	209.65
3	36.000 34.000	2.000	93.33 135.21	228.54	3.561	813.84
4	34.000 28.000	6.000	135.21 260.85	1188.18	7.817	9288.29
Sum				1584.60		10339.25

5.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} \geq FS$$

where,

FS: required factor of safety(1.00)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	28.000	10.500	1181.20	2348.75	1.99>=1.00

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item	value
sum of H force Fd(kN/m)	1181.20
sum of rsst Fr(kN/m)	2348.75
factor of safety Fr/ Fd	1.99>=1.00

2)sum of horizontal force(Fd)

horizontal force in detail		H force
water pressure	Fw	966.88
active earth pressure	Fa	125.13
other load	Fc	0.00
inertia force	Fe	77.76
dynamic hydraulic prrs	Fwd	11.43
sum of H force	Fd(kN/m)	1181.20

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

d.inertia force

table of inertia force when shear deformation failures is check at tip of embedment.

e.dynamic hydraulic pressure

table of dynamic hydraulic press. when shear deform failures is checked at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail		H force
ground H resistance	Fs	894.17
passive earth pressure	Fp	1454.58
sum of resistance	Fr(kN/m)	2348.75

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 8.000+ 1746.00* tan(25.00) Deg.

= 894.17(kN/m)

b. soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (218.25+ 0.00)* 8.000= 1746.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	42.000	4.000	18.0	72.00
3	42.000	41.750	0.250	18.0	4.50
4	41.750	38.500	3.250	9.0	29.25
5	38.500	37.500	1.000	9.0	9.00
6	37.500	35.500	2.000	9.0	18.00
7	35.500	33.500	2.000	9.0	18.00
8	33.500	28.000	5.500	9.0	49.50
Sum			19.000		218.25

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

5.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 8.000, height H= 8.500(m) using the next equation.

$$\frac{Qu}{V - Gam2 * Df * Be} >= FS$$

$$Qu = Be\{ k * c * Nc + k * Gam2 * Df * (Nq - 1) + \frac{1}{2} * Gam1 * Be * NGam \}$$

where,

FS : required factor of safety(1.00)
Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)
V : vertical component on check level(weight inside wall above the level)(kN/m)
Be : effective loading width considering eccentricity (m)
Be= B- 2e
B: wall width
e: eccentricity(e= Mb/ V)
Mb : moment working on check level
k : overdesign coefficient for embedment effect(= 1.0)
c : cohesion below check level
Df : distance from ground level to check level
Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.
Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.
Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)
tan(Alpha) = Hb/ V
Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	28.000	10.500	4898.36	1373.60	3.57>=1.00

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	1746.00
	distance from ground to check level	Df	10.500
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	3.941
	v-compo sum V- Gam2.Df.Be (kN/m)		1373.60
Qu	moment on check level	Mb	3543.77
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	2.030
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		4898.36
factor of safety			3.57>=1.00

2)summery of external force

external force detail		moment Mb(kN.m/m)	H-force Hb(kN/m)
water pressure	Mw(Fw)	7651.77	966.88
active earth pressure	Ma(Fa)	322.78	125.13
passive earth pressure-	Mp(Fp)	5517.12	1454.58
other load	Mc(Fc)	0.00	0.00
inertia force	Me(Fe)	928.56	77.76
dynamic water prss	Mwd(Fwd)	157.78	11.43
external force sum		3543.77	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b. active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

e. inertia load

refer to inertia force in checking shear failure at embedment tip

f. dynamic water pressure

refer to dynamic water pressure in checking shear failure at embedment tip

3)weight of filling soil(V)

refer to 'b.weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 1746.00(kN/m)

4)eccentricity distance(e)calculation

e = Mb/ V

= 3543.77/ 1746.00

= 2.030(m)

Be= B- 2e

= 8.000- 2.0* 2.030

= 3.941(m)

5)calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 1746.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$\text{Gam 2} = \frac{\text{Sum(Gam i hi)}}{\text{Sum(hi)}}$$

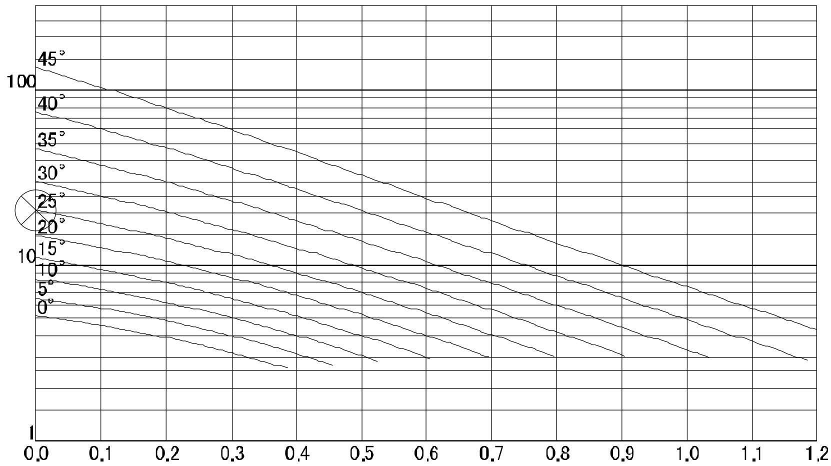
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	38.500	37.500	1.000	9.0	9.00
2	37.500	35.500	2.000	9.0	18.00
3	35.500	33.500	2.000	9.0	18.00
4	33.500	28.000	5.500	9.0	49.50
Sum			10.500		94.50

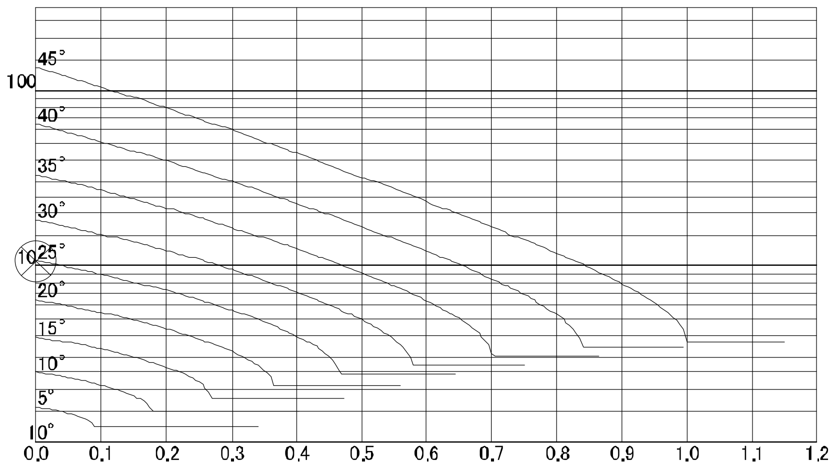
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

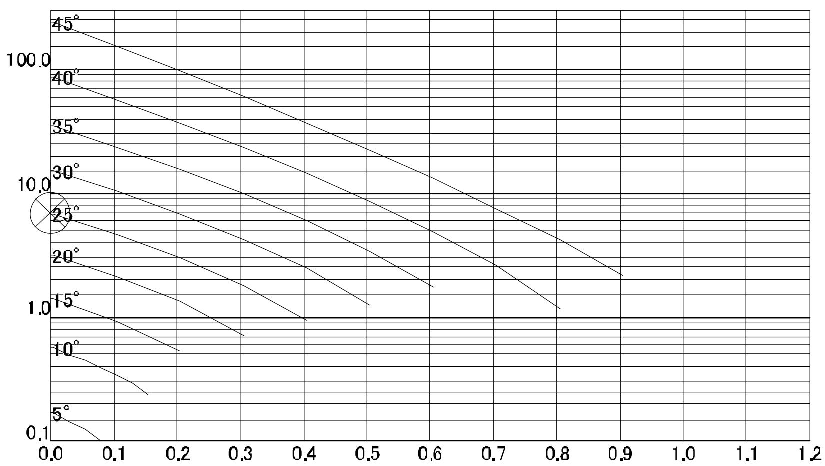
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



5.3 landside sheet pile

5.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.750(m)
L.WL : 37.500(m)

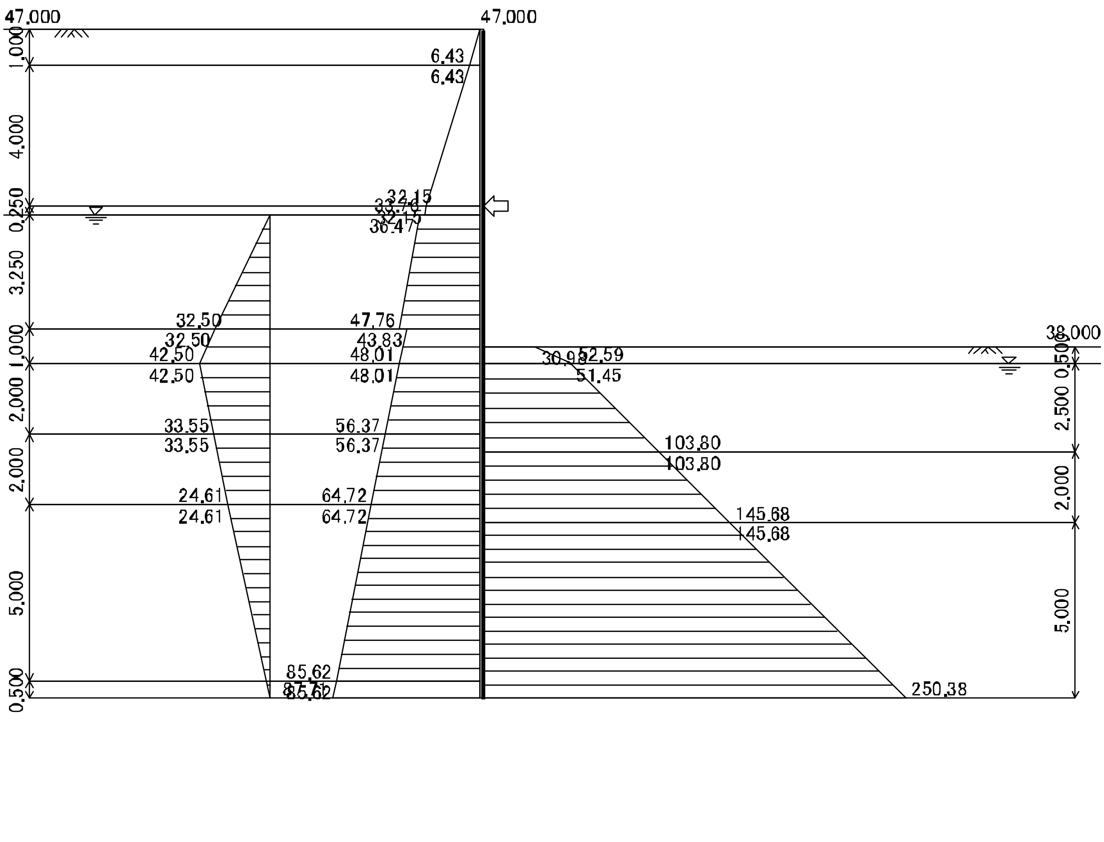
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	32.070	28.000
active sd	Ma+Mw+Mac(kN.m/m)	3839.29	8539.36
passive sd	Mp+Mpc(kN.m/m)	4611.58	14847.00
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.201>=1.20	1.739>=1.20



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.750	0.250	32.15 33.76	8.24	0.126	1.04
2	41.750 38.500	3.250	36.47 47.76	136.88	1.948	266.58
3	38.500 37.500	1.000	43.83 48.01	45.92	4.008	184.02
4	37.500 35.500	2.000	48.01 56.37	104.37	5.527	576.85
5	35.500 33.500	2.000	56.37 64.72	121.09	7.523	910.96
6	33.500 28.500	5.000	64.72 85.62	375.85	11.116	4177.90
7	28.500 28.000	0.500	85.62 87.71	43.33	13.751	595.84
Sum				835.68		6713.19

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.750 38.500	3.250	0.00 32.50	52.81	2.417	127.63
2	38.500 37.500	1.000	32.50 42.50	37.50	4.022	150.83
3	37.500 35.500	2.000	42.50 33.55	76.05	5.461	415.31
4	35.500 33.500	2.000	33.55 24.61	58.16	7.449	433.20
5	33.500 28.000	5.500	24.61 0.00	67.66	10.333	699.20
Sum				292.19		1826.17

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	30.98 52.59	20.89	4.272	89.24
2	37.500 35.000	2.500	51.45 103.80	194.06	5.891	1143.10
3	35.000 33.000	2.000	103.80 145.68	249.48	8.056	2009.78
4	33.000 28.000	5.000	145.68 250.38	990.15	11.720	11604.88
Sum				1454.58		14847.00

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

5.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-274.93	G.L. 38.400
max shear force Smax(kN/m)	-198.55	G.L. 42.000
upper tension mbr rct R1(kN/m)	0.00	G.L. 46.000
lower tension mbr rct R2(kN/m)	-282.18	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 46.000	0.00 6.43	0.00 0.00	- - - - - - - -	- - - - - - - -	0.00 6.43	- - - - - - - -
2	46.000 42.000	6.43 32.15	0.00 0.00	- - - - - - - -	- - - - - - - -	6.43 32.15	- - - - - - - -
3	42.000 41.750	32.15 33.76	0.00 0.00	- - - - - - - -	- - - - - - - -	32.15 33.76	- - - - - - - -
4	41.750 38.500	36.47 47.76	0.00 32.50	- - - - - - - -	- - - - - - - -	36.47 80.26	- - - - - - - -
5	38.500 38.000	43.83 45.92	32.50 37.50	- - - - - - - -	- - - - - - - -	76.33 83.42	- - - - - - - -
6	38.000 37.500	45.92 48.01	37.50 42.50	30.98 52.59	0.00 5.20	83.42 85.31	30.98 47.39
7	37.500 35.500	48.01 56.37	42.50 33.55	51.45 93.33	5.20 15.59	85.31 74.33	46.25 77.74
8	35.500 35.000	56.37 58.46	33.55 31.32	93.33 103.80	15.59 18.19	74.33 71.58	77.74 85.61
9	35.000 33.500	58.46 64.72	31.32 24.61	103.80 135.21	18.19 25.98	71.58 63.35	85.61 109.23
10	33.500 33.000	64.72 66.81	24.61 22.37	135.21 145.68	25.98 28.58	63.35 60.60	109.23 117.10
11	33.000 28.500	66.81 85.62	22.37 2.24	145.68 239.91	28.58 51.96	60.60 35.89	117.10 187.95
12	28.500 28.000	85.62 87.71	2.24 0.00	239.91 250.38	51.96 54.56	35.89 33.14	187.95 195.82

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	38.000	37.500	0.500	16800	8073
2	37.500	35.000	2.500	16800	8073
3	35.000	33.000	2.000	16800	8073
4	33.000	26.000	7.000	19600	9419
5	26.000	21.000	5.000	92400	44404

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.*(2*number*A*E)}{(L*s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000]m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	6818
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	19.29	3.86	--------	--------	--------	--------
17	43.800	On excavation plane	20.58	20.58	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	21.86	21.86	4.37	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
19	43.400	On excavation plane	23.15	23.15	4.63	--------	--------	--------	--------
20	43.200	On excavation plane	24.44	24.44	4.89	--------	--------	--------	--------
21	43.000	On excavation plane	25.72	25.72	5.14	--------	--------	--------	--------
22	42.800	On excavation plane	27.01	27.01	5.40	--------	--------	--------	--------
23	42.600	On excavation plane	28.29	28.29	5.66	--------	--------	--------	--------
24	42.400	On excavation plane	29.58	29.58	5.92	--------	--------	--------	--------
25	42.200	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
26	42.000	Tensile member	32.15	32.15	6.43	--------	--------	--------	122718
27	41.800	On excavation plane	33.44	33.44	4.15	--------	--------	--------	--------
28	41.750	On excavation plane	33.76	36.47	3.62	--------	--------	--------	--------
29	41.600	On excavation plane	38.49	38.49	6.77	--------	--------	--------	--------
30	41.400	On excavation plane	41.19	41.19	8.24	--------	--------	--------	--------
31	41.200	On excavation plane	43.88	43.88	8.78	--------	--------	--------	--------
32	41.000	On excavation plane	46.58	46.58	9.32	--------	--------	--------	--------
33	40.800	On excavation plane	49.27	49.27	9.85	--------	--------	--------	--------
34	40.600	On excavation plane	51.97	51.97	10.39	--------	--------	--------	--------
35	40.400	On excavation plane	54.66	54.66	10.93	--------	--------	--------	--------
36	40.200	On excavation plane	57.36	57.36	11.47	--------	--------	--------	--------
37	40.000	On excavation plane	60.05	60.05	12.01	--------	--------	--------	--------
38	39.800	On excavation plane	62.74	62.74	12.55	--------	--------	--------	--------
39	39.600	On excavation plane	65.44	65.44	13.09	--------	--------	--------	--------
40	39.400	On excavation plane	68.13	68.13	13.63	--------	--------	--------	--------
41	39.200	On excavation plane	70.83	70.83	14.17	--------	--------	--------	--------
42	39.000	On excavation plane	73.52	73.52	14.70	--------	--------	--------	--------
43	38.800	On excavation plane	76.22	76.22	15.24	--------	--------	--------	--------
44	38.600	On excavation plane	78.91	78.91	11.79	--------	--------	--------	--------
45	38.500	On excavation plane	80.26	76.33	7.83	--------	--------	--------	--------
46	38.400	On excavation plane	77.75	77.75	11.72	--------	--------	--------	--------
47	38.200	On excavation plane	80.58	80.58	16.12	--------	--------	--------	--------
48	38.000	Pa plas.	83.42	83.42	16.63	0.00	30.98	3.26	--------
49	37.800	Pa plas.	84.18	84.18	16.84	37.55	37.55	7.51	--------
50	37.600	Pa plas.	84.93	84.93	12.73	44.11	44.11	6.49	--------
51	37.500	Pa plas.	85.31	85.31	8.52	47.39	46.25	4.66	--------
52	37.400	Pa plas.	84.76	84.76	12.69	47.83	47.83	7.23	--------
53	37.200	Pa plas.	83.66	83.66	16.73	50.97	50.97	10.19	--------
54	37.000	Pa plas.	82.57	82.57	16.51	54.12	54.12	10.82	--------
55	36.800	Pa plas.	81.47	81.47	16.29	57.27	57.27	11.45	--------
56	36.600	Pa plas.	80.37	80.37	16.07	60.42	60.42	12.08	--------
57	36.400	Pa plas.	79.27	79.27	15.85	63.57	63.57	12.71	--------
58	36.200	Pa plas.	78.17	78.17	15.63	66.72	66.72	13.34	--------
59	36.000	Pa plas.	77.08	77.08	15.42	69.87	69.87	13.97	--------
60	35.800	Pa plas.	75.98	75.98	15.20	73.02	73.02	14.60	--------
61	35.600	Pa plas.	74.88	74.88	11.25	76.16	76.16	11.37	--------

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN m
			above nd kN m2	below nd kN m2	cntrt ld kN m2	above nd kN m2	below nd kN m2	cntrt ld kN m2	
62	35.500	Pa plas.	74.33	74.33	7.43	77.74	77.74	7.77	--------
63	35.400	Pa plas.	73.78	73.78	11.05	79.31	79.31	11.96	--------
64	35.200	Pa plas.	72.68	72.68	14.54	82.46	82.46	16.49	--------
65	35.000	Pa plas.	71.58	71.58	14.32	85.61	85.61	17.12	--------
66	34.800	Pa plas.	70.49	70.49	14.10	88.76	88.76	17.75	--------
67	34.600	Pa plas.	69.39	69.39	13.88	91.91	91.91	18.38	--------
68	34.400	Pa plas.	68.29	68.29	13.66	95.06	95.06	19.01	--------
69	34.200	Pa plas.	67.19	67.19	13.44	98.21	98.21	19.64	--------
70	34.000	Pa plas.	66.09	66.09	13.22	101.35	101.35	20.27	--------
71	33.800	Pa plas.	64.99	64.99	13.00	104.50	104.50	20.90	--------
72	33.600	Pa plas.	63.90	63.90	9.60	107.65	107.65	16.09	--------
73	33.500	Pa plas.	63.35	63.35	6.33	109.23	109.23	10.92	--------
74	33.400	Pa plas.	62.80	62.80	9.40	110.80	110.80	16.68	--------
75	33.200	Pas ela.	61.70	61.70	12.34	113.95	113.95	--------	1615
76	33.000	Pas ela.	60.60	60.60	12.12	117.10	117.10	--------	1749
77	32.800	Pas ela.	59.50	59.50	11.90	120.25	120.25	--------	1884
78	32.600	Pas ela.	58.40	58.40	11.68	123.40	123.40	--------	1884
79	32.400	Pas ela.	57.31	57.31	11.46	126.55	126.55	--------	1884
80	32.200	Pas ela.	56.21	56.21	11.24	129.69	129.69	--------	1884
81	32.000	Pas ela.	55.11	55.11	11.02	132.84	132.84	--------	1884
82	31.800	Pas ela.	54.01	54.01	10.80	135.99	135.99	--------	1884
83	31.600	Pas ela.	52.91	52.91	10.58	139.14	139.14	--------	1884
84	31.400	Pas ela.	51.81	51.81	10.36	142.29	142.29	--------	1884
85	31.200	Pas ela.	50.72	50.72	10.14	145.44	145.44	--------	1884
86	31.000	Pas ela.	49.62	49.62	9.92	148.59	148.59	--------	1884
87	30.800	Pas ela.	48.52	48.52	9.70	151.74	151.74	--------	1884
88	30.600	Pas ela.	47.42	47.42	9.48	154.88	154.88	--------	1884
89	30.400	Pas ela.	46.32	46.32	9.26	158.03	158.03	--------	1884
90	30.200	Pas ela.	45.23	45.23	9.05	161.18	161.18	--------	1884
91	30.000	Pas ela.	44.13	44.13	8.83	164.33	164.33	--------	1884
92	29.800	Pas ela.	43.03	43.03	8.61	167.48	167.48	--------	1884
93	29.600	Pas ela.	41.93	41.93	8.39	170.63	170.63	--------	1884
94	29.400	Pas ela.	40.83	40.83	8.17	173.78	173.78	--------	1884
95	29.200	Pas ela.	39.73	39.73	7.95	176.93	176.93	--------	1884
96	29.000	Pas ela.	38.64	38.64	7.73	180.07	180.07	--------	1884
97	28.800	Pas ela.	37.54	37.54	7.51	183.22	183.22	--------	1884
98	28.600	Pas ela.	36.44	36.44	5.49	186.37	186.37	--------	1413
99	28.500	Pas ela.	35.89	35.89	3.59	187.95	187.95	--------	942
100	28.400	Pas ela.	35.34	35.34	5.28	189.52	189.52	--------	1413
101	28.200	Pas ela.	34.24	34.24	6.85	192.67	192.67	--------	1884
102	28.000	Pas ela.	33.14	0.00	3.34	195.82	0.00	--------	942
Sum					923.10			352.71	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= -41.14mm(G.L. 47.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-41.14	- - - -	- - - -
2	46.800	on exv	- - - -	-39.51	- - - -	- - - -
3	46.600	on exv	- - - -	-37.89	- - - -	- - - -
4	46.400	on exv	- - - -	-36.26	- - - -	- - - -
5	46.200	on exv	- - - -	-34.63	- - - -	- - - -
6	46.000	on exv	6818	-33.00	- - - -	Note: 0.00
7	45.800	on exv	- - - -	-31.37	- - - -	- - - -
8	45.600	on exv	- - - -	-29.74	- - - -	- - - -
9	45.400	on exv	- - - -	-28.10	- - - -	- - - -
10	45.200	on exv	- - - -	-26.47	- - - -	- - - -
11	45.000	on exv	- - - -	-24.83	- - - -	- - - -
12	44.800	on exv	- - - -	-23.18	- - - -	- - - -
13	44.600	on exv	- - - -	-21.53	- - - -	- - - -
14	44.400	on exv	- - - -	-19.87	- - - -	- - - -
15	44.200	on exv	- - - -	-18.19	- - - -	- - - -
16	44.000	on exv	- - - -	-16.50	- - - -	- - - -
17	43.800	on exv	- - - -	-14.79	- - - -	- - - -
18	43.600	on exv	- - - -	-13.06	- - - -	- - - -
19	43.400	on exv	- - - -	-11.30	- - - -	- - - -
20	43.200	on exv	- - - -	-9.51	- - - -	- - - -
21	43.000	on exv	- - - -	-7.68	- - - -	- - - -
22	42.800	on exv	- - - -	-5.80	- - - -	- - - -
23	42.600	on exv	- - - -	-3.87	- - - -	- - - -
24	42.400	on exv	- - - -	-1.89	- - - -	- - - -
25	42.200	on exv	- - - -	0.17	- - - -	- - - -
26	42.000	on exv	122718	2.30	- - - -	Note: -282.18
27	41.800	on exv	- - - -	4.51	- - - -	- - - -
28	41.750	on exv	- - - -	5.08	- - - -	- - - -
29	41.600	on exv	- - - -	6.79	- - - -	- - - -
30	41.400	on exv	- - - -	9.10	- - - -	- - - -
31	41.200	on exv	- - - -	11.42	- - - -	- - - -
32	41.000	on exv	- - - -	13.73	- - - -	- - - -
33	40.800	on exv	- - - -	16.01	- - - -	- - - -
34	40.600	on exv	- - - -	18.24	- - - -	- - - -
35	40.400	on exv	- - - -	20.40	- - - -	- - - -
36	40.200	on exv	- - - -	22.46	- - - -	- - - -
37	40.000	on exv	- - - -	24.43	- - - -	- - - -
38	39.800	on exv	- - - -	26.27	- - - -	- - - -
39	39.600	on exv	- - - -	27.97	- - - -	- - - -
40	39.400	on exv	- - - -	29.53	- - - -	- - - -
41	39.200	on exv	- - - -	30.94	- - - -	- - - -
42	39.000	on exv	- - - -	32.18	- - - -	- - - -
43	38.800	on exv	- - - -	33.24	- - - -	- - - -
44	38.600	on exv	- - - -	34.14	- - - -	- - - -
45	38.500	on exv	- - - -	34.52	- - - -	- - - -
46	38.400	on exv	- - - -	34.85	- - - -	- - - -
47	38.200	on exv	- - - -	35.39	- - - -	- - - -
48	38.000	pssv pl	- - - -	35.75	4.04	- - - -
49	37.800	pssv pl	- - - -	35.94	4.65	- - - -
50	37.600	pssv pl	- - - -	35.96	5.36	- - - -
51	37.500	pssv pl	- - - -	35.91	5.77	- - - -
52	37.400	pssv pl	- - - -	35.82	5.97	- - - -
53	37.200	pssv pl	- - - -	35.52	6.31	- - - -
54	37.000	pssv pl	- - - -	35.08	6.70	- - - -
55	36.800	pssv pl	- - - -	34.50	7.09	- - - -
56	36.600	pssv pl	- - - -	33.80	7.48	- - - -
57	36.400	pssv pl	- - - -	32.98	7.87	- - - -
58	36.200	pssv pl	- - - -	32.06	8.26	- - - -
59	36.000	pssv pl	- - - -	31.04	8.65	- - - -
60	35.800	pssv pl	- - - -	29.95	9.04	- - - -
61	35.600	pssv pl	- - - -	28.79	9.39	- - - -
62	35.500	pssv pl	- - - -	28.19	9.63	- - - -
63	35.400	pssv pl	- - - -	27.57	9.87	- - - -
64	35.200	pssv pl	- - - -	26.31	10.21	- - - -
65	35.000	pssv pl	- - - -	25.02	10.60	- - - -
66	34.800	pssv pl	- - - -	23.71	10.99	- - - -
67	34.600	pssv pl	- - - -	22.39	11.38	- - - -
68	34.400	pssv pl	- - - -	21.08	11.77	- - - -
69	34.200	pssv pl	- - - -	19.78	12.16	- - - -
70	34.000	pssv pl	- - - -	18.50	12.55	- - - -
71	33.800	pssv pl	- - - -	17.25	12.94	- - - -
72	33.600	pssv pl	- - - -	16.05	13.29	- - - -
73	33.500	pssv pl	- - - -	15.46	13.53	- - - -
74	33.400	pssv pl	- - - -	14.89	13.77	- - - -
75	33.200	pssv el	1615	13.79	14.11	-22.26
76	33.000	pssv el	1749	12.74	13.39	-22.28
77	32.800	pssv el	1884	11.75	12.77	-22.14
78	32.600	pssv el	1884	10.83	13.10	-20.40
79	32.400	pssv el	1884	9.97	13.44	-18.78
80	32.200	pssv el	1884	9.17	13.77	-17.28
81	32.000	pssv el	1884	8.44	14.10	-15.90
82	31.800	pssv el	1884	7.76	14.44	-14.63
83	31.600	pssv el	1884	7.15	14.77	-13.46

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
84	31.400	pssv el	1884	6.58	15.11	-12.40
85	31.200	pssv el	1884	6.07	15.44	-11.43
86	31.000	pssv el	1884	5.60	15.78	-10.55
87	30.800	pssv el	1884	5.17	16.11	-9.74
88	30.600	pssv el	1884	4.78	16.44	-9.01
89	30.400	pssv el	1884	4.43	16.78	-8.34
90	30.200	pssv el	1884	4.10	17.11	-7.72
91	30.000	pssv el	1884	3.80	17.45	-7.15
92	29.800	pssv el	1884	3.52	17.78	-6.62
93	29.600	pssv el	1884	3.25	18.12	-6.13
94	29.400	pssv el	1884	3.01	18.45	-5.66
95	29.200	pssv el	1884	2.77	18.78	-5.21
96	29.000	pssv el	1884	2.54	19.12	-4.78
97	28.800	pssv el	1884	2.32	19.45	-4.36
98	28.600	pssv el	1413	2.10	19.75	-2.96
99	28.500	pssv el	942	1.99	19.95	-1.87
100	28.400	pssv el	1413	1.88	20.16	-2.65
101	28.200	pssv el	1884	1.66	20.46	-3.13
102	28.000	pssv el	942	1.45	20.71	-1.36
Sum						-570.39

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)
max bending moment Mmax= -274.93kN.m/m(G.L. 38.400m)
max shear force Smax= -198.55kN/m (G.L. 42.000m)
max displacement Del.xmax= -41.14mm (G.L. 47.000m)

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	0.03	-41.14	------------
2	46.800	0.01	0.01	0.03	0.29	-39.51	------------
3	46.600	0.06	0.06	0.29	0.80	-37.89	------------
4	46.400	0.23	0.23	0.80	1.58	-36.26	------------
5	46.200	0.54	0.54	1.58	2.60	-34.63	------------
6	46.000	1.06	1.06	2.60	3.89	-33.00	* 0.00
7	45.800	1.84	1.84	3.89	5.43	-31.37	------------
8	45.600	2.93	2.93	5.43	7.23	-29.74	------------
9	45.400	4.37	4.37	7.23	9.29	-28.10	------------
10	45.200	6.23	6.23	9.29	11.61	-26.47	------------
11	45.000	8.55	8.55	11.61	14.18	-24.83	------------
12	44.800	11.39	11.39	14.18	17.01	-23.18	------------
13	44.600	14.79	14.79	17.01	20.10	-21.53	------------
14	44.400	18.81	18.81	20.10	23.44	-19.87	------------
15	44.200	23.50	23.50	23.44	27.04	-18.19	------------
16	44.000	28.91	28.91	27.04	30.90	-16.50	------------
17	43.800	35.09	35.09	30.90	35.01	-14.79	------------
18	43.600	42.09	42.09	35.01	39.39	-13.06	------------
19	43.400	49.97	49.97	39.39	44.02	-11.30	------------
20	43.200	58.77	58.77	44.02	48.90	-9.51	------------
21	43.000	68.55	68.55	48.90	54.05	-7.68	------------
22	42.800	79.36	79.36	54.05	59.45	-5.80	------------
23	42.600	91.25	91.25	59.45	65.11	-3.87	------------
24	42.400	104.27	104.27	65.11	71.03	-1.89	------------
25	42.200	118.48	118.48	71.03	77.20	0.17	------------
26	42.000	133.92	133.92	77.20	-198.55	2.30	* -282.18
27	41.800	94.21	94.21	-198.55	-194.40	4.51	------------
28	41.750	84.49	84.49	-194.40	-190.78	5.08	------------
29	41.600	55.87	55.87	-190.78	-184.02	6.79	------------
30	41.400	19.07	19.07	-184.02	-175.78	9.10	------------
31	41.200	-16.09	-16.09	-175.78	-167.00	11.42	------------
32	41.000	-49.49	-49.49	-167.00	-157.69	13.73	------------
33	40.800	-81.02	-81.02	-157.69	-147.83	16.01	------------
34	40.600	-110.59	-110.59	-147.83	-137.44	18.24	------------
35	40.400	-138.08	-138.08	-137.44	-126.51	20.40	------------
36	40.200	-163.38	-163.38	-126.51	-115.04	22.46	------------
37	40.000	-186.39	-186.39	-115.04	-103.03	24.43	------------
38	39.800	-206.99	-206.99	-103.03	-90.48	26.27	------------
39	39.600	-225.09	-225.09	-90.48	-77.39	27.97	------------
40	39.400	-240.57	-240.57	-77.39	-63.76	29.53	------------
41	39.200	-253.32	-253.32	-63.76	-49.60	30.94	------------
42	39.000	-263.24	-263.24	-49.60	-34.89	32.18	------------
43	38.800	-270.22	-270.22	-34.89	-19.65	33.24	------------
44	38.600	-274.15	-274.15	-19.65	-7.86	34.14	------------
45	38.500	-274.93	-274.93	-7.86	-0.03	34.52	------------
46	38.400	-274.93	-274.93	-0.03	11.68	34.85	------------
47	38.200	-272.60	-272.60	11.68	27.80	35.39	------------
48	38.000	-267.04	-267.04	27.80	41.17	35.75	------------
49	37.800	-258.80	-258.80	41.17	50.50	35.94	------------

node No	Y co GL(m)	moment kN.m/m top	bottom	shear force kN/m top	bottom	disp Del.x mm	reaction Q kN/m
50	37.600	-248.70	-248.70	50.50	56.73	35.96	------------
51	37.500	-243.03	-243.03	56.73	60.59	35.91	------------
52	37.400	-236.97	-236.97	60.59	66.05	35.82	------------
53	37.200	-223.76	-223.76	66.05	72.59	35.52	------------
54	37.000	-209.25	-209.25	72.59	78.28	35.08	------------
55	36.800	-193.59	-193.59	78.28	83.11	34.50	------------
56	36.600	-176.97	-176.97	83.11	87.10	33.80	------------
57	36.400	-159.55	-159.55	87.10	90.24	32.98	------------
58	36.200	-141.50	-141.50	90.24	92.54	32.06	------------
59	36.000	-122.99	-122.99	92.54	93.98	31.04	------------
60	35.800	-104.20	-104.20	93.98	94.57	29.95	------------
61	35.600	-85.28	-85.28	94.57	94.46	28.79	------------
62	35.500	-75.84	-75.84	94.46	94.12	28.19	------------
63	35.400	-66.42	-66.42	94.12	93.21	27.57	------------
64	35.200	-47.78	-47.78	93.21	91.25	26.31	------------
65	35.000	-29.53	-29.53	91.25	88.44	25.02	------------
66	34.800	-11.84	-11.84	88.44	84.79	23.71	------------
67	34.600	5.11	5.11	84.79	80.28	22.39	------------
68	34.400	21.17	21.17	80.28	74.93	21.08	------------
69	34.200	36.16	36.16	74.93	68.73	19.78	------------
70	34.000	49.90	49.90	68.73	61.68	18.50	------------
71	33.800	62.24	62.24	61.68	53.77	17.25	------------
72	33.600	72.99	72.99	53.77	47.29	16.05	------------
73	33.500	77.72	77.72	47.29	42.70	15.46	------------
74	33.400	81.99	81.99	42.70	35.42	14.89	------------
75	33.200	89.08	89.08	35.42	25.50	13.79	-22.26
76	33.000	94.18	94.18	25.50	15.34	12.74	-22.28
77	32.800	97.24	97.24	15.34	5.10	11.75	-22.14
78	32.600	98.27	98.27	5.10	-3.61	10.83	-20.40
79	32.400	97.54	97.54	-3.61	-10.93	9.97	-18.78
80	32.200	95.36	95.36	-10.93	-16.97	9.17	-17.28
81	32.000	91.96	91.96	-16.97	-21.84	8.44	-15.90
82	31.800	87.59	87.59	-21.84	-25.67	7.76	-14.63
83	31.600	82.46	82.46	-25.67	-28.55	7.15	-13.46
84	31.400	76.75	76.75	-28.55	-30.58	6.58	-12.40
85	31.200	70.63	70.63	-30.58	-31.87	6.07	-11.43
86	31.000	64.26	64.26	-31.87	-32.49	5.60	-10.55
87	30.800	57.76	57.76	-32.49	-32.53	5.17	-9.74
88	30.600	51.26	51.26	-32.53	-32.05	4.78	-9.01
89	30.400	44.85	44.85	-32.05	-31.12	4.43	-8.34
90	30.200	38.62	38.62	-31.12	-29.80	4.10	-7.72
91	30.000	32.66	32.66	-29.80	-28.13	3.80	-7.15
92	29.800	27.04	27.04	-28.13	-26.15	3.52	-6.62
93	29.600	21.81	21.81	-26.15	-23.89	3.25	-6.13
94	29.400	17.03	17.03	-23.89	-21.38	3.01	-5.66
95	29.200	12.75	12.75	-21.38	-18.65	2.77	-5.21
96	29.000	9.02	9.02	-18.65	-15.71	2.54	-4.78
97	28.800	5.88	5.88	-15.71	-12.56	2.32	-4.36
98	28.600	3.37	3.37	-12.56	-10.04	2.10	-2.96
99	28.500	2.37	2.37	-10.04	-8.32	1.99	-1.87
100	28.400	1.53	1.53	-8.32	-5.69	1.88	-2.65
101	28.200	0.40	0.40	-5.69	-1.98	1.66	-3.13
102	28.000	0.00	----------	-1.98	----------	1.45	-1.36

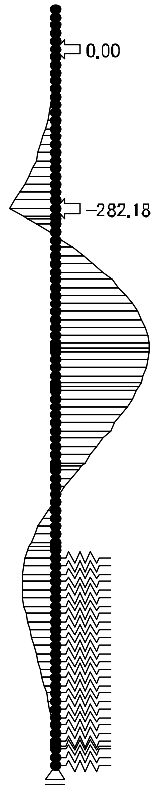
Note: * mark shows reaction of tensile member

(5)Member force diagram

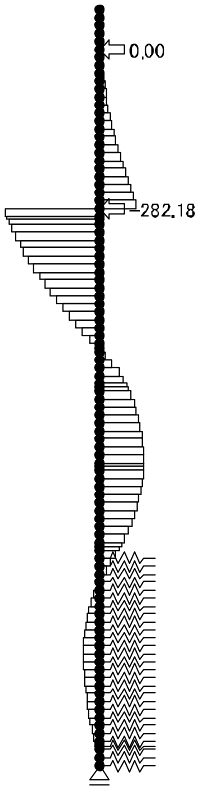
max bending moment Mmax= -274.93kN m/m(G.L. 38.400m)

max shear force Smax= -198.55kN m (G.L. 42.000m)

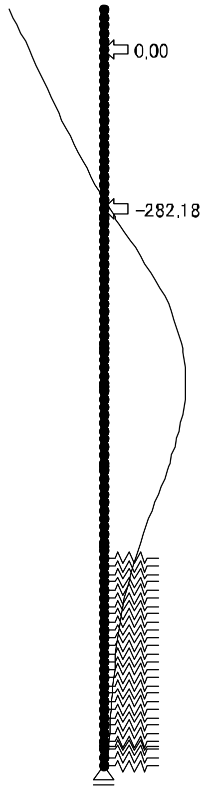
max displacement Del.xmax= -41.14mm (G.L. 47.000m)



Moment graph



Shear force diagram



Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/m)

5.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	274.93	0.00	198.55

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	153	324	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	9	150	OK

5.3.4 Tensile member stress

(1)Upper stage check on tensile member

1)member in use

diameter in use : Phi 25(mm)
material in use : ,'£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2)calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
0.00	3.600	0.00

3)stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* A} <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
0	264	OK

(2)Lower stage check on tensile member

1)member in use

diameter in use : Phi 75(mm)
material in use : ,'£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2)calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
282.18	1.800	507.92

3)stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* A} <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
115	264	OK

5.3.5 Waling member stress

(1) Upper stage Wailing check

1) member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 3.600(m)

2) moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
0.00	3.600	0.00

3) stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \le Sig.a$$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
0	210	OK

(2) Lower stage Wailing check

1) member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 1.800(m)

2) moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
507.92	1.800	91.43

3) stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \le Sig.a$$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
97	210	OK

5.4 riverside sheet pile

5.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.500(m)
L.WL : 40.000(m)

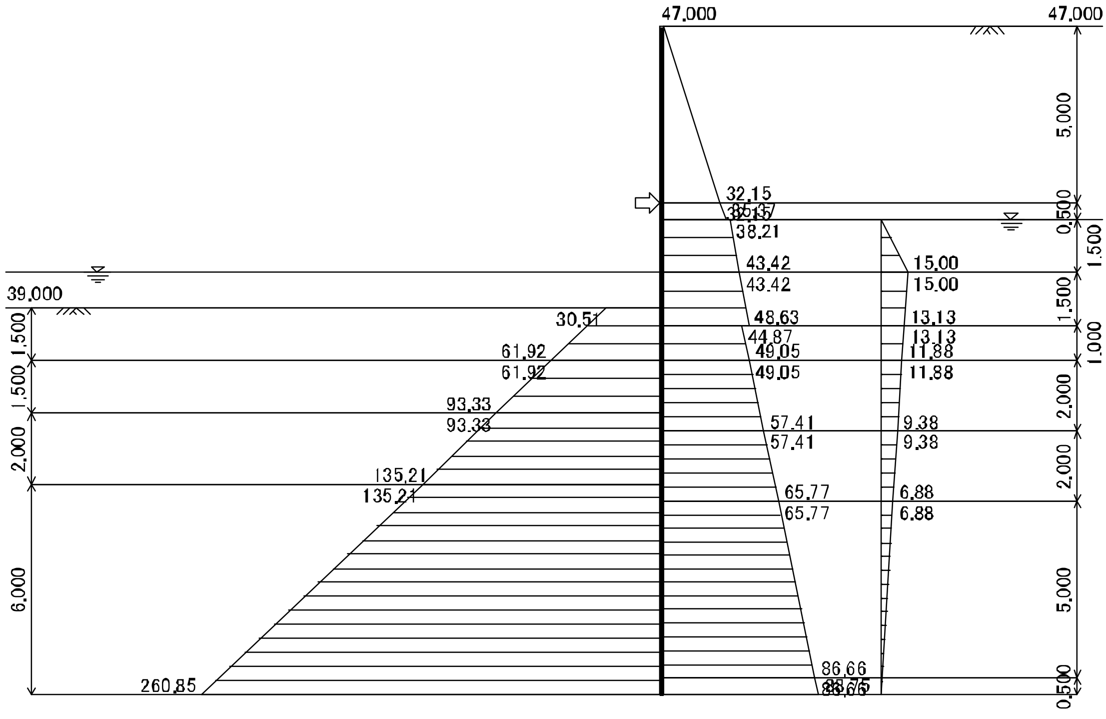
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	34.570	28.000
active sd	Ma+Mw+Mac(kN.m/m)	1605.93	7371.04
passive sd	Mp+Mpc(kN.m/m)	1928.06	15943.66
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.201>=1.20	2.163>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.500	0.500	32.15 35.37	16.88	0.254	4.29
2	41.500 40.000	1.500	38.21 43.42	61.22	1.266	77.50
3	40.000 38.500	1.500	43.42 48.63	69.04	2.764	190.82
4	38.500 37.500	1.000	44.87 49.05	46.96	4.007	188.20
5	37.500 35.500	2.000	49.05 57.41	106.46	5.526	588.34
6	35.500 33.500	2.000	57.41 65.77	123.18	7.523	926.63
7	33.500 28.500	5.000	65.77 86.66	381.08	11.114	4235.36
8	28.500 28.000	0.500	86.66 88.75	43.85	13.751	603.03
Sum				848.67		6814.17

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.500 40.000	1.500	0.00 15.00	11.25	1.500	16.88
2	40.000 38.500	1.500	15.00 13.13	21.09	2.733	57.66
3	38.500 37.500	1.000	13.13 11.88	12.50	3.992	49.90
4	37.500 35.500	2.000	11.88 9.38	21.25	5.461	116.04
5	35.500 33.500	2.000	9.38 6.88	16.25	7.449	121.04
6	33.500 28.000	5.500	6.88 0.00	18.91	10.333	195.36
Sum				101.25		556.88

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 37.500	1.500	30.51 61.92	69.32	3.835	265.83
2	37.500 36.000	1.500	61.92 93.33	116.43	5.301	617.17
3	36.000 34.000	2.000	93.33 135.21	228.54	7.061	1613.72
4	34.000 28.000	6.000	135.21 260.85	1188.18	11.317	13446.93
Sum				1602.47		15943.66

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

5.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-120.54	G.L. 42.000
max shear force Smax(kN/m)	132.03	G.L. 42.000
upper tension mbr rct R1(kN/m)	3.34	G.L. 46.000
lower tension mbr rct R2(kN/m)	212.32	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 42.000	0.00 32.15	0.00 0.00	- - - - - - - -	- - - - - - - -	0.00 32.15	- - - - - - - -
2	42.000 41.500	32.15 35.37	0.00 0.00	- - - - - - - -	- - - - - - - -	32.15 35.37	- - - - - - - -
3	41.500 40.000	38.21 43.42	0.00 15.00	- - - - - - - -	- - - - - - - -	38.21 58.42	- - - - - - - -
4	40.000 39.000	43.42 46.89	15.00 13.75	- - - - - - - -	- - - - - - - -	58.42 60.64	- - - - - - - -
5	39.000 38.500	46.89 48.63	13.75 13.13	30.51 40.98	0.00 2.60	60.64 59.16	30.51 38.38
6	38.500 37.500	44.87 49.05	13.13 11.88	40.98 61.92	2.60 7.79	55.40 53.13	38.38 54.12
7	37.500 36.000	49.05 55.32	11.88 10.00	61.92 93.33	7.79 15.59	53.13 49.73	54.12 77.74
8	36.000 35.500	55.32 57.41	10.00 9.38	93.33 103.80	15.59 18.19	49.73 48.60	77.74 85.61
9	35.500 34.000	57.41 63.68	9.38 7.50	103.80 135.21	18.19 25.98	48.60 45.20	85.61 109.23
10	34.000 33.500	63.68 65.77	7.50 6.88	135.21 145.68	25.98 28.58	45.20 44.06	109.23 117.10
11	33.500 28.500	65.77 86.66	6.88 0.63	145.68 250.38	28.58 54.56	44.06 32.72	117.10 195.82
12	28.500 28.000	86.66 88.75	0.63 0.00	250.38 260.85	54.56 57.16	32.72 31.59	195.82 203.69

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	39.000	37.500	1.500	16800	8073
2	37.500	36.000	1.500	16800	8073
3	36.000	34.000	2.000	16800	8073
4	34.000	27.000	7.000	19600	9419
5	27.000	22.000	5.000	92400	44404

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.*(2*number*A*E)}{(L*s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000] m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
wall section (filling soil). back and active side pressure are considered. no ground spring.

* passive elastic
in embedment section, displacement on excavation side is within limit displacement.
effective active side prss from back is considered. ground springs exist. no exv load.

* passive plastic
in embedment section, displacement on excavation side exceeds limit displacement.
effective active side prss from back is considered. no ground spring. exv load exists

* active elastic
in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	6818
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	19.29	3.86	--------	--------	--------	--------
17	43.800	On excavation plane	20.58	20.58	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	21.86	21.86	4.37	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
19	43.400	On excavation plane	23.15	23.15	4.63	--------	--------	--------	--------
20	43.200	On excavation plane	24.44	24.44	4.89	--------	--------	--------	--------
21	43.000	On excavation plane	25.72	25.72	5.14	--------	--------	--------	--------
22	42.800	On excavation plane	27.01	27.01	5.40	--------	--------	--------	--------
23	42.600	On excavation plane	28.29	28.29	5.66	--------	--------	--------	--------
24	42.400	On excavation plane	29.58	29.58	5.92	--------	--------	--------	--------
25	42.200	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
26	42.000	Tensile member	32.15	32.15	6.43	--------	--------	--------	122718
27	41.800	On excavation plane	33.44	33.44	6.69	--------	--------	--------	--------
28	41.600	On excavation plane	34.73	34.73	5.18	--------	--------	--------	--------
29	41.500	On excavation plane	35.37	38.21	3.69	--------	--------	--------	--------
30	41.400	On excavation plane	39.56	39.56	5.98	--------	--------	--------	--------
31	41.200	On excavation plane	42.25	42.25	8.45	--------	--------	--------	--------
32	41.000	On excavation plane	44.94	44.94	8.99	--------	--------	--------	--------
33	40.800	On excavation plane	47.64	47.64	9.53	--------	--------	--------	--------
34	40.600	On excavation plane	50.33	50.33	10.07	--------	--------	--------	--------
35	40.400	On excavation plane	53.03	53.03	10.61	--------	--------	--------	--------
36	40.200	On excavation plane	55.72	55.72	11.14	--------	--------	--------	--------
37	40.000	On excavation plane	58.42	58.42	11.63	--------	--------	--------	--------
38	39.800	On excavation plane	58.86	58.86	11.77	--------	--------	--------	--------
39	39.600	On excavation plane	59.31	59.31	11.86	--------	--------	--------	--------
40	39.400	On excavation plane	59.75	59.75	11.95	--------	--------	--------	--------
41	39.200	On excavation plane	60.20	60.20	12.04	--------	--------	--------	--------
42	39.000	Pa plas.	60.64	60.64	12.10	0.00	30.51	3.13	--------
43	38.800	Pa plas.	60.05	60.05	12.01	33.66	33.66	6.73	--------
44	38.600	Pa plas.	59.45	59.45	8.93	36.80	36.80	5.46	--------
45	38.500	Pa plas.	59.16	55.40	5.73	38.38	38.38	3.84	--------
46	38.400	Pa plas.	55.17	55.17	8.27	39.95	39.95	6.05	--------
47	38.200	Pa plas.	54.72	54.72	10.94	43.10	43.10	8.62	--------
48	38.000	Pa plas.	54.27	54.27	10.85	46.25	46.25	9.25	--------
49	37.800	Pa plas.	53.81	53.81	10.76	49.40	49.40	9.88	--------
50	37.600	Pa plas.	53.36	53.36	8.01	52.55	52.55	7.82	--------
51	37.500	Pa plas.	53.13	53.13	5.31	54.12	54.12	5.41	--------
52	37.400	Pa plas.	52.91	52.91	7.93	55.70	55.70	8.41	--------
53	37.200	Pa plas.	52.45	52.45	10.49	58.85	58.85	11.77	--------
54	37.000	Pa plas.	52.00	52.00	10.40	62.00	62.00	12.40	--------
55	36.800	Pa plas.	51.55	51.55	10.31	65.14	65.14	13.03	--------
56	36.600	Pas ela.	51.09	51.09	10.22	68.29	68.29	--------	1615
57	36.400	Pas ela.	50.64	50.64	10.13	71.44	71.44	--------	1615
58	36.200	Pas ela.	50.19	50.19	10.04	74.59	74.59	--------	1615
59	36.000	Pas ela.	49.73	49.73	9.95	77.74	77.74	--------	1615
60	35.800	Pas ela.	49.28	49.28	9.86	80.89	80.89	--------	1615
61	35.600	Pas ela.	48.82	48.82	7.33	84.04	84.04	--------	1211

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
62	35.500	Pas ela.	48.60	48.60	4.86	85.61	85.61	--------	807
63	35.400	Pas ela.	48.37	48.37	7.25	87.19	87.19	--------	1211
64	35.200	Pas ela.	47.92	47.92	9.58	90.33	90.33	--------	1615
65	35.000	Pas ela.	47.46	47.46	9.49	93.48	93.48	--------	1615
66	34.800	Pas ela.	47.01	47.01	9.40	96.63	96.63	--------	1615
67	34.600	Pas ela.	46.56	46.56	9.31	99.78	99.78	--------	1615
68	34.400	Pas ela.	46.10	46.10	9.22	102.93	102.93	--------	1615
69	34.200	Pas ela.	45.65	45.65	9.13	106.08	106.08	--------	1615
70	34.000	Pas ela.	45.20	45.20	9.04	109.23	109.23	--------	1749
71	33.800	Pas ela.	44.74	44.74	8.95	112.38	112.38	--------	1884
72	33.600	Pas ela.	44.29	44.29	6.65	115.52	115.52	--------	1413
73	33.500	Pas ela.	44.06	44.06	4.41	117.10	117.10	--------	942
74	33.400	Pas ela.	43.84	43.84	6.57	118.67	118.67	--------	1413
75	33.200	Pas ela.	43.38	43.38	8.68	121.82	121.82	--------	1884
76	33.000	Pas ela.	42.93	42.93	8.59	124.97	124.97	--------	1884
77	32.800	Pas ela.	42.48	42.48	8.50	128.12	128.12	--------	1884
78	32.600	Pas ela.	42.02	42.02	8.40	131.27	131.27	--------	1884
79	32.400	Pas ela.	41.57	41.57	8.31	134.42	134.42	--------	1884
80	32.200	Pas ela.	41.11	41.11	8.22	137.57	137.57	--------	1884
81	32.000	Pas ela.	40.66	40.66	8.13	140.71	140.71	--------	1884
82	31.800	Pas ela.	40.21	40.21	8.04	143.86	143.86	--------	1884
83	31.600	Pas ela.	39.75	39.75	7.95	147.01	147.01	--------	1884
84	31.400	Pas ela.	39.30	39.30	7.86	150.16	150.16	--------	1884
85	31.200	Pas ela.	38.85	38.85	7.77	153.31	153.31	--------	1884
86	31.000	Pas ela.	38.39	38.39	7.68	156.46	156.46	--------	1884
87	30.800	Pas ela.	37.94	37.94	7.59	159.61	159.61	--------	1884
88	30.600	Pas ela.	37.49	37.49	7.50	162.76	162.76	--------	1884
89	30.400	Pas ela.	37.03	37.03	7.41	165.91	165.91	--------	1884
90	30.200	Pas ela.	36.58	36.58	7.32	169.05	169.05	--------	1884
91	30.000	Pas ela.	36.13	36.13	7.23	172.20	172.20	--------	1884
92	29.800	Pas ela.	35.67	35.67	7.13	175.35	175.35	--------	1884
93	29.600	Pas ela.	35.22	35.22	7.04	178.50	178.50	--------	1884
94	29.400	Pas ela.	34.77	34.77	6.95	181.65	181.65	--------	1884
95	29.200	Pas ela.	34.31	34.31	6.86	184.80	184.80	--------	1884
96	29.000	Pas ela.	33.86	33.86	6.77	187.95	187.95	--------	1884
97	28.800	Pas ela.	33.40	33.40	6.68	191.10	191.10	--------	1884
98	28.600	Pas ela.	32.95	32.95	4.95	194.24	194.24	--------	1413
99	28.500	Pas ela.	32.72	32.72	3.27	195.82	195.82	--------	942
100	28.400	Pas ela.	32.50	32.50	4.87	197.39	197.39	--------	1413
101	28.200	Pas ela.	32.04	32.04	6.41	200.54	200.54	--------	1884
102	28.000	Pas ela.	31.59	0.00	3.17	203.69	0.00	--------	942
Sum					715.92			111.81	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= -9.41mm(G.L. 38.200m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-0.72	- - - -	- - - -
2	46.800	on exv	- - - -	-0.67	- - - -	- - - -
3	46.600	on exv	- - - -	-0.63	- - - -	- - - -
4	46.400	on exv	- - - -	-0.58	- - - -	- - - -
5	46.200	on exv	- - - -	-0.54	- - - -	- - - -
6	46.000	on exv	6818	-0.49	- - - -	Note: 3.34
7	45.800	on exv	- - - -	-0.45	- - - -	- - - -
8	45.600	on exv	- - - -	-0.40	- - - -	- - - -
9	45.400	on exv	- - - -	-0.36	- - - -	- - - -
10	45.200	on exv	- - - -	-0.32	- - - -	- - - -
11	45.000	on exv	- - - -	-0.28	- - - -	- - - -
12	44.800	on exv	- - - -	-0.25	- - - -	- - - -
13	44.600	on exv	- - - -	-0.22	- - - -	- - - -
14	44.400	on exv	- - - -	-0.19	- - - -	- - - -
15	44.200	on exv	- - - -	-0.18	- - - -	- - - -
16	44.000	on exv	- - - -	-0.18	- - - -	- - - -
17	43.800	on exv	- - - -	-0.19	- - - -	- - - -
18	43.600	on exv	- - - -	-0.22	- - - -	- - - -
19	43.400	on exv	- - - -	-0.27	- - - -	- - - -
20	43.200	on exv	- - - -	-0.35	- - - -	- - - -
21	43.000	on exv	- - - -	-0.46	- - - -	- - - -
22	42.800	on exv	- - - -	-0.61	- - - -	- - - -
23	42.600	on exv	- - - -	-0.80	- - - -	- - - -
24	42.400	on exv	- - - -	-1.05	- - - -	- - - -
25	42.200	on exv	- - - -	-1.36	- - - -	- - - -
26	42.000	on exv	122718	-1.73	- - - -	Note: 212.32
27	41.800	on exv	- - - -	-2.18	- - - -	- - - -
28	41.600	on exv	- - - -	-2.69	- - - -	- - - -
29	41.500	on exv	- - - -	-2.96	- - - -	- - - -
30	41.400	on exv	- - - -	-3.24	- - - -	- - - -
31	41.200	on exv	- - - -	-3.83	- - - -	- - - -
32	41.000	on exv	- - - -	-4.43	- - - -	- - - -
33	40.800	on exv	- - - -	-5.03	- - - -	- - - -
34	40.600	on exv	- - - -	-5.62	- - - -	- - - -
35	40.400	on exv	- - - -	-6.19	- - - -	- - - -
36	40.200	on exv	- - - -	-6.74	- - - -	- - - -
37	40.000	on exv	- - - -	-7.24	- - - -	- - - -
38	39.800	on exv	- - - -	-7.70	- - - -	- - - -
39	39.600	on exv	- - - -	-8.10	- - - -	- - - -
40	39.400	on exv	- - - -	-8.45	- - - -	- - - -
41	39.200	on exv	- - - -	-8.75	- - - -	- - - -
42	39.000	pssv pl	- - - -	-8.99	3.88	- - - -
43	38.800	pssv pl	- - - -	-9.17	4.17	- - - -
44	38.600	pssv pl	- - - -	-9.30	4.51	- - - -
45	38.500	pssv pl	- - - -	-9.35	4.75	- - - -
46	38.400	pssv pl	- - - -	-9.38	5.00	- - - -
47	38.200	pssv pl	- - - -	-9.41	5.34	- - - -
48	38.000	pssv pl	- - - -	-9.40	5.73	- - - -
49	37.800	pssv pl	- - - -	-9.35	6.12	- - - -
50	37.600	pssv pl	- - - -	-9.26	6.46	- - - -
51	37.500	pssv pl	- - - -	-9.20	6.70	- - - -
52	37.400	pssv pl	- - - -	-9.14	6.95	- - - -
53	37.200	pssv pl	- - - -	-8.99	7.29	- - - -
54	37.000	pssv pl	- - - -	-8.83	7.68	- - - -
55	36.800	pssv pl	- - - -	-8.64	8.07	- - - -
56	36.600	pssv el	1615	-8.44	8.46	13.63
57	36.400	pssv el	1615	-8.23	8.85	13.29
58	36.200	pssv el	1615	-8.01	9.24	12.94
59	36.000	pssv el	1615	-7.79	9.63	12.58
60	35.800	pssv el	1615	-7.57	10.02	12.22
61	35.600	pssv el	1211	-7.34	10.36	8.89
62	35.500	pssv el	807	-7.23	10.60	5.84
63	35.400	pssv el	1211	-7.12	10.85	8.62
64	35.200	pssv el	1615	-6.90	11.19	11.14
65	35.000	pssv el	1615	-6.68	11.58	10.79
66	34.800	pssv el	1615	-6.47	11.97	10.45
67	34.600	pssv el	1615	-6.27	12.36	10.12
68	34.400	pssv el	1615	-6.07	12.75	9.81
69	34.200	pssv el	1615	-5.88	13.14	9.50
70	34.000	pssv el	1749	-5.70	12.49	9.98
71	33.800	pssv el	1884	-5.53	11.93	10.42
72	33.600	pssv el	1413	-5.37	12.22	7.58
73	33.500	pssv el	942	-5.29	12.43	4.98
74	33.400	pssv el	1413	-5.21	12.64	7.37
75	33.200	pssv el	1884	-5.07	12.93	9.55
76	33.000	pssv el	1884	-4.93	13.27	9.29
77	32.800	pssv el	1884	-4.81	13.60	9.05
78	32.600	pssv el	1884	-4.69	13.94	8.83
79	32.400	pssv el	1884	-4.58	14.27	8.62
80	32.200	pssv el	1884	-4.47	14.61	8.43
81	32.000	pssv el	1884	-4.38	14.94	8.25
82	31.800	pssv el	1884	-4.29	15.27	8.08
83	31.600	pssv el	1884	-4.20	15.61	7.92

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
84	31.400	pssv el	1884	-4.13	15.94	7.77
85	31.200	pssv el	1884	-4.05	16.28	7.64
86	31.000	pssv el	1884	-3.99	16.61	7.51
87	30.800	pssv el	1884	-3.92	16.95	7.39
88	30.600	pssv el	1884	-3.86	17.28	7.27
89	30.400	pssv el	1884	-3.80	17.61	7.16
90	30.200	pssv el	1884	-3.75	17.95	7.06
91	30.000	pssv el	1884	-3.69	18.28	6.96
92	29.800	pssv el	1884	-3.64	18.62	6.86
93	29.600	pssv el	1884	-3.59	18.95	6.77
94	29.400	pssv el	1884	-3.54	19.29	6.68
95	29.200	pssv el	1884	-3.50	19.62	6.59
96	29.000	pssv el	1884	-3.45	19.95	6.50
97	28.800	pssv el	1884	-3.40	20.29	6.41
98	28.600	pssv el	1413	-3.36	20.58	4.74
99	28.500	pssv el	942	-3.33	20.79	3.14
100	28.400	pssv el	1413	-3.31	21.00	4.67
101	28.200	pssv el	1884	-3.26	21.29	6.15
102	28.000	pssv el	942	-3.22	21.54	3.03
Sum						604.11

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -120.54kN m/m(G.L. 42.000m)
max shear force Smax= 132.03kN/m (G.L. 42.000m)
max displacement Del.xmax= -9.41mm (G.L. 38.200m)

node No	Y co GL(m)	moment kN.m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-0.03	-0.72	------------
2	46.800	-0.01	-0.01	-0.03	-0.29	-0.67	------------
3	46.600	-0.06	-0.06	-0.29	-0.80	-0.63	------------
4	46.400	-0.23	-0.23	-0.80	-1.58	-0.58	------------
5	46.200	-0.54	-0.54	-1.58	-2.60	-0.54	------------
6	46.000	-1.06	-1.06	-2.60	-0.55	-0.49	* 3.34
7	45.800	-1.17	-1.17	-0.55	-2.09	-0.45	------------
8	45.600	-1.59	-1.59	-2.09	-3.89	-0.40	------------
9	45.400	-2.37	-2.37	-3.89	-5.95	-0.36	------------
10	45.200	-3.56	-3.56	-5.95	-8.26	-0.32	------------
11	45.000	-5.21	-5.21	-8.26	-10.84	-0.28	------------
12	44.800	-7.38	-7.38	-10.84	-13.67	-0.25	------------
13	44.600	-10.11	-10.11	-13.67	-16.75	-0.22	------------
14	44.400	-13.46	-13.46	-16.75	-20.10	-0.19	------------
15	44.200	-17.48	-17.48	-20.10	-23.70	-0.18	------------
16	44.000	-22.22	-22.22	-23.70	-27.56	-0.18	------------
17	43.800	-27.73	-27.73	-27.56	-31.67	-0.19	------------
18	43.600	-34.06	-34.06	-31.67	-36.04	-0.22	------------
19	43.400	-41.27	-41.27	-36.04	-40.67	-0.27	------------
20	43.200	-49.41	-49.41	-40.67	-45.56	-0.35	------------
21	43.000	-58.52	-58.52	-45.56	-50.71	-0.46	------------
22	42.800	-68.66	-68.66	-50.71	-56.11	-0.61	------------
23	42.600	-79.88	-79.88	-56.11	-61.77	-0.80	------------
24	42.400	-92.23	-92.23	-61.77	-67.68	-1.05	------------
25	42.200	-105.77	-105.77	-67.68	-73.86	-1.36	------------
26	42.000	-120.54	-120.54	-73.86	132.03	-1.73	* 212.32
27	41.800	-94.14	-94.14	132.03	125.34	-2.18	------------
28	41.600	-69.07	-69.07	125.34	120.16	-2.69	------------
29	41.500	-57.05	-57.05	120.16	116.47	-2.96	------------
30	41.400	-45.41	-45.41	116.47	110.49	-3.24	------------
31	41.200	-23.31	-23.31	110.49	102.04	-3.83	------------
32	41.000	-2.90	-2.90	102.04	93.05	-4.43	------------
33	40.800	15.71	15.71	93.05	83.52	-5.03	------------
34	40.600	32.41	32.41	83.52	73.45	-5.62	------------
35	40.400	47.10	47.10	73.45	62.85	-6.19	------------
36	40.200	59.67	59.67	62.85	51.70	-6.74	------------
37	40.000	70.01	70.01	51.70	40.07	-7.24	------------
38	39.800	78.03	78.03	40.07	28.30	-7.70	------------
39	39.600	83.69	83.69	28.30	16.44	-8.10	------------
40	39.400	86.97	86.97	16.44	4.49	-8.45	------------
41	39.200	87.87	87.87	4.49	-7.55	-8.75	------------
42	39.000	86.36	86.36	-7.55	-16.52	-8.99	------------
43	38.800	83.06	83.06	-16.52	-21.80	-9.17	------------
44	38.600	78.70	78.70	-21.80	-25.27	-9.30	------------
45	38.500	76.17	76.17	-25.27	-27.16	-9.35	------------
46	38.400	73.45	73.45	-27.16	-29.38	-9.38	------------
47	38.200	67.58	67.58	-29.38	-31.70	-9.41	------------
48	38.000	61.24	61.24	-31.70	-33.30	-9.40	------------
49	37.800	54.58	54.58	-33.30	-34.19	-9.35	------------

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
50	37.600	47.74	47.74	-34.19	-34.37	-9.26	------------
51	37.500	44.30	44.30	-34.37	-34.28	-9.20	------------
52	37.400	40.88	40.88	-34.28	-33.79	-9.14	------------
53	37.200	34.12	34.12	-33.79	-32.51	-8.99	------------
54	37.000	27.62	27.62	-32.51	-30.51	-8.83	------------
55	36.800	21.51	21.51	-30.51	-27.79	-8.64	------------
56	36.600	15.95	15.95	-27.79	-24.38	-8.44	13.63
57	36.400	11.08	11.08	-24.38	-21.22	-8.23	13.29
58	36.200	6.83	6.83	-21.22	-18.32	-8.01	12.94
59	36.000	3.17	3.17	-18.32	-15.69	-7.79	12.58
60	35.800	0.03	0.03	-15.69	-13.33	-7.57	12.22
61	35.600	-2.63	-2.63	-13.33	-11.77	-7.34	8.89
62	35.500	-3.81	-3.81	-11.77	-10.79	-7.23	5.84
63	35.400	-4.89	-4.89	-10.79	-9.42	-7.12	8.62
64	35.200	-6.77	-6.77	-9.42	-7.87	-6.90	11.14
65	35.000	-8.35	-8.35	-7.87	-6.57	-6.68	10.79
66	34.800	-9.66	-9.66	-6.57	-5.52	-6.47	10.45
67	34.600	-10.76	-10.76	-5.52	-4.70	-6.27	10.12
68	34.400	-11.70	-11.70	-4.70	-4.12	-6.07	9.81
69	34.200	-12.53	-12.53	-4.12	-3.75	-5.88	9.50
70	34.000	-13.28	-13.28	-3.75	-2.81	-5.70	9.98
71	33.800	-13.84	-13.84	-2.81	-1.34	-5.53	10.42
72	33.600	-14.11	-14.11	-1.34	-0.41	-5.37	7.58
73	33.500	-14.15	-14.15	-0.41	0.17	-5.29	4.98
74	33.400	-14.13	-14.13	0.17	0.97	-5.21	7.37
75	33.200	-13.94	-13.94	0.97	1.84	-5.07	9.55
76	33.000	-13.57	-13.57	1.84	2.55	-4.93	9.29
77	32.800	-13.06	-13.06	2.55	3.11	-4.81	9.05
78	32.600	-12.44	-12.44	3.11	3.53	-4.69	8.83
79	32.400	-11.73	-11.73	3.53	3.84	-4.58	8.62
80	32.200	-10.96	-10.96	3.84	4.04	-4.47	8.43
81	32.000	-10.16	-10.16	4.04	4.16	-4.38	8.25
82	31.800	-9.32	-9.32	4.16	4.19	-4.29	8.08
83	31.600	-8.49	-8.49	4.19	4.16	-4.20	7.92
84	31.400	-7.65	-7.65	4.16	4.08	-4.13	7.77
85	31.200	-6.84	-6.84	4.08	3.95	-4.05	7.64
86	31.000	-6.05	-6.05	3.95	3.78	-3.99	7.51
87	30.800	-5.29	-5.29	3.78	3.58	-3.92	7.39
88	30.600	-4.58	-4.58	3.58	3.35	-3.86	7.27
89	30.400	-3.91	-3.91	3.35	3.11	-3.80	7.16
90	30.200	-3.28	-3.28	3.11	2.85	-3.75	7.06
91	30.000	-2.71	-2.71	2.85	2.59	-3.69	6.96
92	29.800	-2.20	-2.20	2.59	2.32	-3.64	6.86
93	29.600	-1.73	-1.73	2.32	2.04	-3.59	6.77
94	29.400	-1.32	-1.32	2.04	1.77	-3.54	6.68
95	29.200	-0.97	-0.97	1.77	1.49	-3.50	6.59
96	29.000	-0.67	-0.67	1.49	1.21	-3.45	6.50
97	28.800	-0.43	-0.43	1.21	0.94	-3.40	6.41
98	28.600	-0.24	-0.24	0.94	0.73	-3.36	4.74
99	28.500	-0.17	-0.17	0.73	0.60	-3.33	3.14
100	28.400	-0.11	-0.11	0.60	0.40	-3.31	4.67
101	28.200	-0.03	-0.03	0.40	0.14	-3.26	6.15
102	28.000	0.00	----------	0.14	----------	-3.22	3.03

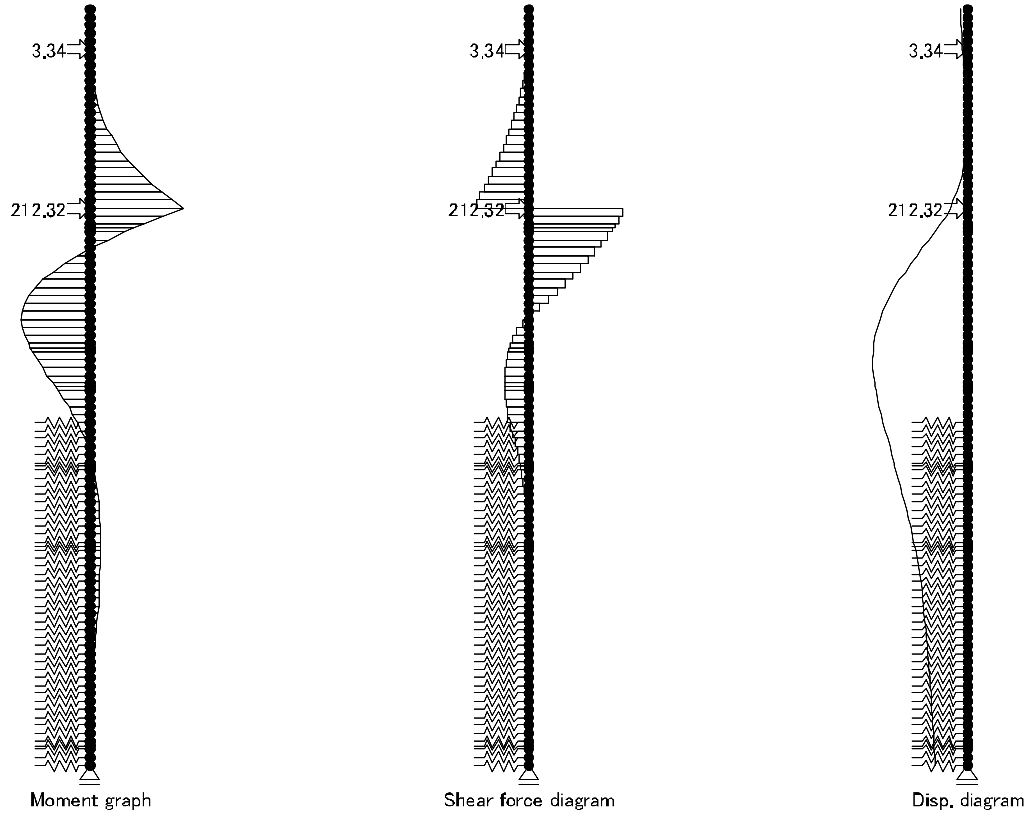
Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -120.54kN m/m(G.L. 42.000m)

max shear force Smax= 132.03kN m (G.L. 42.000m)

max displacement Del.xmax= -9.41mm (G.L. 38.200m)



* in figure, number in arrow shows tensile reaction (kN/m)

5.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	120.54	0.00	132.03

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	67	324	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	6	150	OK

5.4.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,'£-í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
3.34	3.600	12.04

3) stress

$$Sig. = \frac{P * 10^3}{n * A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
25	264	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,'£-í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
212.32	1.800	382.17

3) stress

$$Sig. = \frac{P * 10^3}{n * A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
87	264	OK

5.4.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$$M= \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
12.04	3.600	4.33

3)stress

$$Sig.= \frac{M*10^6}{Z*10^3} \quad <=Sig.a$$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
10	210	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M= \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
382.17	1.800	68.79

3)stress

$$Sig.= \frac{M*10^6}{Z*10^3} \quad <=Sig.a$$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
73	210	OK

6 Calculation on impermeability

(1)check method

impermeability effect (seepage pass) is checked through two passes.

water level condition is ordinary case for stability (and landside sheet pile as well).

1)seepage pass part 1 (along sheet pile)

$$F1 = \frac{L1}{h1} >= FS$$

2)seepage pass part 2(pass through excavation bottom in land side: omit if no shape)

$$F2 = \frac{L2}{h2} >= FS$$

where,

FS: required factor of safety(Sandy foundation: 3.25)

Fi: factor of safety

L1: seepage pass part 1(along sheet pile)

h1: water level difference part 1(from ordinal H.W.L. to landside ground surface)

L2: seepage pass part 2(pass through landside excavation bottom)

h2: water level difference part 2(from ordinal H.W.L. to landside ground surface)

(2)calculation result summery

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
nomal time	29.000	8.000	3.63>=3.25

(3)seepage pass part 1(along sheet pile)

L1= D1+ Lb+ D2

where,

D1: sheet pile embedment length on riverside(m)

D2: sheet pile embedment length on landside(m)

Lb: distance between sheet piles(m)

$Lb = Sqrt(B^2 + Del.L^2)$

B : embankment width (8.000m)

Del.L: difference of sheet pile between riverside and landside(0.000m)

L1= 11.000+ 8.000+ 10.000

= 29.000(m)

(4)seepage pass part 2(pass through landside excavation bottom)

Because of no excavation shape, omit calculation.

Cover

(2) Ibrahimia Canal

Contents

1 Design condition

File name:Ibrahimia 42,355

1.1 Properties

(1)wall scale

final wall width : 8.000(m)
length of landside final sheet pile : 19.000(m)
length of riverside final sheet pile : 19.000(m)

(2)basic data

title : Ibrahimia 1
comment :
wall type : Steel sheet pile
influence of water level : Yes consider
water unit weight Gamw : 10.00(kN/m3)
check earthquake case : Yes
check liquefaction case : No
check riverside sheet pile : Yes
tensile member installation position

No	position G.L.(m)
1	46.000
2	42.000

1.2 shape

(1)plane

wall extension

wall No	inter wl len.(m)	angle (deg)	object wall
1	46.400	----.---	
2	88.600	90.000	
3	63.600	125.000	OK

wall direction: Hor.

(2)side

top of filling soil : G.L. 47.000(m)
top of landside sheet pile : G.L. 47.000(m)
top of riverside sheet pile : G.L. 47.000(m)

(3)tensile member planar layout

tensile member adjusting installation method : Equally layout

wall 1

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	3.600	3.000	3	3.00	3
2	1.800	3.000	3	3.00	3

wall 2

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	3.600	3.000	3	3.00	3
2	1.800	3.000	3	3.00	3

wall 3

row	standard pitch (m)	start side adjust LS (m)	start side adjust number	end side adjust LE (m)	end side adjust number
1	1.800	3.000	3	3.00	3
2	1.800	3.000	3	3.00	3

1.3 Method

(1) check points

Check 4* C > Sum(Gam h) : No check
Check shielding effect : check sand ground
Check discharge : No
Check circle slope : No
Check, change of bearing capacity : No

(2) design method

shear deformation failure check points
search the position of min FS : No
ditto searching pitch : 1.00(m)
calculation of self-weight : Conforming design manual
consider external force above tensile member with the limit equivalent method : No consider
elasto-plastic analysis and calculation condition member force in liquefaction
coefficient of allowance when tensile member spring is calculated Alp. : 1.0
equivalent loading width for calculation BH : 10.0m
deformation coefficient in earthquake : 2.00 of ordinary time (input)
wall tip bearing condition : Free
calculation pitch : 0.20(m)
check elastic zone in elasto-plastic calculation : No
required elastic zone rate as above : 50.0%
design of residual water level
residual water level setting(riverside water level - landside water level)* ratio: 0.500

1.4 Strata data

(1) soil character of filling soil

filled soil	soil unit weight			inter fric angle	cohesion	
	wet kN/m3	submrg kN/m3	satur. kN/m3	(deg)	Co kN/m2	increment k kN/m3
Sandy soil	18.0	9.0	19.0	30.0	0.0	0.0

(2) River side section(current ground level G.L. 39.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m³		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	5.0	18.0	9.0	19.0	20.0	10.0	0.0	14000
2	5.000	Sandy	15.0	18.0	9.0	19.0	25.0	10.0	0.0	42000
3	4.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
4	8.000	Sandy	38.0	18.0	9.0	19.0	25.0	10.0	0.0	106400

(3) Embankment body section(current ground level G.L. 38.500m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m²		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	5.0	18.0	9.0	19.0	20.0	10.0	0.0	14000
2	5.000	Sandy	15.0	18.0	9.0	19.0	25.0	10.0	0.0	42000
3	4.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
4	8.000	Sandy	38.0	18.0	9.0	19.0	25.0	10.0	0.0	106400

(4) Land side section(current ground level G.L. 38.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m³		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	5.0	18.0	9.0	19.0	20.0	10.0	0.0	14000
2	5.000	Sandy	15.0	18.0	9.0	19.0	25.0	10.0	0.0	42000
3	4.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
4	8.000	Sandy	38.0	18.0	9.0	19.0	25.0	10.0	0.0	106400

1.5 members

(1) wall data

effective rate of sheet pile

moment of inertia (stress deformation calculation) : 0.45

modulus of section : 0.60

landside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

riverside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

(2) tensile member, wailing data

tensile member

No	position G.L.(m)	tns mbr spring tns	tns mbr H-pitch m	tns mbr dia mm	tns mbr mat	tns mbr number	tns mbr direct iput	tns spring sprg cost. kN/m/m	wailing material
1	46.000	Use	3.600	25.0	7	1	No	----------	SS400
2	42.000	Use	1.800	75.0	7	1	No	----------	SS400

waling member

wailing member : H-steel

wailing check equation : TL/10

1.5 Study case data

(1) check case [deal Normal time]

check case name : ıžž

internal setting

e-prss	soil spring	allowable
Normal time	Normal time	Normal time

water level condition

* stability calculation and check of landside sheet pile

riverside water level : G.L. 46.000(m)

landside water level : G.L. 37.500(m)

* check of riverside sheet pile

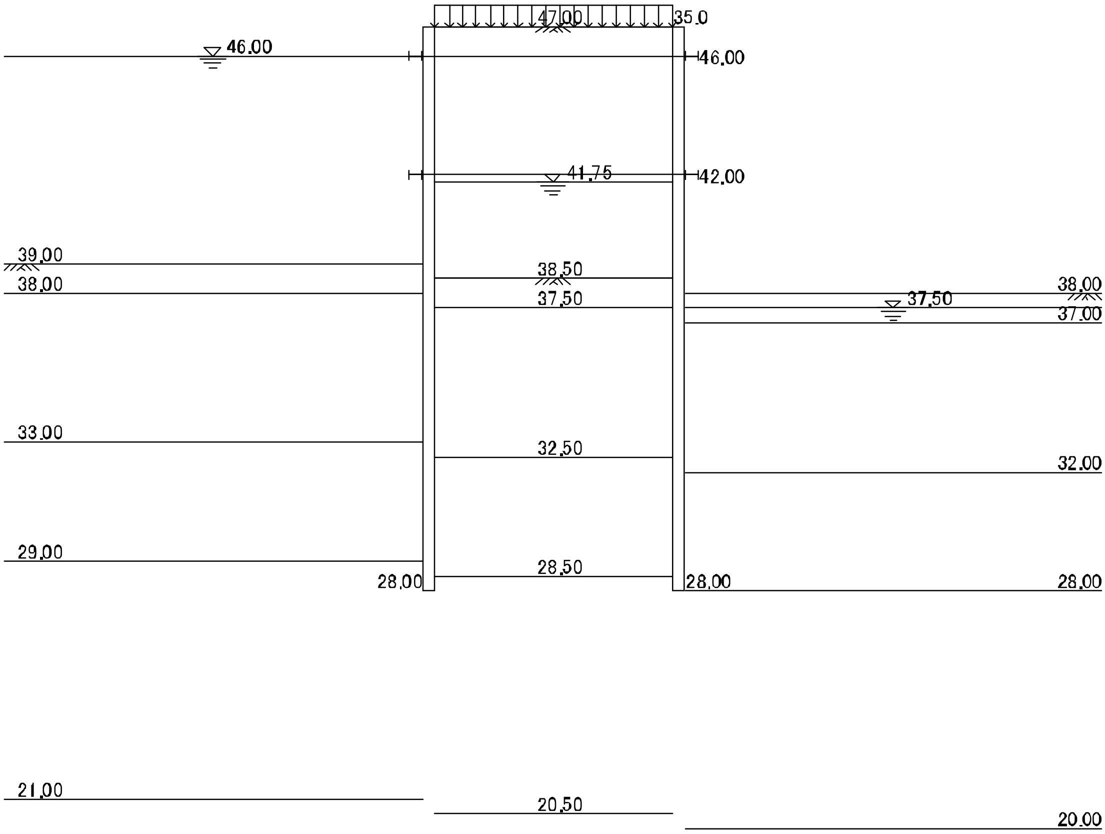
wall residual water level : G.L. 41.500(m)

riverside water level : G.L. 39.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	35.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



(2)check case [deal Earthquake time]
check case name : ′n kŽž
internal setting

e-prss	soil spring	allowable
Earthquake time	Earthquake time	Earthquake time

design seismicity
* design seismicity : 0.04
* seismic assumption : River standard method
resistant moment above shear deformation check level : Normal time
water level condition
* stability calculation and check of landside sheet pile
riverside water level : G.L. 40.000(m)
landside water level : G.L. 37.500(m)
* check of riverside sheet pile
wall residual water level : G.L. 41.750(m)
riverside water level : G.L. 40.000(m)

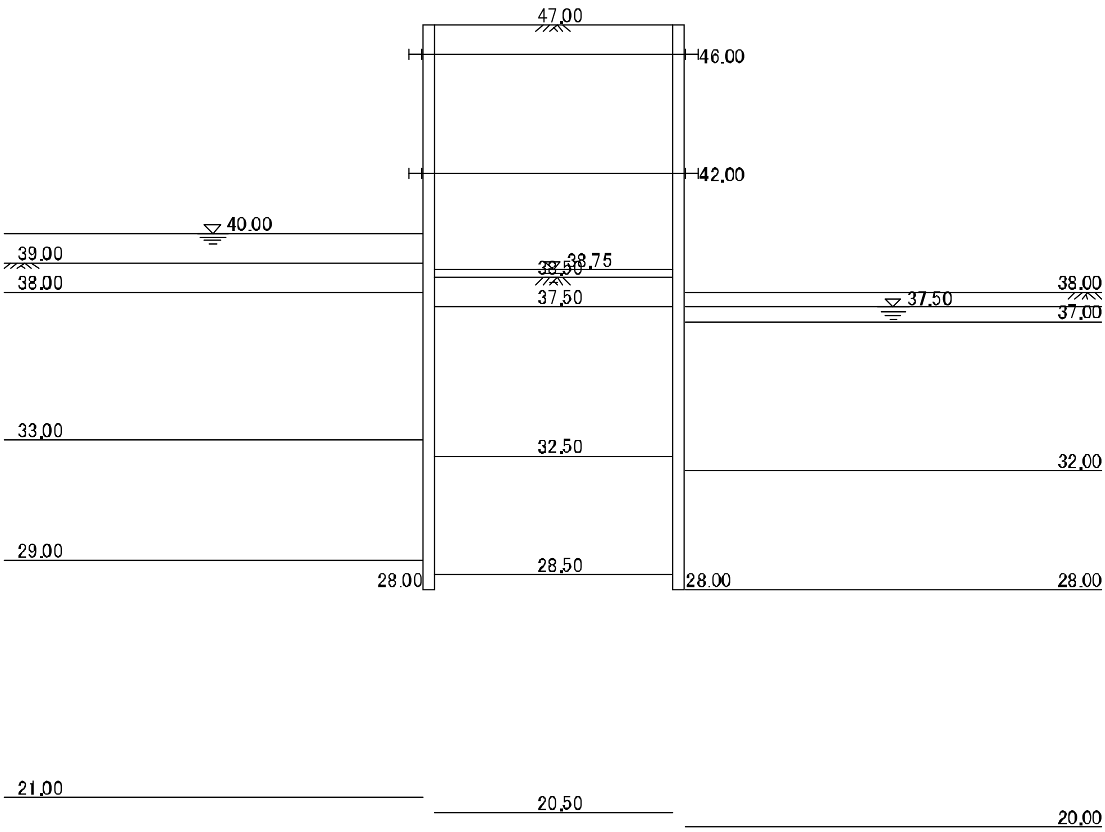
surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)

riverside sheet pile

* vertical force (stress calculation) : 0.00(kN m)



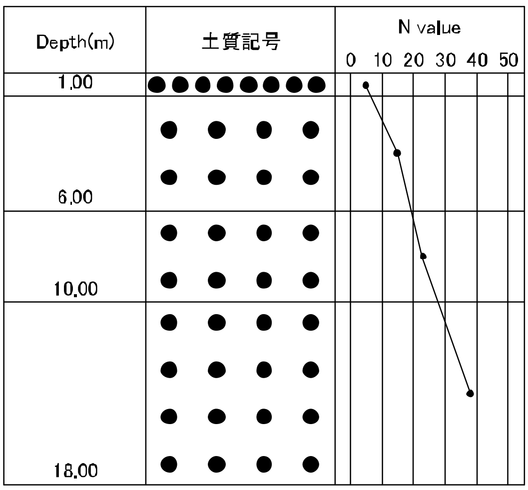
1.7 circular failure

Not calculate circular failure

1.8 discharge data

not check discharge

1.9 Drillhole log



1. 10 Steel data

steel sheet pile

No	steel name	w (mm)	h (mm)	W (kg/m2)	A (cm2/m)	I (cm4/m)	Z (cm3/m)
1	IIŒ^	400	100	48.0	153.00	8740	874
2	IIIŒ^	400	125	60.0	191.00	16800	1340
3	IIIŒ^	400	130	60.0	191.00	17400	1340
4	IVŒ^	400	170	76.1	242.50	38600	2270
5	VLŒ^	500	200	105.0	267.60	63000	3150
6	PU28+1	600	228	106.2	226.00	68380	3000

Wailing(H steel)

No	steel name	h (mm)	B (mm)	,"w (mm)	,",l (mm)	A (m2)	w (kg/m)	Zx (cm3)
1	H｜100 ~100 ~ 6 ~ 8	100	100	6.0	8	21.59	16.9	76
2	H｜125 ~125 ~ 6 ~ 9	125	125	6.5	9	30.00	23.6	134
3	H｜150 ~150 ~ 7 ~10	150	150	7.0	10	39.65	31.1	216
4	H｜175 ~175 ~ 7 ~11	175	175	7.5	11	51.42	40.4	331
5	H｜200 ~200 ~ 8 ~12	200	200	8.0	12	63.53	49.9	472
6	H｜250 ~250 ~ 9 ~14	250	250	9.0	14	91.43	71.8	860
7	H｜300 ~300 ~10 ~15	300	300	10.0	15	118.40	93.0	1350
8	H｜350 ~350 ~12 ~19	350	350	12.0	19	171.90	135.0	2280
9	H｜400 ~400 ~13 ~21	400	400	13.0	21	218.70	172.0	3330
10	H｜400 ~400 ~18 ~28	414	405	18.0	28	295.40	232.0	4480
11	H｜400 ~400 ~20 ~35	428	407	20.0	35	360.70	283.0	5570
12	H｜400 ~400 ~30 ~50	458	417	30.0	50	528.60	415.0	8170
13	H｜400 ~400 ~45 ~70	498	432	45.0	70	770.10	605.0	12000
14	H｜150 ~100 ~ 6 ~ 9	148	100	6.0	9	26.35	20.7	135
15	H｜200 ~150 ~ 6 ~ 9	194	150	6.0	9	38.11	29.9	271
16	H｜250 ~175 ~ 7 ~11	244	175	7.0	11	55.49	43.6	495
17	H｜300 ~200 ~ 8 ~12	294	200	8.0	12	71.05	55.8	756
18	H｜350 ~250 ~ 9 ~14	340	250	9.0	14	99.53	78.1	1250
19	H｜400 ~300 ~10 ~16	390	300	10.0	16	133.20	105.0	1940
20	H｜450 ~300 ~11 ~18	440	300	11.0	18	153.90	121.0	2490
21	H｜500 ~300 ~11 ~18	488	300	11.0	18	159.20	125.0	2820
22	H｜600 ~300 ~12 ~20	588	300	12.0	20	187.20	147.0	3890
23	H｜700 ~300 ~13 ~24	700	300	13.0	24	231.50	182.0	5640
24	H｜800 ~300 ~14 ~26	800	300	14.0	26	263.50	207.0	7160
25	H｜900 ~300 ~15 ~23	890	299	15.0	23	266.90	210.0	7610
26	H｜900 ~300 ~16 ~28	900	300	16.0	28	305.80	240.0	8990
27	H｜150 ~ 75 ~ 5 ~ 7	150	75	5.0	7	17.85	14.0	89
28	H｜175 ~ 90 ~ 5 ~ 8	175	90	5.0	8	22.90	18.0	138
29	H｜200 ~100 ~ 5 ~ 8	200	100	5.5	8	26.67	20.9	181
30	H｜250 ~125 ~ 6 ~ 9	250	125	6.0	9	36.97	29.0	317
31	H｜300 ~150 ~ 6 ~ 9	300	150	6.5	9	46.78	36.7	481
32	H｜350 ~175 ~ 7 ~11	350	175	7.0	11	62.91	49.4	771
33	H｜400 ~200 ~ 8 ~13	400	200	8.0	13	83.37	65.4	1170
34	H｜450 ~200 ~ 9 ~14	450	200	9.0	14	95.43	74.9	1460
35	H｜500 ~200 ~10 ~16	500	200	10.0	16	112.20	88.2	1870
36	H｜600 ~200 ~11 ~17	600	200	11.0	17	131.70	103.0	2520
37	H｜200 ~200 ~ 8 ~12 E	200	200	8.0	12	51.53	55.0	366
38	H｜250 ~250 ~ 9 ~14 E	250	250	9.0	14	78.18	80.0	708
39	H｜300 ~300 ~10 ~15 E	300	300	10.0	15	104.80	100.0	1150
40	H｜350 ~350 ~12 ~19 E	350	350	12.0	19	154.90	150.0	2000
41	H｜400 ~400 ~13 ~21 E	400	400	13.0	21	197.70	200.0	2950

Note: Use one set of two sheets for stress check, and doubly consider in process.

1.11 material data

steel sheet pile material

Young's modulus : $2.00*10^5$ N/mm2

unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SY295		SY390	
	normal	earthq.	normal	earthq.
allw bending str	216	324	235	353
allw shear str	99	150	110	165

Material of steel pipe pile

Young's modulus : $2.00*10^5$ N/mm2

Unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SKY400		SY490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	278
allw shear str	80	120	106	160

material of wailing member

Young's modulus : $2.00*10^5$ N/mm2

allowable stress (unit: N/mm2)	SS400		SM490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	280

material of tensile member

Young's modulus : $2.00*10^5$ N/mm2

No	type	allw M stress (unit: N/mm2)	
		normal	earthq.
1	SS400 i ≦40mm j	94	141
2	SS400 i „40mm j	86	129
3	SS490 i ≦40mm j	110	165
4	SS490 i „40mm j	102	153
5	,'£–Í |490	125	195
6	,'£–Í |590	155	235
7	,'£–Í |690	176	264

1.12 standard value

(1)factor of safety

check items	requrie FS	
	normal	earthq.
check shear deform failure check slide check bear cap of found grnd check circular slope	1.20 1.20 1.20 1.20	1.00 1.00 1.00 1.00
chk embedment (sand grnd) chk embedment (clay grnd)	1.50 1.20	1.20 1.20
chk shielding (sand grnd) chk shielding (clay grnd)	3.25 3.00	------ ------

(2)design method for liquefaction

1)seismicity for evaluating liquefaction

region	strong	middle	weak
earthq.	0.18	0.15	0.12

2)soil layer classification according to FL

FL range	class
<= 1.00 1.00<= and <=1.30 >= 1.30	liquefied semi-liquefied non-liquefied

3)classification

internally fixed

classifi-cation	increment vibration	active passive
liquefied semi-liq non-liq	consider not not	not not ordinary

4)minimum embedment length to non-liquefied layer at tip: 1.000(m)

5)evaluation method of embedment length : suppose both front and back side of wall satisfied

2 Abbreviation Table

No	Abbreviation	Standard nomenclature
1	actv	active
2	agl	angle
3	bear cap. fac	bearing capacity factor
4	bf	before
5	bt	between
6	cntrt	concentrated
7	co. coord.	coordinate
8	coeff	coefficient
9	coh	cohesion, cohesive
10	comb	combination
11	coord	coordinate
12	crs area	cross section area
13	cs	case
14	dfr	deformation
15	dia	diameter
16	earthq.	earthquake
17	ecc	eccentricity
18	effsrchg	effective surcharge
19	el	elastic
20	embd L	embedment length
21	e-prss	earth pressure
22	exv	excavation
23	frc	force
24	freq compo	frequency component
25	fric	friction
26	Fs	safety factor
27	H	horizontal
28	inc	increment
29	inrt	inertia force
30	inter	internal, inner
31	ld	load
32	LEM	limit equilibrium method
33	liq	liquefaction
34	lv	level
35	ly	layer
36	lyr thck	layer thickness
37	mat	material
38	max	maximum
39	mbr	member
40	min	minimum
41	mt	moment
42	mthd	method
43	nd	node

FORUM8

No	Abbreviation	Standard nomenclature
44	non-liq	non-liquefaction
45	num	number
46	pl	plastic
47	prss	pressure
48	pssv	passive
49	rct	reaction (force)
50	rdc fcr	reduction factor
51	relstiff	relative stiffness
52	rfrm	reinforcement force, deterrent force
53	rsd	residual
54	rslt frc	resultant force
55	rsst	resistance
56	satur	saturation
57	sd	side
58	semi-liq	semi-liquefaction
59	stbl	stability
60	stffns	stiffness, deformation modulus(coeff.)
61	stnd	standard
62	str	stress
63	submrg	submerge, under water
64	Sum	summation
65	tns	tension, tensile
66	w/	with consideration
67	wl	wall
68	wt	weight
69	WT	water, water line, water level
70	wtr prss	water pressure

3 Result table

3.1 table of stability calculation result

Results of wall width B= 8.000(m), L of sheet pile landside LR= 19.000(m), riverside LL= 19.000(m)

(1)check result on shear deformation failure

*)check case: íŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m m/m)	rsst moment Mr(kN.m m/m)	Factor of safety F
Embedment tip	28.000	10.500	2175.30	7645.46	3.51 >= 1.20
Layer boundary surface	28.500	10.000	2378.84	7379.74	3.10 >= 1.20
Layer boundary surface	32.500	6.000	2603.46	5678.08	2.18 >= 1.20
Layer boundary surface	37.500	1.000	1019.21	3439.27	3.37 >= 1.20
Current ground level	38.500	0.000	703.13	2983.06	4.24 >= 1.20

*)check case: 'n kŽ%

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m m/m)	rsst moment Mr(kN.m m/m)	Factor of safety F
Embedment tip	28.000	10.500	0.00	7403.66	999.99 >= 1.00
Layer boundary surface	28.500	10.000	0.00	7140.73	999.99 >= 1.00
Layer boundary surface	32.500	6.000	0.00	5882.34	999.99 >= 1.00
Layer boundary surface	37.500	1.000	282.05	3487.77	12.37 >= 1.00
Current ground level	38.500	0.000	213.92	2949.14	13.79 >= 1.00

(2)check result for slide

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	H-frc sum Fd(kN/m)	rsst sum Fr(kN/m)	Factor of safety F
íŽž	28.000	10.500	1069.93	2549.37	2.38 >= 1.20
'n kŽ%	28.000	10.500	412.50	2443.37	5.92 >= 1.00

(3)check result on bearing capacity of foundational ground

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam 2.Df.Be (kN/m)	Factor of safety F
íŽž	28.000	10.500	7623.43	1472.93	5.18>=1.20
'n kŽž	28.000	10.500	10955.61	1206.00	9.08>=1.00

* check result on embedment

(1)check result based on the limit equilibrium method

*)landside sheet pile

total length= 19.000m(G.L. 28.000m)

check case	required length (m)	final length (m)	active moment (kN.m m/m)	passive moment (kN.m m/m)	Factor of safety F
'Ž%	17.280	19.000	9042.12	15610.30	1.73 >= 1.50
'n kŽž	14.670	19.000	8428.07	14819.05	1.76 >= 1.20

*)riverside sheet pile

total length= 19.000 m(G.L. 28.000m)

check case	required length (m)	final length (m)	active moment (kN.m m/m)	passive moment (kN.m m/m)	Factor of safety F
'Ž%	15.220	19.000	8289.53	16781.61	2.02 >= 1.50
'n kŽž	12.640	19.000	7406.55	15926.88	2.15 >= 1.20

(2)check result on water shielding effect

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
íŽž	29.000	8.000	3.63>=3.25

(3) check about 4c > Sum(Gam h)

Not check about 4c > Sum(Gam h)

3.2 table of member force check result

(1)bending, shear, displacement results

*)landside sheet pile

Total length = 19.000m(G.L. 28.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
≤Žž	-276.37	38.200	-247.24	42.000	34.85	37.600
'n kŽž	-175.36	38.400	-154.52	42.000	18.45	38.000

*)riverside sheet pile

Total length = 19.000m(G.L. 28.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
≤Žž	-187.80	42.000	179.75	42.000	-14.17	38.000
'n kŽž	-117.59	42.000	137.92	42.000	-8.31	38.600

(2)result of tensile member reaction

*)landside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
´Ž%	0.00	-384.77
'n kŽž	0.00	-238.15

*)riverside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
≤Žž	20.75	296.54
'n kŽ%	4.08	217.47

(3)table of check result on length of elastic state

Not check for elastic state

3.3 table of member force calculation result (wall, tensile member, wailing)

(1) wall

section type: Steel sheet pile

unit(N/mm^2)

	Landside sheet pile		River side sheet pile	
Steel name Steel name	PU28+1 SY295		PU28+1 SY295	
Examined case	Bending stress	Shear stress	Bending stress	Shear stress
ˊŽž ’n kŽ%.	153.5<= 216.0 97.4<= 324.0	10.9<= 99.0 6.8<= 150.0	104.3<= 216.0 65.3<= 324.0	8.0<= 99.0 6.1<= 150.0

(2) tensile member

1) upper tensile member

diameter : Phi 25(mm)
material : ,’ f. ť |690
installing pitch : 3.600(m)
number in use : 1
unit(N/mm^2)

Examined case	Landside sheet pile tension force : Bending stress	River side sheet pile extension force : Bending stress
ˊŽž ’n kŽ%.	0.0<= 176.0 0.0<= 264.0	152.1<= 176.0 29.9<= 264.0

2) lower tensile member

diameter : Phi 75(mm)
material : ,’ f. ť |690
installing pitch : 1.800(m)
number in use : 1
unit(N/mm^2)

Examined case	Landside sheet pile tension force : Bending stress	River side sheet pile extension force : Bending stress
ˊŽž ’n kŽž	156.8<= 176.0 97.0<= 264.0	120.8<= 176.0 88.6<= 264.0

(3) wailing member

1) upper wiling member

steel material : H |150 ~150 ~ 7 ~10
material in use : SS400
unit(N/mm^2)

Examined case	Landside sheet pile tension force : Bending stress	River side sheet pile extension force : Bending stress
ˊŽž ’n kŽž	0.0<= 140.0 0.0<= 210.0	62.2<= 140.0 12.2<= 210.0

2) lower wailing member

steel material : H |200 ~200 ~ 8 ~12
material in use : SS400
unit(N/mm^2)

Examined case	Landside sheet pile tension force : Bending stress	River side sheet pile extension force : Bending stress
’Ž%. ’n kŽž	132.1<= 140.0 81.7<= 210.0	101.8<= 140.0 74.6<= 210.0

4 Check case (nomal time)

4.1 calculation of external forces

4.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1) water pressure table (riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 42.000	4.000	0.00 40.00
2	42.000 41.750	0.250	40.00 42.50
3	41.750 39.000	2.750	42.50 70.00
4	39.000 38.000	1.000	70.00 80.00
5	38.000 37.500	0.500	80.00 85.00
6	37.500 33.000	4.500	85.00 64.87
7	33.000 29.000	4.000	64.87 46.97
8	29.000 28.000	1.000	46.97 42.50

(2) active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h) + q) - 2c*Sqrt(Ka)

$$Ka= \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1+ Sqrt\{\sin(Phi) * \sin(Phi - Theta)/ \cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	39.000 38.000	1.000	9.0	20.00	10.0 10.0	0.00 9.00	0.490	-14.00 -9.59	0.00 0.00
2	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	0.406	-9.09 -7.26	0.00 0.00
3	37.500 35.512	1.988	9.0	25.00	10.0 10.0	13.50 31.39	0.406	-7.26 0.00	0.00 0.00
4	35.512 33.000	2.512	9.0	25.00	10.0 10.0	31.39 54.00	0.406	0.00 9.17	0.00 9.17
5	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	0.406	9.17 23.79	9.17 23.79
6	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	0.406	23.79 53.01	23.79 53.01

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp=\frac{\cos^2(Phi-Theta)}{\cos^2(Theta)*[1-Sqrt\{\sin(Phi)*\sin(Phi-Theta)/\cos(Theta)\}]^2}$$

where, assume Theta=0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	20.00	10.0 10.0	0.00 9.00	2.040	28.56 46.92
2	37.500 37.000	0.500	9.0	20.00	10.0 10.0	9.00 13.50	2.040	46.92 56.10
3	37.000 32.000	5.000	9.0	25.00	10.0 10.0	13.50 58.50	2.464	64.66 175.53
4	32.000 28.000	4.000	9.0	25.00	10.0 10.0	58.50 94.50	2.464	175.53 264.23
5	28.000 20.000	8.000	9.0	25.00	10.0 10.0	94.50 166.50	2.464	264.23 441.64

(4)active earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	0.333	11.67 17.67	11.67 17.67
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	0.333	17.67 41.67	17.67 41.67
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	0.333	41.67 43.17	41.67 43.17
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	0.333	43.17 52.92	43.17 52.92
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	158.75 167.75	0.490	63.83 68.24	63.83 68.24
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	167.75 212.75	0.406	55.34 73.60	55.34 73.60
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	212.75 248.75	0.406	73.60 88.22	73.60 88.22
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	248.75 320.75	0.406	88.22 117.44	88.22 117.44

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	3.000	105.00 159.00
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	3.000	159.00 375.00
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	3.000	375.00 388.50
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	3.000	388.50 476.25
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	158.75 167.75	2.040	352.35 370.71
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	167.75 212.75	2.464	444.72 555.59
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	212.75 248.75	2.464	555.59 644.29
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	248.75 320.75	2.464	644.29 821.69

(6)passive earth pressure intensity table (out of embankment: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 38.000	1.000	9.0	20.00	10.0 10.0	0.00 9.00	2.040	28.56 46.92
2	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	2.464	53.57 64.66
3	37.500 33.000	4.500	9.0	25.00	10.0 10.0	13.50 54.00	2.464	64.66 164.45
4	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	2.464	164.45 253.15
5	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	2.464	253.15 430.55

4.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 41.750(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.750 38.500	3.250	0.00 32.50
2	38.500 37.500	1.000	32.50 42.50
3	37.500 32.500	5.000	42.50 20.13
4	32.500 28.500	4.000	20.13 2.24
5	28.500 28.000	0.500	2.24 0.00

(2) active earth pressure intensity table (embankment section: working external force)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	35.00 53.00	0.333	11.67 17.67	11.67 17.67
2	46.000 42.000	4.000	18.0	30.00	0.0 0.0	53.00 125.00	0.333	17.67 41.67	17.67 41.67
3	42.000 41.750	0.250	18.0	30.00	0.0 0.0	125.00 129.50	0.333	41.67 43.17	41.67 43.17
4	41.750 38.500	3.250	9.0	30.00	0.0 0.0	129.50 158.75	0.333	43.17 52.92	43.17 52.92
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	158.75 167.75	0.490	63.83 68.24	63.83 68.24
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	167.75 212.75	0.406	55.34 73.60	55.34 73.60
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	212.75 248.75	0.406	73.60 88.22	73.60 88.22
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	248.75 320.75	0.406	88.22 117.44	88.22 117.44

(3) passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	20.00	10.0 10.0	0.00 9.00	2.040	28.56 46.92
2	37.500 37.000	0.500	9.0	20.00	10.0 10.0	9.00 13.50	2.040	46.92 56.10
3	37.000 32.000	5.000	9.0	25.00	10.0 10.0	13.50 58.50	2.464	64.66 175.53
4	32.000 28.000	4.000	9.0	25.00	10.0 10.0	58.50 94.50	2.464	175.53 264.23
5	28.000 20.000	8.000	9.0	25.00	10.0 10.0	94.50 166.50	2.464	264.23 441.64

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

po= Ko(Sum(Gam h)+ q)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ko	active e-prss po (kN m2)
1	38.000 37.500	0.500	18.0	0.00 9.00	0.658	0.00 5.92
2	37.500 37.000	0.500	9.0	9.00 13.50	0.658	5.92 8.88
3	37.000 32.000	5.000	9.0	13.50 58.50	0.577	7.79 33.78
4	32.000 28.000	4.000	9.0	58.50 94.50	0.577	33.78 54.56
5	28.000 20.000	8.000	9.0	94.50 166.50	0.577	54.56 96.13

Note: is a layer without earth pressure in calculation.

4.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 41.500(m)

L.W.L. 39.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.500 39.000	2.500	0.00 25.00
2	39.000 38.500	0.500	25.00 23.86
3	38.500 37.500	1.000	23.86 21.59
4	37.500 32.500	5.000	21.59 10.23
5	32.500 28.500	4.000	10.23 1.14
6	28.500 28.000	0.500	1.14 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	35.00 125.00	0.333	11.67 41.67	11.67 41.67
2	42.000 41.500	0.500	18.0	30.00	0.0 0.0	125.00 134.00	0.333	41.67 44.67	41.67 44.67
3	41.500 39.000	2.500	9.0	30.00	0.0 0.0	134.00 156.50	0.333	44.67 52.17	44.67 52.17
4	39.000 38.500	0.500	9.0	30.00	0.0 0.0	156.50 161.00	0.333	52.17 53.67	52.17 53.67
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	161.00 170.00	0.490	64.93 69.35	64.93 69.35
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	170.00 215.00	0.406	56.25 74.52	56.25 74.52
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	215.00 251.00	0.406	74.52 89.13	74.52 89.13
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	251.00 323.00	0.406	89.13 118.35	89.13 118.35

(3) passive earth pressure intensity table(out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 38.000	1.000	9.0	20.00	10.0 10.0	0.00 9.00	2.040	28.56 46.92
2	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	2.464	53.57 64.66
3	37.500 33.000	4.500	9.0	25.00	10.0 10.0	13.50 54.00	2.464	64.66 164.45
4	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	2.464	164.45 253.15
5	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	2.464	253.15 430.55

Note:is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	39.000 38.000	1.000	9.0	0.00 9.00	0.658	0.00 5.92
2	38.000 37.500	0.500	9.0	9.00 13.50	0.577	5.20 7.79
3	37.500 33.000	4.500	9.0	13.50 54.00	0.577	7.79 31.18
4	33.000 29.000	4.000	9.0	54.00 90.00	0.577	31.18 51.96
5	29.000 21.000	8.000	9.0	90.00 162.00	0.577	51.96 93.54

Note: is a layer without earth pressure in calculation.

4.2 Stability analysis

4.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.20)

Md: shear deformation moment on check plane(kN*m/m)

Mr: shear resistant moment on check plane(kN*m/m)

$$Mr = Mro*(1+\frac{d}{H})+Msp$$

$$Mro = \int_{0}^{yo}(pRP-pRA)ydy$$

where,

Mro: basic shear resistant moment of filling soil

d : depth from current ground surface to check level

H : wall height(from top of wall to ground level in embankment range)

pRP: passive earth pressure above check level with a distance y(kN/m2)

pRA: active earth pressure above check level with a distance y(kN/m2)

y : a distance from the location of pRP, pRA working(m)

yo : cross point coordinates of the failure plane in filling soil

Msp: resistant moment caused by two rows sheet piles

smaller resistance either landside or riverside and make double to evaluate

Msp= 2* (smaller value either Msp1 or Msp2)

Msp1: resistant moment derived from sheet pile

Msp1= Sig.a* Zsp

Sig.a: allowable stress of sheet pile in use(N/mm2)

Zsp : section modulus considering joint(splice) of sheet pile in use(mm³/m)

Msp2: resistant moment allowed by embedment deeper than check level.

Msp2= Ppu* hpu

Ppu: passive resultant force from check elevation to sheet pile tip

hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	2175.30	7645.46	3.51>=1.20
Layer boundary surface	28.500	10.000	2378.84	7379.74	3.10>=1.20
Layer boundary surface	32.500	6.000	2603.46	5678.08	2.18>=1.20
Layer boundary surface	37.500	1.000	1019.21	3439.27	3.37>=1.20
Current ground level	38.500	0.000	703.13	2983.06	4.24>=1.20

(2)check level(Embedment tip: G.L. 28.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2175.30
resistant moment	Mr(kN.m/m)	7645.46
factor of safety	Mr/Md	3.51>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	7651.77
active earth-prss moment	Ma	258.05
pssv earth-prss moment	-Mp	5734.52
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	2175.30

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	15.333	1226.67
2	42.000 41.750	0.250	40.00 42.50	10.31	13.874	143.07
3	41.750 39.000	2.750	42.50 70.00	154.69	12.263	1896.93
4	39.000 38.000	1.000	70.00 80.00	75.00	10.489	786.67
5	38.000 37.500	0.500	80.00 85.00	41.25	9.747	402.08
6	37.500 33.000	4.500	85.00 64.87	337.20	7.351	2478.70
7	33.000 29.000	4.000	64.87 46.97	223.68	3.107	694.91
8	29.000 28.000	1.000	46.97 42.50	44.74	0.508	22.74
Sum				966.88		7651.77

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.000	1.000	0.00 0.00	0.00	10.500	0.00
2	38.000 37.500	0.500	0.00 0.00	0.00	9.750	0.00
3	37.500 35.512	1.988	0.00 0.00	0.00	8.506	0.00
4	35.512 33.000	2.512	0.00 9.17	11.52	5.837	67.26
5	33.000 29.000	4.000	9.17 23.79	65.92	2.704	178.28
6	29.000 28.000	1.000	23.79 27.44	25.61	0.488	12.50
Sum				103.06		258.05

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.56 46.92	18.87	9.730	183.61
2	37.500 37.000	0.500	46.92 56.10	25.75	9.243	238.04
3	37.000 32.000	5.000	64.66 175.53	600.47	6.115	3672.08
4	32.000 28.000	4.000	175.53 264.23	879.53	1.866	1640.80
Sum				1524.63		5734.52

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	7645.46 0.00 388.80 0.00
rsst moment Mr(kN.m/m)	7645.46

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 3420.34* (1+ 1.235)= 7645.46(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	31.625 28.500	3.125	574.99 644.29	76.80 88.22	498.19 556.08	1647.30	2.034	3350.44
2	28.500 28.000	0.500	644.29 655.38	88.22 90.04	556.08 565.34	280.35	0.249	69.90
Sum						1927.65		3420.34

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active

Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	31.625	28.500	3.125	25.00	0.00	32.50	4.905	57.50	1.991	6.896
2	28.500	28.000	0.500	25.00	0.00	32.50	0.785	57.50	0.319	1.103
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(388.80, 0.00)= 0.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 28.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	2378.84
resistant moment	Mr(kN.m/m)	7379.74
factor of safety	Mr/ Md	3.10>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	7173.74
active earth-prss moment	Ma	209.87
pssv earth-prss moment	- Mp	5004.77
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	2378.84

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	14.833	1186.67
2	42.000 41.750	0.250	40.00 42.50	10.31	13.374	137.92
3	41.750 39.000	2.750	42.50 70.00	154.69	11.763	1819.58
4	39.000 38.000	1.000	70.00 80.00	75.00	9.989	749.17
5	38.000 37.500	0.500	80.00 85.00	41.25	9.247	381.46
6	37.500 33.000	4.500	85.00 64.87	337.20	6.851	2310.10
7	33.000 29.000	4.000	64.87 46.97	223.68	2.607	583.07
8	29.000 28.500	0.500	46.97 44.74	22.93	0.252	5.78
Sum				945.07		7173.74

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.000	1.000	0.00 0.00	0.00	10.000	0.00
2	38.000 37.500	0.500	0.00 0.00	0.00	9.250	0.00
3	37.500 35.512	1.988	0.00 0.00	0.00	8.006	0.00
4	35.512 33.000	2.512	0.00 9.17	11.52	5.337	61.50
5	33.000 29.000	4.000	9.17 23.79	65.92	2.204	145.32
6	29.000 28.500	0.500	23.79 25.61	12.35	0.247	3.05
Sum				89.79		209.87

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.56 46.92	18.87	9.230	174.17
2	37.500 37.000	0.500	46.92 56.10	25.75	8.743	225.16
3	37.000 32.000	5.000	64.66 175.53	600.47	5.615	3371.85
4	32.000 28.500	3.500	175.53 253.15	750.19	1.644	1233.60
Sum				1395.29		5004.77

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	7311.83 67.91 388.80 33.95
rsst moment Mr(kN.m/m)	7379.74

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 3359.49* (1+ 1.176)= 7311.83(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	32.125 28.500	3.625	563.91 644.29	74.97 88.22	488.93 556.08	1894.08	1.774	3359.49
Sum						1894.08		3359.49

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	32.125	28.500	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xip= 90.0- $\tan^{-1}$ (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xia= 90.0- $\tan^{-1}$ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(388.80, 33.95) = 67.91(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $*10^{-6}$ m^3/m - - - - - - - - $*10^{-6}$ m^3/m $*10^{3}$ kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	28.500 28.000	0.500	264.23 275.32	134.89	0.252	33.95
Sum				134.89		33.95

(4) check level(Layer boundary surface: G.L. 32.500m)

1) check result

item		value
deformation moment	Md(kN.m/m)	2603.46
resistant moment	Mr(kN.m/m)	5678.08
factor of safety	Mr/ Md	2.18>=1.20

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	3799.09 16.63 1212.26 0.00
deformation moment	Md(kN.m/m)	2603.46

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	10.833	866.67
2	42.000 41.750	0.250	40.00 42.50	10.31	9.374	96.67
3	41.750 39.000	2.750	42.50 70.00	154.69	7.763	1200.83
4	39.000 38.000	1.000	70.00 80.00	75.00	5.989	449.17
5	38.000 37.500	0.500	80.00 85.00	41.25	5.247	216.46
6	37.500 33.000	4.500	85.00 64.87	337.20	2.851	961.28
7	33.000 32.500	0.500	64.87 62.63	31.88	0.251	8.02
Sum				730.33		3799.09

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.000	1.000	0.00 0.00	0.00	6.000	0.00
2	38.000 37.500	0.500	0.00 0.00	0.00	5.250	0.00
3	37.500 35.512	1.988	0.00 0.00	0.00	4.006	0.00
4	35.512 33.000	2.512	0.00 9.17	11.52	1.337	15.41
5	33.000 32.500	0.500	9.17 11.00	5.04	0.242	1.22
Sum				16.57		16.63

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.56 46.92	18.87	5.230	98.69
2	37.500 37.000	0.500	46.92 56.10	25.75	4.743	122.14
3	37.000 32.500	4.500	64.66 164.45	515.48	1.923	991.43
Sum				560.10		1212.26

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	4900.48 777.60 388.80 2450.84
rsst moment Mr(kN.m/m)	5678.08

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2872.69* (1+ 0.706)= 4900.48(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	36.125 32.500	3.625	475.21 555.59	60.36 73.60	414.84 481.99	1625.50	1.767	2872.69
Sum						1625.50		2872.69

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis- angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	36.125	32.500	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(388.80, 2450.84)= 777.60(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^3$ kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN*m/m	388.80	388.80

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	32.500 29.000	3.500	175.53 253.15	750.19	1.856	1392.06
2	29.000 28.000	1.000	253.15 275.32	264.23	4.007	1058.78

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
Sum				1014.42		2450.84

(5)check level(Layer boundary surface: G.L. 37.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	1019.21
resistant moment	Mr(kN.m/m)	3439.27
factor of safety	Mr/ Md	3.37>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	1023.54
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	4.34
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	1019.21

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	5.833	466.67
2	42.000 41.750	0.250	40.00 42.50	10.31	4.374	45.10
3	41.750 39.000	2.750	42.50 70.00	154.69	2.763	427.40
4	39.000 38.000	1.000	70.00 80.00	75.00	0.989	74.17
5	38.000 37.500	0.500	80.00 85.00	41.25	0.247	10.21
Sum				361.25		1023.54

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.000	1.000	0.00 0.00	0.00	1.000	0.00
2	38.000 37.500	0.500	0.00 0.00	0.00	0.250	0.00
Sum				0.00		0.00

c.passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.56 46.92	18.87	0.230	4.34
Sum				18.87		4.34

d. other load moment
* Sum(Pc) = 0.00(kN.m/m)
* Sum(Mc) = 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	2661.67 777.60 388.80 9255.12
rsst moment Mr(kN.m/m)	3439.27

a. resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro* (1+ d/ H) = 2381.49* (1+ 0.118) = 2661.67(kN.m/m)
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.042 38.500	2.542	407.62 476.25	45.29 52.92	362.33 423.33	998.57	2.238	2234.91
2	38.500 37.500	1.000	352.35 370.71	63.83 68.24	288.52 302.46	295.49	0.496	146.58
Sum						1294.07		2381.49

b. yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active
Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	41.042 38.500	38.500 37.500	2.542 1.000	30.00 20.00	0.00 0.00	30.00 35.00	4.403 1.428	60.00 55.00	1.468 0.700	5.870 2.128
Interval Sum(Bp) + Ba										7.999

* passive failure plane
Bp= cot(xip)* h

$$cot(xip) = tan(Phi) + sec(Phi) * Sqrt(-\frac{cos(-Theta) sin(Phi)}{sin(Phi - Theta)})$$

xip= 90.0- tan⁻¹ (cot(xip))
* active failure plane
Ba= cot(xia)* h

$$cot(xia) = - tan(Phi) + sec(Phi) * Sqrt(-\frac{cos(Theta) sin(Phi)}{sin(Phi - Theta)})$$

xia= 90.0- tan⁻¹ (cot(xia))
* If sin(Phi- Theta)<=0, cot(xip) = cot(xia) = tan(Phi)+sec(Phi)

c. passive resistant moment below check level
Msp= 2* min(Msp1, Msp2)
= 2* min(388.80, 9255.12) = 777.60(kN.m/m)

d. resistant moment (Msp1) of sheet pile
It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 216.0	PU28+1 3000 0.60 1800 216.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	388.80	388.80

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	37.500 33.000	4.500	64.66 164.45	515.48	2.577	1328.22
2	33.000 29.000	4.000	164.45 253.15	835.18	6.642	5546.95
3	29.000 28.000	1.000	253.15 275.32	264.23	9.007	2379.95
Sum				1614.89		9255.12

(6)check level(Current ground level: G.L. 38.500m)

1)check result

item		value
deformation moment	MH(kN.m/m)	703.13
resistant moment	Mr(kN.m/m)	2983.06
factor of safety	Mr/ MH	4.24>=1.20

2)deformation moment(MH)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	703.13 0.00 0.00 0.00
deformation moment	MH(kN.m/m)	703.13

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 42.000	4.000	0.00 40.00	80.00	4.833	386.67
2	42.000 41.750	0.250	40.00 42.50	10.31	3.374	34.79
3	41.750 39.000	2.750	42.50 70.00	154.69	1.763	272.71
4	39.000 38.500	0.500	70.00 75.00	36.25	0.247	8.96
Sum				281.25		703.13

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.500	0.500	0.00 0.00	0.00	0.250	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H)	2205.46
Msp= 2* min(Msp1, Msp2)	777.60
Msp1	388.80
Msp2	10897.89
rsst moment Mr(kN.m/m)	2983.06

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2205.46* (1+ 0.000)= 2205.46(kN.m/m)

Armlength = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.964 41.750	0.214	376.94 388.50	41.88 43.17	335.06 345.33	72.80	3.356	244.36
2	41.750 38.500	3.250	388.50 476.25	43.17 52.92	345.33 423.33	1249.08	1.570	1961.10
Sum						1321.89		2205.46

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	41.964	41.750	0.214	30.00	0.00	30.00	0.371	60.00	0.124	0.494
2	41.750	38.500	3.250	30.00	0.00	30.00	5.629	60.00	1.876	7.506
Interval Sum(Bp) + Ba										8.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan^{-1} (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(388.80, 10897.89)= 777.60(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item		unit	landside	riverside
Steel material name		- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z		* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.		- - - - - - - -	0.60	0.60
section modulus in use	Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress	Sig.a	* 10^{3} kN/m2	216.0	216.0
resistant mt Msp1 = Sig.a* Alp.Z		kN* m/m	388.80	388.80

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	38.500 38.000	0.500	37.74 46.92	21.17	0.259	5.48
2	38.000 37.500	0.500	53.57 64.66	29.56	0.758	22.40
3	37.500 33.000	4.500	64.66 164.45	515.48	3.577	1843.70
4	33.000 29.000	4.000	164.45 253.15	835.18	7.642	6382.13
5	29.000 28.000	1.000	253.15 275.32	264.23	10.007	2644.18
Sum				1665.62		10897.89

4.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.20)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H-frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	28.000	10.500	1069.93	2549.37	2.38>=1.20

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item	value
sum of H-force Fd(kN/m)	1069.93
sum of rsst Fr(kN/m)	2549.37
factor of safety Fr/ Fd	2.38>=1.20

2)sum of horizontal force(Fd)

horizontal force in detail		H-force
water pressure	Fw	966.88
active earth pressure	Fa	103.06
other load	Fc	0.00
sum of H-force	Fd(kN/m)	1069.93

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail		H-force
ground H-resistance	Fs	1024.74
passive earth pressure	Fp	1524.63
sum of resistance	Fr(kN/m)	2549.37

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 8.000+ 2026.00* tan(25.00) Deg.

= 1024.74(kN/m)

b.soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (218.25+ 35.00)* 8.000= 2026.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	42.000	4.000	18.0	72.00
3	42.000	41.750	0.250	18.0	4.50
4	41.750	38.500	3.250	9.0	29.25
5	38.500	37.500	1.000	9.0	9.00
6	37.500	32.500	5.000	9.0	45.00
7	32.500	28.500	4.000	9.0	36.00
8	28.500	28.000	0.500	9.0	4.50
Sum			19.000		218.25

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

4.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 8.000, height H= 8.500(m) using the next equation.

$$\frac{Qu}{V-Gam2*Df*Be} >= FS$$

$$Qu = Be\{ k*c*Nc+k*Gam2*Df*(Nq-1)+\frac{1}{2}*Gam1*Be*NGam \}$$

where,

FS : required factor of safety(1.20)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B-2e

B: wall width

e: eccentricity(e= Mb/ V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/ V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	28.000	10.500	7623.43	1472.93	5.18>=1.20

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	2026.00
	distance from ground to check level	Df	10.500
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	5.853
	v-compo sum V-Gam2.Df.Be (kN/m)		1472.93
Qu	moment on check level	Mb	2175.30
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	1.074
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		7623.43
factor of safety			5.18>=1.20

2)summery of external force

external force detail		moment Mb(kN.m/m)	H-force Hb(kN/m)
water pressure	Mw(Fw)	7651.77	966.88
active earth pressure	Ma(Fa)	258.05	103.06
passive earth pressure-	Mp(Fp)	5734.52	1524.63
other load	Mc(Fc)	0.00	0.00
external force sum		2175.30	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b.active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

3)weight of filling soil(V)

refer to 'b.weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 2026.00(kN/m)

4)eccentricity distance(e)calculation

e = Mb/ V

= 2175.30/ 2026.00

= 1.074(m)

Be= B- 2e

= 8.000- 2.0* 1.074

= 5.853(m)

5)calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 2026.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\ 2 = \frac{Sum(Gam\ i\ hi)}{Sum(hi)}$$

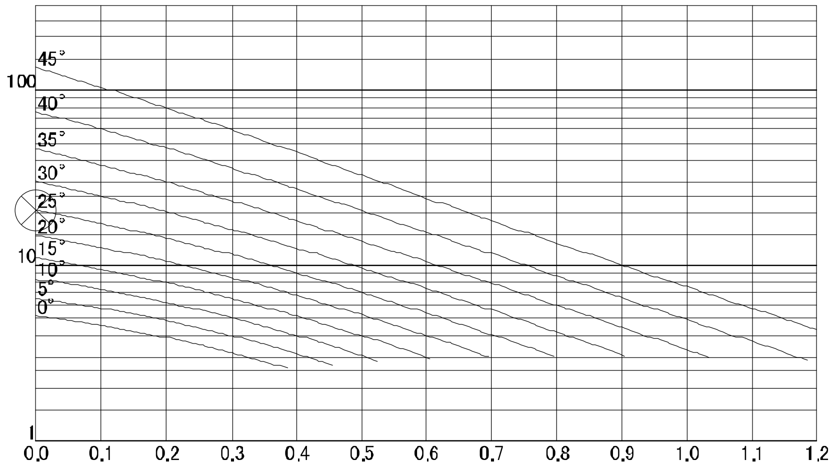
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	38.500	37.500	1.000	9.0	9.00
2	37.500	32.500	5.000	9.0	45.00
3	32.500	28.500	4.000	9.0	36.00
4	28.500	28.000	0.500	9.0	4.50
Sum			10.500		94.50

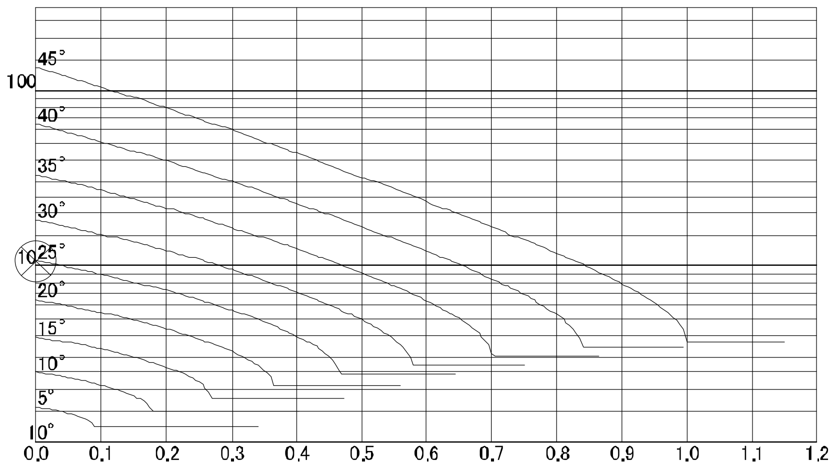
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

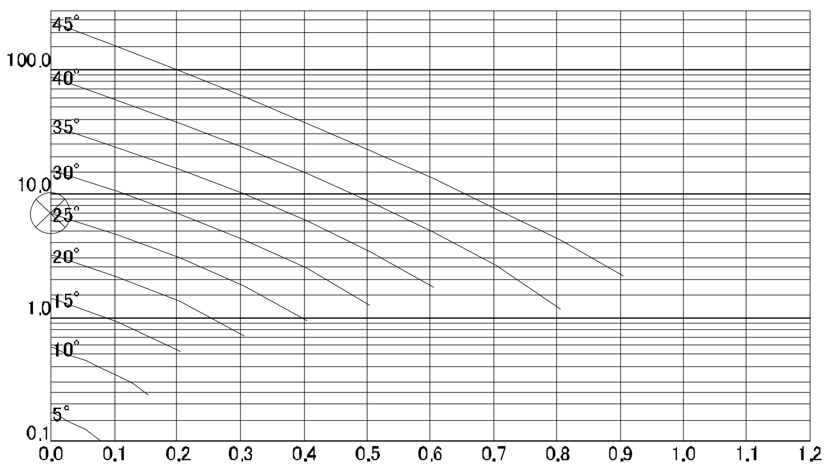
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



4.3 landside sheet pile

4.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.750(m)
L.WL : 37.500(m)

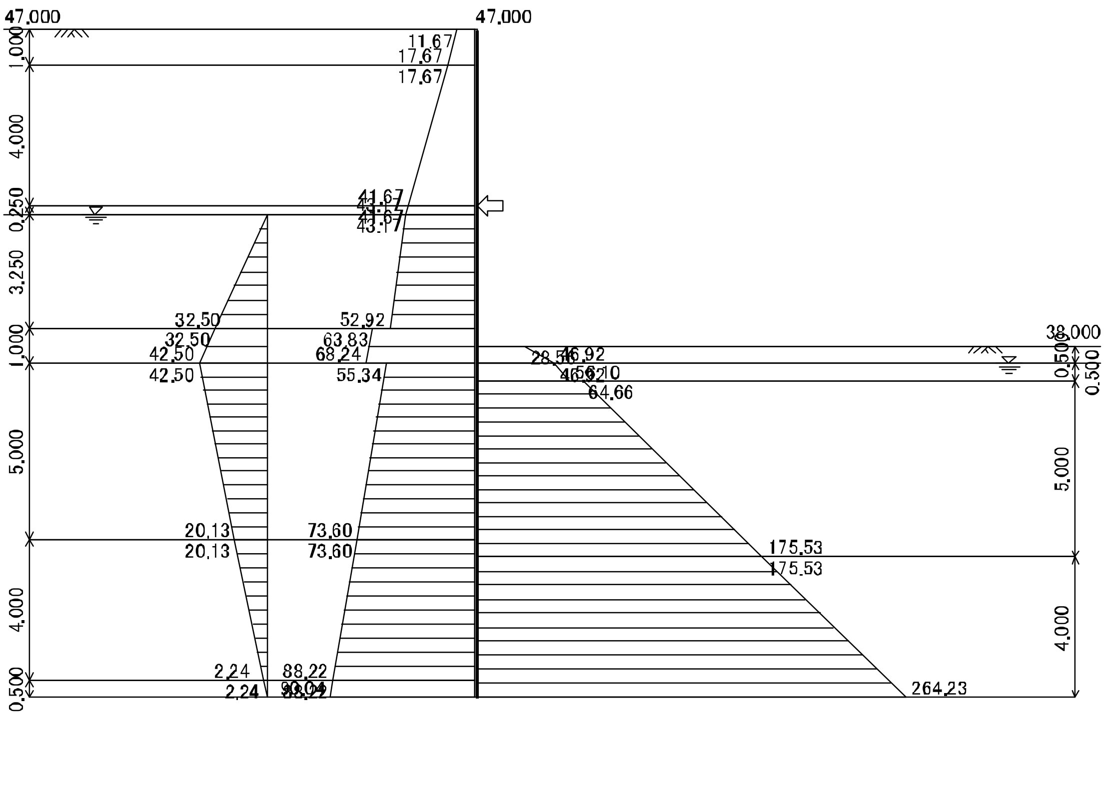
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	29.720	28.000
active sd	Ma+Mw+Mac(kN m/m)	6701.54	9042.12
passive sd	Mp+Mpc(kN m/m)	10060.02	15610.30
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.501>=1.50	1.726>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.750	0.250	41.67 43.17	10.60	0.126	1.33
2	41.750 38.500	3.250	43.17 52.92	156.14	1.930	301.34
3	38.500 37.500	1.000	63.83 68.24	66.04	4.006	264.51
4	37.500 32.500	5.000	55.34 73.60	322.37	7.118	2294.61
5	32.500 28.500	4.000	73.60 88.22	323.64	11.560	3741.36
6	28.500 28.000	0.500	88.22 90.04	44.56	13.751	612.80
Sum				923.35		7215.95

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.750 38.500	3.250	0.00 32.50	52.81	2.417	127.63
2	38.500 37.500	1.000	32.50 42.50	37.50	4.022	150.83
3	37.500 32.500	5.000	42.50 20.13	156.58	6.702	1049.45
4	32.500 28.500	4.000	20.13 2.24	44.74	10.967	490.61
5	28.500 28.000	0.500	2.24 0.00	0.56	13.667	7.64
Sum				292.19		1826.17

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.56 46.92	18.87	4.270	80.58
2	37.500 37.000	0.500	46.92 56.10	25.75	4.757	122.52
3	37.000 32.000	5.000	64.66 175.53	600.47	7.885	4734.54
4	32.000 28.000	4.000	175.53 264.23	879.53	12.134	10672.65
Sum				1524.63		15610.30

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

4.3.2 Calculation on wall member forces

(1) result summery

1) calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-276.37	G.L. 38.200
max shear force Smax(kN/m)	-247.24	G.L. 42.000
upper tension mbr rct R1(kN/m)	0.00	G.L. 46.000
lower tension mbr rct R2(kN/m)	-384.77	G.L. 42.000

2) load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	11.67 17.67	0.00 0.00	---- ----	---- ----	11.67 17.67	---- ----
2	46.000 42.000	17.67 41.67	0.00 0.00	---- ----	---- ----	17.67 41.67	---- ----
3	42.000 41.750	41.67 43.17	0.00 0.00	---- ----	---- ----	41.67 43.17	---- ----
4	41.750 38.500	43.17 52.92	0.00 32.50	---- ----	---- ----	43.17 85.42	---- ----
5	38.500 38.000	63.83 66.04	32.50 37.50	---- ----	---- ----	96.33 103.54	---- ----
6	38.000 37.500	66.04 68.24	37.50 42.50	28.56 46.92	0.00 5.92	103.54 104.82	28.56 41.00
7	37.500 37.000	55.34 57.17	42.50 40.26	46.92 56.10	5.92 8.88	91.92 88.55	41.00 47.21
8	37.000 32.500	57.17 73.60	40.26 20.13	64.66 164.45	7.79 31.18	89.64 62.56	56.86 133.27
9	32.500 32.000	73.60 75.43	20.13 17.89	164.45 175.53	31.18 33.78	62.56 59.55	133.27 141.76
10	32.000 28.500	75.43 88.22	17.89 2.24	175.53 253.15	33.78 51.96	59.55 38.49	141.76 201.18
11	28.500 28.000	88.22 90.04	2.24 0.00	253.15 264.23	51.96 54.56	38.49 35.48	201.18 209.67

Note: is non-effective for earth pressure in calculation.

other load

3) spring condition

passive spring is given by the following equation.

$$kH = Eta^* \frac{1}{0.3} {}^* Alpha\ Eo^* \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	38.000	37.500	0.500	14000	3364
2	37.500	37.000	0.500	14000	3364
3	37.000	32.000	5.000	42000	10092
4	32.000	28.000	4.000	64400	15474
5	28.000	20.000	8.000	106400	25566

Note: in non-effective for spring constant.

4) table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.^*(2^*number^*A^*E)}{(L^*s)}$$

where,

FORUM8

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000]m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	11.67	1.20	--------	--------	--------	--------
2	46.800	On excavation plane	12.87	12.87	2.57	--------	--------	--------	--------
3	46.600	On excavation plane	14.07	14.07	2.81	--------	--------	--------	--------
4	46.400	On excavation plane	15.27	15.27	3.05	--------	--------	--------	--------
5	46.200	On excavation plane	16.47	16.47	3.29	--------	--------	--------	--------
6	46.000	Tensile member	17.67	17.67	3.53	--------	--------	--------	6818
7	45.800	On excavation plane	18.87	18.87	3.77	--------	--------	--------	--------
8	45.600	On excavation plane	20.07	20.07	4.01	--------	--------	--------	--------
9	45.400	On excavation plane	21.27	21.27	4.25	--------	--------	--------	--------
10	45.200	On excavation plane	22.47	22.47	4.49	--------	--------	--------	--------
11	45.000	On excavation plane	23.67	23.67	4.73	--------	--------	--------	--------
12	44.800	On excavation plane	24.87	24.87	4.97	--------	--------	--------	--------
13	44.600	On excavation plane	26.07	26.07	5.21	--------	--------	--------	--------
14	44.400	On excavation plane	27.27	27.27	5.45	--------	--------	--------	--------
15	44.200	On excavation plane	28.47	28.47	5.69	--------	--------	--------	--------
16	44.000	On excavation plane	29.67	29.67	5.93	--------	--------	--------	--------
17	43.800	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
18	43.600	On excavation plane	32.07	32.07	6.41	--------	--------	--------	--------
19	43.400	On excavation plane	33.27	33.27	6.65	--------	--------	--------	--------
20	43.200	On excavation plane	34.47	34.47	6.89	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
21	43.000	On excavation plane	35.67	35.67	7.13	--------	--------	--------	--------
22	42.800	On excavation plane	36.87	36.87	7.37	--------	--------	--------	--------
23	42.600	On excavation plane	38.07	38.07	7.61	--------	--------	--------	--------
24	42.400	On excavation plane	39.27	39.27	7.85	--------	--------	--------	--------
25	42.200	On excavation plane	40.47	40.47	8.09	--------	--------	--------	--------
26	42.000	Tensile member	41.67	41.67	8.33	--------	--------	--------	122718
27	41.800	On excavation plane	42.87	42.87	5.33	--------	--------	--------	--------
28	41.750	On excavation plane	43.17	43.17	4.35	--------	--------	--------	--------
29	41.600	On excavation plane	45.12	45.12	7.92	--------	--------	--------	--------
30	41.400	On excavation plane	47.72	47.72	9.54	--------	--------	--------	--------
31	41.200	On excavation plane	50.32	50.32	10.06	--------	--------	--------	--------
32	41.000	On excavation plane	52.92	52.92	10.58	--------	--------	--------	--------
33	40.800	On excavation plane	55.52	55.52	11.10	--------	--------	--------	--------
34	40.600	On excavation plane	58.12	58.12	11.62	--------	--------	--------	--------
35	40.400	On excavation plane	60.72	60.72	12.14	--------	--------	--------	--------
36	40.200	On excavation plane	63.32	63.32	12.66	--------	--------	--------	--------
37	40.000	On excavation plane	65.92	65.92	13.18	--------	--------	--------	--------
38	39.800	On excavation plane	68.52	68.52	13.70	--------	--------	--------	--------
39	39.600	On excavation plane	71.12	71.12	14.22	--------	--------	--------	--------
40	39.400	On excavation plane	73.72	73.72	14.74	--------	--------	--------	--------
41	39.200	On excavation plane	76.32	76.32	15.26	--------	--------	--------	--------
42	39.000	On excavation plane	78.92	78.92	15.78	--------	--------	--------	--------
43	38.800	On excavation plane	81.52	81.52	16.30	--------	--------	--------	--------
44	38.600	On excavation plane	84.12	84.12	12.57	--------	--------	--------	--------
45	38.500	On excavation plane	85.42	96.33	9.09	--------	--------	--------	--------
46	38.400	On excavation plane	97.77	97.77	14.72	--------	--------	--------	--------
47	38.200	On excavation plane	100.65	100.65	20.13	--------	--------	--------	--------
48	38.000	Pa plas.	103.54	103.54	20.65	0.00	28.56	2.98	--------
49	37.800	Pa plas.	104.05	104.05	20.81	33.54	33.54	6.71	--------
50	37.600	Pa plas.	104.56	104.56	15.67	38.51	38.51	5.68	--------
51	37.500	Pa plas.	104.82	91.92	9.83	41.00	41.00	4.08	--------
52	37.400	Pa plas.	91.25	91.25	13.66	42.24	42.24	6.38	--------
53	37.200	Pa plas.	89.90	89.90	17.98	44.73	44.73	8.95	--------
54	37.000	Pa plas.	88.55	89.64	17.82	47.21	56.86	10.43	--------
55	36.800	Pa plas.	88.43	88.43	17.69	60.26	60.26	12.05	--------
56	36.600	Pa plas.	87.23	87.23	17.45	63.65	63.65	12.73	--------
57	36.400	Pa plas.	86.03	86.03	17.21	67.05	67.05	13.41	--------
58	36.200	Pa plas.	84.82	84.82	16.96	70.44	70.44	14.09	--------
59	36.000	Pa plas.	83.62	83.62	16.72	73.84	73.84	14.77	--------
60	35.800	Pa plas.	82.42	82.42	16.48	77.24	77.24	15.45	--------
61	35.600	Pa plas.	81.21	81.21	16.24	80.63	80.63	16.13	--------
62	35.400	Pa plas.	80.01	80.01	16.00	84.03	84.03	16.81	--------
63	35.200	Pa plas.	78.80	78.80	15.76	87.42	87.42	17.48	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
64	35.000	Pa plas.	77.60	77.60	15.52	90.82	90.82	18.16	--------
65	34.800	Pa plas.	76.40	76.40	15.28	94.22	94.22	18.84	--------
66	34.600	Pa plas.	75.19	75.19	15.04	97.61	97.61	19.52	--------
67	34.400	Pa plas.	73.99	73.99	14.80	101.01	101.01	20.20	--------
68	34.200	Pa plas.	72.79	72.79	14.56	104.40	104.40	20.88	--------
69	34.000	Pa plas.	71.58	71.58	14.32	107.80	107.80	21.56	--------
70	33.800	Pa plas.	70.38	70.38	14.08	111.19	111.19	22.24	--------
71	33.600	Pa plas.	69.18	69.18	13.84	114.59	114.59	22.92	--------
72	33.400	Pa plas.	67.97	67.97	13.59	117.99	117.99	23.60	--------
73	33.200	Pa plas.	66.77	66.77	13.35	121.38	121.38	24.28	--------
74	33.000	Pas ela.	65.57	65.57	13.11	124.78	124.78	--------	2018
75	32.800	Pas ela.	64.36	64.36	12.87	128.17	128.17	--------	2018
76	32.600	Pas ela.	63.16	63.16	9.50	131.57	131.57	--------	1514
77	32.500	Pas ela.	62.56	62.56	6.26	133.27	133.27	--------	1009
78	32.400	Pas ela.	61.96	61.96	9.27	134.96	134.96	--------	1514
79	32.200	Pas ela.	60.75	60.75	12.15	138.36	138.36	--------	2018
80	32.000	Pas ela.	59.55	59.55	11.91	141.76	141.76	--------	2557
81	31.800	Pas ela.	58.35	58.35	11.67	145.15	145.15	--------	3095
82	31.600	Pas ela.	57.14	57.14	11.43	148.55	148.55	--------	3095
83	31.400	Pas ela.	55.94	55.94	11.19	151.94	151.94	--------	3095
84	31.200	Pas ela.	54.74	54.74	10.95	155.34	155.34	--------	3095
85	31.000	Pas ela.	53.53	53.53	10.71	158.73	158.73	--------	3095
86	30.800	Pas ela.	52.33	52.33	10.47	162.13	162.13	--------	3095
87	30.600	Pas ela.	51.12	51.12	10.22	165.53	165.53	--------	3095
88	30.400	Pas ela.	49.92	49.92	9.98	168.92	168.92	--------	3095
89	30.200	Pas ela.	48.72	48.72	9.74	172.32	172.32	--------	3095
90	30.000	Pas ela.	47.51	47.51	9.50	175.71	175.71	--------	3095
91	29.800	Pas ela.	46.31	46.31	9.26	179.11	179.11	--------	3095
92	29.600	Pas ela.	45.11	45.11	9.02	182.50	182.50	--------	3095
93	29.400	Pas ela.	43.90	43.90	8.78	185.90	185.90	--------	3095
94	29.200	Pas ela.	42.70	42.70	8.54	189.30	189.30	--------	3095
95	29.000	Pas ela.	41.50	41.50	8.30	192.69	192.69	--------	3095
96	28.800	Pas ela.	40.29	40.29	8.06	196.09	196.09	--------	3095
97	28.600	Pas ela.	39.09	39.09	5.89	199.48	199.48	--------	2321
98	28.500	Pas ela.	38.49	38.49	3.85	201.18	201.18	--------	1547
99	28.400	Pas ela.	37.89	37.89	5.66	202.88	202.88	--------	2321
100	28.200	Pas ela.	36.68	36.68	7.34	206.28	206.28	--------	3095
101	28.000	Pas ela.	35.48	0.00	3.58	209.67	0.00	--------	1547
Sum					1063.08			390.33	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= 34.85mm(G.L. 37.600m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-10.54	- - - -	- - - -
2	46.800	on exv	- - - -	-10.29	- - - -	- - - -
3	46.600	on exv	- - - -	-10.05	- - - -	- - - -
4	46.400	on exv	- - - -	-9.80	- - - -	- - - -
5	46.200	on exv	- - - -	-9.55	- - - -	- - - -
6	46.000	on exv	6818	-9.29	- - - -	Note: 0.00
7	45.800	on exv	- - - -	-9.04	- - - -	- - - -
8	45.600	on exv	- - - -	-8.77	- - - -	- - - -
9	45.400	on exv	- - - -	-8.50	- - - -	- - - -
10	45.200	on exv	- - - -	-8.21	- - - -	- - - -
11	45.000	on exv	- - - -	-7.91	- - - -	- - - -
12	44.800	on exv	- - - -	-7.59	- - - -	- - - -
13	44.600	on exv	- - - -	-7.24	- - - -	- - - -
14	44.400	on exv	- - - -	-6.86	- - - -	- - - -
15	44.200	on exv	- - - -	-6.45	- - - -	- - - -
16	44.000	on exv	- - - -	-5.99	- - - -	- - - -
17	43.800	on exv	- - - -	-5.47	- - - -	- - - -
18	43.600	on exv	- - - -	-4.90	- - - -	- - - -
19	43.400	on exv	- - - -	-4.26	- - - -	- - - -
20	43.200	on exv	- - - -	-3.54	- - - -	- - - -
21	43.000	on exv	- - - -	-2.73	- - - -	- - - -
22	42.800	on exv	- - - -	-1.81	- - - -	- - - -
23	42.600	on exv	- - - -	-0.79	- - - -	- - - -
24	42.400	on exv	- - - -	0.37	- - - -	- - - -
25	42.200	on exv	- - - -	1.67	- - - -	- - - -
26	42.000	on exv	122718	3.14	- - - -	Note: -384.77
27	41.800	on exv	- - - -	4.76	- - - -	- - - -
28	41.750	on exv	- - - -	5.20	- - - -	- - - -
29	41.600	on exv	- - - -	6.54	- - - -	- - - -
30	41.400	on exv	- - - -	8.42	- - - -	- - - -
31	41.200	on exv	- - - -	10.39	- - - -	- - - -
32	41.000	on exv	- - - -	12.42	- - - -	- - - -
33	40.800	on exv	- - - -	14.47	- - - -	- - - -
34	40.600	on exv	- - - -	16.52	- - - -	- - - -
35	40.400	on exv	- - - -	18.55	- - - -	- - - -
36	40.200	on exv	- - - -	20.53	- - - -	- - - -
37	40.000	on exv	- - - -	22.45	- - - -	- - - -
38	39.800	on exv	- - - -	24.28	- - - -	- - - -
39	39.600	on exv	- - - -	26.00	- - - -	- - - -
40	39.400	on exv	- - - -	27.60	- - - -	- - - -
41	39.200	on exv	- - - -	29.07	- - - -	- - - -
42	39.000	on exv	- - - -	30.39	- - - -	- - - -
43	38.800	on exv	- - - -	31.55	- - - -	- - - -
44	38.600	on exv	- - - -	32.54	- - - -	- - - -
45	38.500	on exv	- - - -	32.97	- - - -	- - - -
46	38.400	on exv	- - - -	33.36	- - - -	- - - -
47	38.200	on exv	- - - -	34.00	- - - -	- - - -
48	38.000	pssv pl	- - - -	34.46	8.86	- - - -
49	37.800	pssv pl	- - - -	34.74	9.97	- - - -
50	37.600	pssv pl	- - - -	34.85	11.26	- - - -
51	37.500	pssv pl	- - - -	34.84	12.14	- - - -
52	37.400	pssv pl	- - - -	34.79	12.65	- - - -
53	37.200	pssv pl	- - - -	34.56	13.30	- - - -
54	37.000	pssv pl	- - - -	34.18	7.75	- - - -
55	36.800	pssv pl	- - - -	33.66	5.97	- - - -
56	36.600	pssv pl	- - - -	33.00	6.31	- - - -
57	36.400	pssv pl	- - - -	32.21	6.64	- - - -
58	36.200	pssv pl	- - - -	31.31	6.98	- - - -
59	36.000	pssv pl	- - - -	30.31	7.32	- - - -
60	35.800	pssv pl	- - - -	29.22	7.65	- - - -
61	35.600	pssv pl	- - - -	28.06	7.99	- - - -
62	35.400	pssv pl	- - - -	26.83	8.33	- - - -
63	35.200	pssv pl	- - - -	25.56	8.66	- - - -
64	35.000	pssv pl	- - - -	24.25	9.00	- - - -
65	34.800	pssv pl	- - - -	22.91	9.34	- - - -
66	34.600	pssv pl	- - - -	21.56	9.67	- - - -
67	34.400	pssv pl	- - - -	20.21	10.01	- - - -
68	34.200	pssv pl	- - - -	18.86	10.35	- - - -
69	34.000	pssv pl	- - - -	17.54	10.68	- - - -
70	33.800	pssv pl	- - - -	16.25	11.02	- - - -
71	33.600	pssv pl	- - - -	15.00	11.35	- - - -
72	33.400	pssv pl	- - - -	13.80	11.69	- - - -
73	33.200	pssv pl	- - - -	12.65	12.03	- - - -
74	33.000	pssv el	2018	11.56	12.36	-23.33
75	32.800	pssv el	2018	10.53	12.70	-21.25
76	32.600	pssv el	1514	9.56	13.00	-14.48
77	32.500	pssv el	1009	9.11	13.21	-9.19
78	32.400	pssv el	1514	8.66	13.42	-13.12
79	32.200	pssv el	2018	7.83	13.71	-15.81
80	32.000	pssv el	2557	7.07	11.09	-18.06
81	31.800	pssv el	3095	6.36	9.38	-19.70
82	31.600	pssv el	3095	5.73	9.60	-17.73
83	31.400	pssv el	3095	5.15	9.82	-15.95
84	31.200	pssv el	3095	4.64	10.04	-14.35
85	31.000	pssv el	3095	4.17	10.26	-12.92
86	30.800	pssv el	3095	3.76	10.48	-11.64

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
87	30.600	pssv el	3095	3.39	10.70	-10.50
88	30.400	pssv el	3095	3.07	10.92	-9.49
89	30.200	pssv el	3095	2.77	11.14	-8.59
90	30.000	pssv el	3095	2.51	11.36	-7.78
91	29.800	pssv el	3095	2.28	11.57	-7.05
92	29.600	pssv el	3095	2.07	11.79	-6.39
93	29.400	pssv el	3095	1.87	12.01	-5.79
94	29.200	pssv el	3095	1.69	12.23	-5.23
95	29.000	pssv el	3095	1.52	12.45	-4.70
96	28.800	pssv el	3095	1.35	12.67	-4.19
97	28.600	pssv el	2321	1.19	12.86	-2.77
98	28.500	pssv el	1547	1.12	13.00	-1.73
99	28.400	pssv el	2321	1.04	13.14	-2.41
100	28.200	pssv el	3095	0.88	13.33	-2.73
101	28.000	pssv el	1547	0.73	13.49	-1.13
Sum						-672.75

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -276.37kN.m/m(G.L. 38.200m)
max shear force Smax= -247.24kN/m (G.L. 42.000m)
max displacement Del.xmax= 34.85mm (G.L. 37.600m)

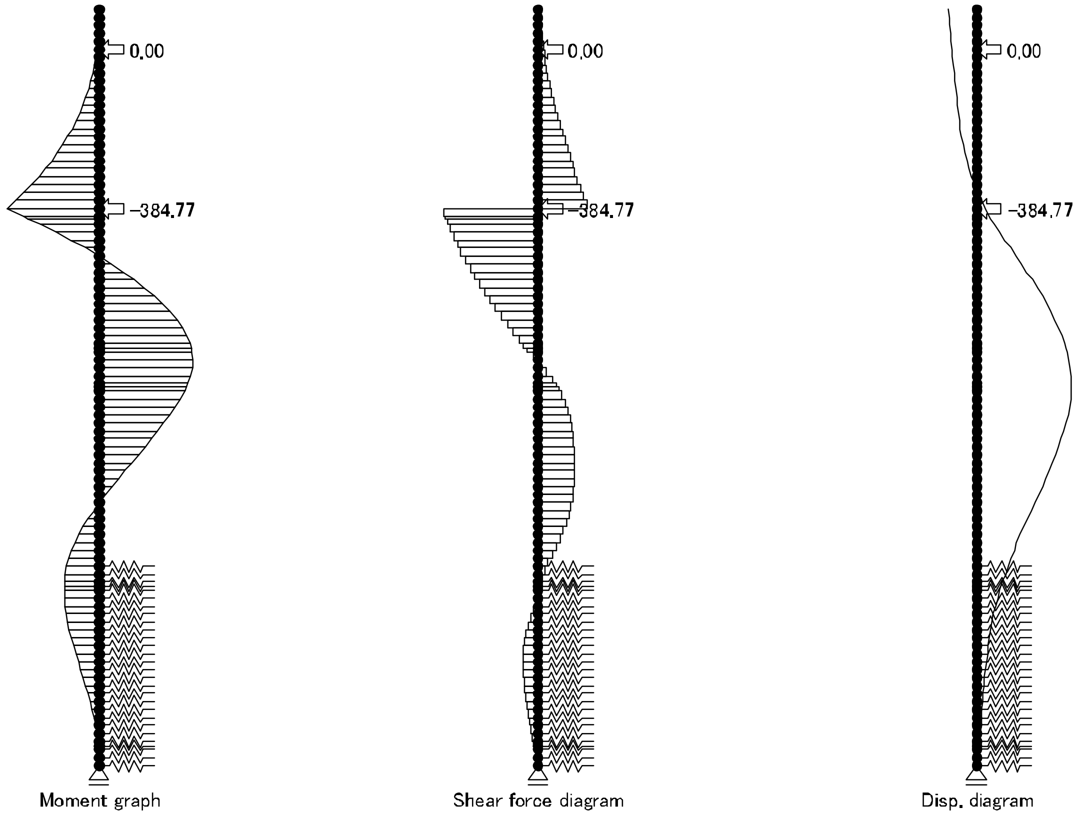
node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	1.20	-10.54	------------
2	46.800	0.24	0.24	1.20	3.77	-10.29	------------
3	46.600	0.99	0.99	3.77	6.58	-10.05	------------
4	46.400	2.31	2.31	6.58	9.64	-9.80	------------
5	46.200	4.24	4.24	9.64	12.93	-9.55	------------
6	46.000	6.82	6.82	12.93	16.46	-9.29	* 0.00
7	45.800	10.12	10.12	16.46	20.24	-9.04	------------
8	45.600	14.16	14.16	20.24	24.25	-8.77	------------
9	45.400	19.01	19.01	24.25	28.50	-8.50	------------
10	45.200	24.71	24.71	28.50	33.00	-8.21	------------
11	45.000	31.31	31.31	33.00	37.73	-7.91	------------
12	44.800	38.86	38.86	37.73	42.70	-7.59	------------
13	44.600	47.40	47.40	42.70	47.92	-7.24	------------
14	44.400	56.98	56.98	47.92	53.37	-6.86	------------
15	44.200	67.66	67.66	53.37	59.06	-6.45	------------
16	44.000	79.47	79.47	59.06	65.00	-5.99	------------
17	43.800	92.47	92.47	65.00	71.17	-5.47	------------
18	43.600	106.70	106.70	71.17	77.58	-4.90	------------
19	43.400	122.22	122.22	77.58	84.24	-4.26	------------
20	43.200	139.07	139.07	84.24	91.13	-3.54	------------
21	43.000	157.29	157.29	91.13	98.26	-2.73	------------
22	42.800	176.95	176.95	98.26	105.64	-1.81	------------
23	42.600	198.07	198.07	105.64	113.25	-0.79	------------
24	42.400	220.72	220.72	113.25	121.10	0.37	------------
25	42.200	244.94	244.94	121.10	129.20	1.67	------------
26	42.000	270.78	270.78	129.20	-247.24	3.14	* -384.77
27	41.800	221.33	221.33	-247.24	-241.91	4.76	------------
28	41.750	209.24	209.24	-241.91	-237.56	5.20	------------
29	41.600	173.60	173.60	-237.56	-229.64	6.54	------------
30	41.400	127.68	127.68	-229.64	-220.09	8.42	------------
31	41.200	83.66	83.66	-220.09	-210.03	10.39	------------
32	41.000	41.65	41.65	-210.03	-199.45	12.42	------------
33	40.800	1.76	1.76	-199.45	-188.34	14.47	------------
34	40.600	-35.91	-35.91	-188.34	-176.72	16.52	------------
35	40.400	-71.25	-71.25	-176.72	-164.58	18.55	------------
36	40.200	-104.17	-104.17	-164.58	-151.91	20.53	------------
37	40.000	-134.55	-134.55	-151.91	-138.73	22.45	------------
38	39.800	-162.30	-162.30	-138.73	-125.03	24.28	------------
39	39.600	-187.30	-187.30	-125.03	-110.80	26.00	------------
40	39.400	-209.46	-209.46	-110.80	-96.06	27.60	------------
41	39.200	-228.68	-228.68	-96.06	-80.80	29.07	------------
42	39.000	-244.83	-244.83	-80.80	-65.01	30.39	------------
43	38.800	-257.84	-257.84	-65.01	-48.71	31.55	------------
44	38.600	-267.58	-267.58	-48.71	-36.14	32.54	------------
45	38.500	-271.19	-271.19	-36.14	-27.05	32.97	------------
46	38.400	-273.90	-273.90	-27.05	-12.33	33.36	------------
47	38.200	-276.37	-276.37	-12.33	7.80	34.00	------------
48	38.000	-274.81	-274.81	7.80	25.46	34.46	------------
49	37.800	-269.71	-269.71	25.46	39.57	34.74	------------
50	37.600	-261.80	-261.80	39.57	49.56	34.85	------------
51	37.500	-256.85	-256.85	49.56	55.30	34.84	------------
52	37.400	-251.32	-251.32	55.30	62.58	34.79	------------
53	37.200	-238.80	-238.80	62.58	71.61	34.56	------------

node No	Y co GL(m)	moment kN.m/m top	bottom	shear force kN/m top	bottom	disp Del.x mm	reaction Q kN/m
54	37.000	-224.48	-224.48	71.61	79.00	34.18	------------
55	36.800	-208.68	-208.68	79.00	84.64	33.66	------------
56	36.600	-191.75	-191.75	84.64	89.35	33.00	------------
57	36.400	-173.88	-173.88	89.35	93.15	32.21	------------
58	36.200	-155.25	-155.25	93.15	96.02	31.31	------------
59	36.000	-136.04	-136.04	96.02	97.98	30.31	------------
60	35.800	-116.45	-116.45	97.98	99.02	29.22	------------
61	35.600	-96.65	-96.65	99.02	99.13	28.06	------------
62	35.400	-76.82	-76.82	99.13	98.33	26.83	------------
63	35.200	-57.15	-57.15	98.33	96.60	25.56	------------
64	35.000	-37.83	-37.83	96.60	93.96	24.25	------------
65	34.800	-19.04	-19.04	93.96	90.40	22.91	------------
66	34.600	-0.96	-0.96	90.40	85.91	21.56	------------
67	34.400	16.22	16.22	85.91	80.51	20.21	------------
68	34.200	32.32	32.32	80.51	74.19	18.86	------------
69	34.000	47.16	47.16	74.19	66.94	17.54	------------
70	33.800	60.55	60.55	66.94	58.78	16.25	------------
71	33.600	72.31	72.31	58.78	49.70	15.00	------------
72	33.400	82.25	82.25	49.70	39.70	13.80	------------
73	33.200	90.19	90.19	39.70	28.77	12.65	------------
74	33.000	95.94	95.94	28.77	18.56	11.56	-23.33
75	32.800	99.65	99.65	18.56	10.18	10.53	-21.25
76	32.600	101.69	101.69	10.18	5.20	9.56	-14.48
77	32.500	102.21	102.21	5.20	2.26	9.11	-9.19
78	32.400	102.43	102.43	2.26	-1.58	8.66	-13.12
79	32.200	102.12	102.12	-1.58	-5.24	7.83	-15.81
80	32.000	101.07	101.07	-5.24	-11.39	7.07	-18.06
81	31.800	98.79	98.79	-11.39	-19.42	6.36	-19.70
82	31.600	94.91	94.91	-19.42	-25.72	5.73	-17.73
83	31.400	89.76	89.76	-25.72	-30.48	5.15	-15.95
84	31.200	83.66	83.66	-30.48	-33.88	4.64	-14.35
85	31.000	76.89	76.89	-33.88	-36.09	4.17	-12.92
86	30.800	69.67	69.67	-36.09	-37.26	3.76	-11.64
87	30.600	62.22	62.22	-37.26	-37.54	3.39	-10.50
88	30.400	54.71	54.71	-37.54	-37.04	3.07	-9.49
89	30.200	47.30	47.30	-37.04	-35.88	2.77	-8.59
90	30.000	40.12	40.12	-35.88	-34.16	2.51	-7.78
91	29.800	33.29	33.29	-34.16	-31.95	2.28	-7.05
92	29.600	26.90	26.90	-31.95	-29.32	2.07	-6.39
93	29.400	21.04	21.04	-29.32	-26.33	1.87	-5.79
94	29.200	15.77	15.77	-26.33	-23.02	1.69	-5.23
95	29.000	11.17	11.17	-23.02	-19.41	1.52	-4.70
96	28.800	7.28	7.28	-19.41	-15.54	1.35	-4.19
97	28.600	4.18	4.18	-15.54	-12.43	1.19	-2.77
98	28.500	2.93	2.93	-12.43	-10.31	1.12	-1.73
99	28.400	1.90	1.90	-10.31	-7.06	1.04	-2.41
100	28.200	0.49	0.49	-7.06	-2.45	0.88	-2.73
101	28.000	0.00	----------	-2.45	----------	0.73	-1.13

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -276.37kN m/m(G.L. 38.200m)
max shear force Smax= -247.24kN/m (G.L. 42.000m)
max displacement Del.xmax= 34.85mm (G.L. 37.600m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	276.37	0.00	247.24

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	154	216	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	11	99	OK

4.3.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
0.00	3.600	0.00

3) stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
0	176	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
384.77	1.800	692.59

3) stress

$$Sig. = \frac{P^* \cdot 10^3}{n^* A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
157	176	OK

4.3.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H|150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$M = \frac{P*L}{10}$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
0.00	3.600	0.00

3)stress

$Sig. = \frac{M*10^6}{Z*10^3} <= Sig.a$

Z: section modulus (= 216* 2cm3)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
0	140	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H|200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$M = \frac{P*L}{10}$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
692.59	1.800	124.67

3)stress

$Sig. = \frac{M*10^6}{Z*10^3} <= Sig.a$

Z: section modulus (= 472* 2cm3)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
132	140	OK

4.4 riverside sheet pile

4.4.1 Calculation of embedment length

(1) result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.500(m)
L.WL : 39.000(m)

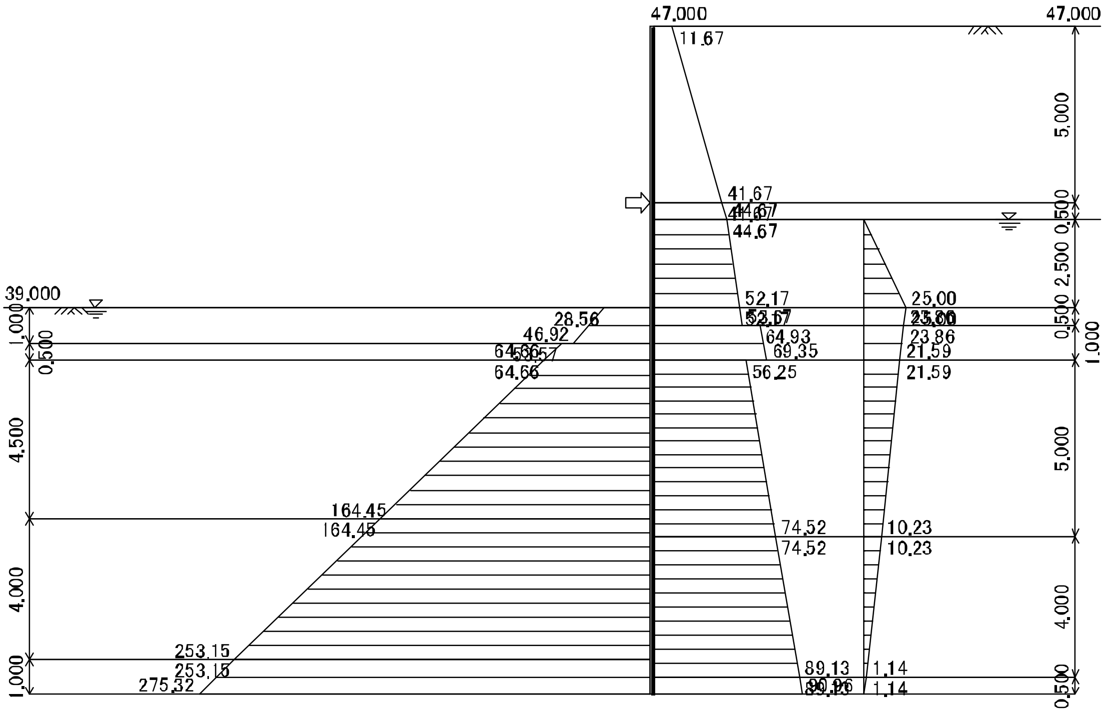
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	31.780	28.000
active sd	Ma+Mw+Mac(kN.m/m)	3996.83	8289.53
passive sd	Mp+Mpc(kN.m/m)	5997.28	16781.61
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.501>=1.50	2.024>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.500	0.500	41.67 44.67	21.58	0.253	5.46
2	41.500 39.000	2.500	44.67 52.17	121.04	1.782	215.73
3	39.000 38.500	0.500	52.17 53.67	26.46	3.251	86.02
4	38.500 37.500	1.000	64.93 69.35	67.14	4.005	268.92
5	37.500 32.500	5.000	56.25 74.52	326.93	7.116	2326.57
6	32.500 28.500	4.000	74.52 89.13	327.29	11.560	3783.37
7	28.500 28.000	0.500	89.13 90.96	45.02	13.751	619.08
Sum				935.47		7305.15

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.500 39.000	2.500	0.00 25.00	31.25	2.167	67.71
2	39.000 38.500	0.500	25.00 23.86	12.22	3.248	39.68
3	38.500 37.500	1.000	23.86 21.59	22.73	3.992	90.72
4	37.500 32.500	5.000	21.59 10.23	79.55	6.702	533.14
5	32.500 28.500	4.000	10.23 1.14	22.73	10.967	249.24
6	28.500 28.000	0.500	1.14 0.00	0.28	13.667	3.88
Sum				168.75		984.37

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	28.56 46.92	37.74	3.541	133.62
2	38.000 37.500	0.500	53.57 64.66	29.56	4.258	125.85
3	37.500 33.000	4.500	64.66 164.45	515.48	7.077	3647.87
4	33.000 29.000	4.000	164.45 253.15	835.18	11.142	9305.27
5	29.000 28.000	1.000	253.15 275.32	264.23	13.507	3569.00
Sum				1682.19		16781.61

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

4.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-187.80	G.L. 42.000
max shear force Smax(kN/m)	179.75	G.L. 42.000
upper tension mbr rct R1(kN/m)	20.75	G.L. 46.000
lower tension mbr rct R2(kN/m)	296.54	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 42.000	11.67 41.67	0.00 0.00	---- ----	---- ----	11.67 41.67	---- ----
2	42.000 41.500	41.67 44.67	0.00 0.00	---- ----	---- ----	41.67 44.67	---- ----
3	41.500 39.000	44.67 52.17	0.00 25.00	---- ----	---- ----	44.67 77.17	---- ----
4	39.000 38.500	52.17 53.67	25.00 23.86	28.56 37.74	0.00 2.96	77.17 74.57	28.56 34.78
5	38.500 38.000	64.93 67.14	23.86 22.73	37.74 46.92	2.96 5.92	85.84 83.94	34.78 41.00
6	38.000 37.500	67.14 69.35	22.73 21.59	53.57 64.66	5.20 7.79	84.67 83.14	48.37 56.86
7	37.500 33.000	56.25 72.69	21.59 11.36	64.66 164.45	7.79 31.18	70.05 52.88	56.86 133.27
8	33.000 32.500	72.69 74.52	11.36 10.23	164.45 175.53	31.18 33.78	52.88 50.97	133.27 141.76
9	32.500 29.000	74.52 87.30	10.23 2.27	175.53 253.15	33.78 51.96	50.97 37.61	141.76 201.18
10	29.000 28.500	87.30 89.13	2.27 1.14	253.15 264.23	51.96 54.56	37.61 35.70	201.18 209.67
11	28.500 28.000	89.13 90.96	1.14 0.00	264.23 275.32	54.56 57.16	35.70 33.79	209.67 218.16

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta^* \frac{1}{0.3} {}^* Alpha\ Eo^* \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	39.000	38.000	1.000	14000	3364
2	38.000	37.500	0.500	42000	10092
3	37.500	33.000	4.500	42000	10092
4	33.000	29.000	4.000	64400	15474
5	29.000	21.000	8.000	106400	25566

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.^*(2^*number^*A^*E)}{(L^*s)}$$

where,

FORUM8

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000] m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
wall section (filling soil). back and active side pressure are considered. no ground spring.

* passive elastic
in embedment section, displacement on excavation side is within limit displacement.
effective active side prss from back is considered. ground springs exist. no exv load.

* passive plastic
in embedment section, displacement on excavation side exceeds limit displacement.
effective active side prss from back is considered. no ground spring. exv load exists

* active elastic
in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	11.67	1.20	--------	--------	--------	--------
2	46.800	On excavation plane	12.87	12.87	2.57	--------	--------	--------	--------
3	46.600	On excavation plane	14.07	14.07	2.81	--------	--------	--------	--------
4	46.400	On excavation plane	15.27	15.27	3.05	--------	--------	--------	--------
5	46.200	On excavation plane	16.47	16.47	3.29	--------	--------	--------	--------
6	46.000	Tensile member	17.67	17.67	3.53	--------	--------	--------	6818
7	45.800	On excavation plane	18.87	18.87	3.77	--------	--------	--------	--------
8	45.600	On excavation plane	20.07	20.07	4.01	--------	--------	--------	--------
9	45.400	On excavation plane	21.27	21.27	4.25	--------	--------	--------	--------
10	45.200	On excavation plane	22.47	22.47	4.49	--------	--------	--------	--------
11	45.000	On excavation plane	23.67	23.67	4.73	--------	--------	--------	--------
12	44.800	On excavation plane	24.87	24.87	4.97	--------	--------	--------	--------
13	44.600	On excavation plane	26.07	26.07	5.21	--------	--------	--------	--------
14	44.400	On excavation plane	27.27	27.27	5.45	--------	--------	--------	--------
15	44.200	On excavation plane	28.47	28.47	5.69	--------	--------	--------	--------
16	44.000	On excavation plane	29.67	29.67	5.93	--------	--------	--------	--------
17	43.800	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
18	43.600	On excavation plane	32.07	32.07	6.41	--------	--------	--------	--------
19	43.400	On excavation plane	33.27	33.27	6.65	--------	--------	--------	--------
20	43.200	On excavation plane	34.47	34.47	6.89	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN m
			above nd kN m2	below nd kN m2	cntrt ld kN m2	above nd kN m2	below nd kN m2	cntrt ld kN m2	
21	43.000	On excavation plane	35.67	35.67	7.13	--------	--------	--------	--------
22	42.800	On excavation plane	36.87	36.87	7.37	--------	--------	--------	--------
23	42.600	On excavation plane	38.07	38.07	7.61	--------	--------	--------	--------
24	42.400	On excavation plane	39.27	39.27	7.85	--------	--------	--------	--------
25	42.200	On excavation plane	40.47	40.47	8.09	--------	--------	--------	--------
26	42.000	Tensile member	41.67	41.67	8.33	--------	--------	--------	122718
27	41.800	On excavation plane	42.87	42.87	8.57	--------	--------	--------	--------
28	41.600	On excavation plane	44.07	44.07	6.59	--------	--------	--------	--------
29	41.500	On excavation plane	44.67	44.67	4.48	--------	--------	--------	--------
30	41.400	On excavation plane	45.97	45.97	6.94	--------	--------	--------	--------
31	41.200	On excavation plane	48.57	48.57	9.71	--------	--------	--------	--------
32	41.000	On excavation plane	51.17	51.17	10.23	--------	--------	--------	--------
33	40.800	On excavation plane	53.77	53.77	10.75	--------	--------	--------	--------
34	40.600	On excavation plane	56.37	56.37	11.27	--------	--------	--------	--------
35	40.400	On excavation plane	58.97	58.97	11.79	--------	--------	--------	--------
36	40.200	On excavation plane	61.57	61.57	12.31	--------	--------	--------	--------
37	40.000	On excavation plane	64.17	64.17	12.83	--------	--------	--------	--------
38	39.800	On excavation plane	66.77	66.77	13.35	--------	--------	--------	--------
39	39.600	On excavation plane	69.37	69.37	13.87	--------	--------	--------	--------
40	39.400	On excavation plane	71.97	71.97	14.39	--------	--------	--------	--------
41	39.200	On excavation plane	74.57	74.57	14.91	--------	--------	--------	--------
42	39.000	Pa plas.	77.17	77.17	15.34	0.00	28.56	2.92	--------
43	38.800	Pa plas.	76.13	76.13	15.23	31.05	31.05	6.21	--------
44	38.600	Pa plas.	75.09	75.09	11.28	33.54	33.54	4.98	--------
45	38.500	Pa plas.	74.57	85.84	8.02	34.78	34.78	3.48	--------
46	38.400	Pa plas.	85.46	85.46	12.80	36.02	36.02	5.45	--------
47	38.200	Pa plas.	84.70	84.70	16.94	38.51	38.51	7.70	--------
48	38.000	Pa plas.	83.94	84.67	16.87	41.00	48.37	8.96	--------
49	37.800	Pa plas.	84.06	84.06	16.81	51.77	51.77	10.35	--------
50	37.600	Pa plas.	83.45	83.45	12.53	55.16	55.16	8.21	--------
51	37.500	Pa plas.	83.14	70.05	7.66	56.86	56.86	5.69	--------
52	37.400	Pa plas.	69.67	69.67	10.44	58.56	58.56	8.85	--------
53	37.200	Pa plas.	68.91	68.91	13.78	61.96	61.96	12.39	--------
54	37.000	Pa plas.	68.14	68.14	13.63	65.35	65.35	13.07	--------
55	36.800	Pa plas.	67.38	67.38	13.48	68.75	68.75	13.75	--------
56	36.600	Pa plas.	66.62	66.62	13.32	72.14	72.14	14.43	--------
57	36.400	Pa plas.	65.85	65.85	13.17	75.54	75.54	15.11	--------
58	36.200	Pa plas.	65.09	65.09	13.02	78.93	78.93	15.79	--------
59	36.000	Pa plas.	64.33	64.33	12.87	82.33	82.33	16.47	--------
60	35.800	Pa plas.	63.56	63.56	12.71	85.73	85.73	17.15	--------
61	35.600	Pa plas.	62.80	62.80	12.56	89.12	89.12	17.82	--------
62	35.400	Pa plas.	62.04	62.04	12.41	92.52	92.52	18.50	--------
63	35.200	Pas ela.	61.27	61.27	12.25	95.91	95.91	--------	2018

node No	Y co GL(m)	state	back side load above nd kN m2	below nd kN m2	cntrt ld kN m2	excavation side load above nd kN m2	below nd kN m2	cntrt ld kN m2	soil spring kN m
64	35.000	Pas ela.	60.51	60.51	12.10	99.31	99.31	--------	2018
65	34.800	Pas ela.	59.75	59.75	11.95	102.70	102.70	--------	2018
66	34.600	Pas ela.	58.98	58.98	11.80	106.10	106.10	--------	2018
67	34.400	Pas ela.	58.22	58.22	11.64	109.50	109.50	--------	2018
68	34.200	Pas ela.	57.46	57.46	11.49	112.89	112.89	--------	2018
69	34.000	Pas ela.	56.69	56.69	11.34	116.29	116.29	--------	2018
70	33.800	Pas ela.	55.93	55.93	11.19	119.68	119.68	--------	2018
71	33.600	Pas ela.	55.17	55.17	11.03	123.08	123.08	--------	2018
72	33.400	Pas ela.	54.40	54.40	10.88	126.47	126.47	--------	2018
73	33.200	Pas ela.	53.64	53.64	10.73	129.87	129.87	--------	2018
74	33.000	Pas ela.	52.88	52.88	10.58	133.27	133.27	--------	2557
75	32.800	Pas ela.	52.11	52.11	10.42	136.66	136.66	--------	3095
76	32.600	Pas ela.	51.35	51.35	7.72	140.06	140.06	--------	2321
77	32.500	Pas ela.	50.97	50.97	5.10	141.76	141.76	--------	1547
78	32.400	Pas ela.	50.59	50.59	7.57	143.45	143.45	--------	2321
79	32.200	Pas ela.	49.82	49.82	9.96	146.85	146.85	--------	3095
80	32.000	Pas ela.	49.06	49.06	9.81	150.25	150.25	--------	3095
81	31.800	Pas ela.	48.30	48.30	9.66	153.64	153.64	--------	3095
82	31.600	Pas ela.	47.53	47.53	9.51	157.04	157.04	--------	3095
83	31.400	Pas ela.	46.77	46.77	9.35	160.43	160.43	--------	3095
84	31.200	Pas ela.	46.01	46.01	9.20	163.83	163.83	--------	3095
85	31.000	Pas ela.	45.24	45.24	9.05	167.22	167.22	--------	3095
86	30.800	Pas ela.	44.48	44.48	8.90	170.62	170.62	--------	3095
87	30.600	Pas ela.	43.72	43.72	8.74	174.02	174.02	--------	3095
88	30.400	Pas ela.	42.95	42.95	8.59	177.41	177.41	--------	3095
89	30.200	Pas ela.	42.19	42.19	8.44	180.81	180.81	--------	3095
90	30.000	Pas ela.	41.43	41.43	8.29	184.20	184.20	--------	3095
91	29.800	Pas ela.	40.66	40.66	8.13	187.60	187.60	--------	3095
92	29.600	Pas ela.	39.90	39.90	7.98	190.99	190.99	--------	3095
93	29.400	Pas ela.	39.14	39.14	7.83	194.39	194.39	--------	3095
94	29.200	Pas ela.	38.37	38.37	7.67	197.79	197.79	--------	3095
95	29.000	Pas ela.	37.61	37.61	7.52	201.18	201.18	--------	4104
96	28.800	Pas ela.	36.85	36.85	7.37	204.58	204.58	--------	5113
97	28.600	Pas ela.	36.08	36.08	5.43	207.97	207.97	--------	3835
98	28.500	Pas ela.	35.70	35.70	3.57	209.67	209.67	--------	2557
99	28.400	Pas ela.	35.32	35.32	5.28	211.37	211.37	--------	3835
100	28.200	Pas ela.	34.56	34.56	6.91	214.76	214.76	--------	5113
101	28.000	Pas ela.	33.79	0.00	3.40	218.16	0.00	--------	2557
Sum					922.81			227.27	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= -14.17mm(G.L. 38.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-4.16	- - - -	- - - -
2	46.800	on exv	- - - -	-3.94	- - - -	- - - -
3	46.600	on exv	- - - -	-3.71	- - - -	- - - -
4	46.400	on exv	- - - -	-3.49	- - - -	- - - -
5	46.200	on exv	- - - -	-3.26	- - - -	- - - -
6	46.000	on exv	6818	-3.04	- - - -	Note: 20.75
7	45.800	on exv	- - - -	-2.83	- - - -	- - - -
8	45.600	on exv	- - - -	-2.61	- - - -	- - - -
9	45.400	on exv	- - - -	-2.41	- - - -	- - - -
10	45.200	on exv	- - - -	-2.20	- - - -	- - - -
11	45.000	on exv	- - - -	-2.00	- - - -	- - - -
12	44.800	on exv	- - - -	-1.81	- - - -	- - - -
13	44.600	on exv	- - - -	-1.63	- - - -	- - - -
14	44.400	on exv	- - - -	-1.46	- - - -	- - - -
15	44.200	on exv	- - - -	-1.31	- - - -	- - - -
16	44.000	on exv	- - - -	-1.17	- - - -	- - - -
17	43.800	on exv	- - - -	-1.06	- - - -	- - - -
18	43.600	on exv	- - - -	-0.98	- - - -	- - - -
19	43.400	on exv	- - - -	-0.94	- - - -	- - - -
20	43.200	on exv	- - - -	-0.94	- - - -	- - - -
21	43.000	on exv	- - - -	-1.00	- - - -	- - - -
22	42.800	on exv	- - - -	-1.11	- - - -	- - - -
23	42.600	on exv	- - - -	-1.30	- - - -	- - - -
24	42.400	on exv	- - - -	-1.57	- - - -	- - - -
25	42.200	on exv	- - - -	-1.94	- - - -	- - - -
26	42.000	on exv	122718	-2.42	- - - -	Note: 296.54
27	41.800	on exv	- - - -	-3.01	- - - -	- - - -
28	41.600	on exv	- - - -	-3.70	- - - -	- - - -
29	41.500	on exv	- - - -	-4.07	- - - -	- - - -
30	41.400	on exv	- - - -	-4.46	- - - -	- - - -
31	41.200	on exv	- - - -	-5.29	- - - -	- - - -
32	41.000	on exv	- - - -	-6.14	- - - -	- - - -
33	40.800	on exv	- - - -	-7.02	- - - -	- - - -
34	40.600	on exv	- - - -	-7.89	- - - -	- - - -
35	40.400	on exv	- - - -	-8.75	- - - -	- - - -
36	40.200	on exv	- - - -	-9.58	- - - -	- - - -
37	40.000	on exv	- - - -	-10.36	- - - -	- - - -
38	39.800	on exv	- - - -	-11.09	- - - -	- - - -
39	39.600	on exv	- - - -	-11.76	- - - -	- - - -
40	39.400	on exv	- - - -	-12.35	- - - -	- - - -
41	39.200	on exv	- - - -	-12.86	- - - -	- - - -
42	39.000	pssv pl	- - - -	-13.29	8.68	- - - -
43	38.800	pssv pl	- - - -	-13.64	9.23	- - - -
44	38.600	pssv pl	- - - -	-13.90	9.88	- - - -
45	38.500	pssv pl	- - - -	-14.00	10.34	- - - -
46	38.400	pssv pl	- - - -	-14.07	10.80	- - - -
47	38.200	pssv pl	- - - -	-14.16	11.45	- - - -
48	38.000	pssv pl	- - - -	-14.17	6.66	- - - -
49	37.800	pssv pl	- - - -	-14.10	5.13	- - - -
50	37.600	pssv pl	- - - -	-13.96	5.42	- - - -
51	37.500	pssv pl	- - - -	-13.87	5.63	- - - -
52	37.400	pssv pl	- - - -	-13.76	5.84	- - - -
53	37.200	pssv pl	- - - -	-13.49	6.14	- - - -
54	37.000	pssv pl	- - - -	-13.18	6.48	- - - -
55	36.800	pssv pl	- - - -	-12.81	6.81	- - - -
56	36.600	pssv pl	- - - -	-12.41	7.15	- - - -
57	36.400	pssv pl	- - - -	-11.98	7.49	- - - -
58	36.200	pssv pl	- - - -	-11.53	7.82	- - - -
59	36.000	pssv pl	- - - -	-11.05	8.16	- - - -
60	35.800	pssv pl	- - - -	-10.57	8.49	- - - -
61	35.600	pssv pl	- - - -	-10.08	8.83	- - - -
62	35.400	pssv pl	- - - -	-9.59	9.17	- - - -
63	35.200	pssv el	2018	-9.10	9.50	18.37
64	35.000	pssv el	2018	-8.63	9.84	17.41
65	34.800	pssv el	2018	-8.16	10.18	16.48
66	34.600	pssv el	2018	-7.71	10.51	15.57
67	34.400	pssv el	2018	-7.28	10.85	14.69
68	34.200	pssv el	2018	-6.86	11.19	13.86
69	34.000	pssv el	2018	-6.47	11.52	13.05
70	33.800	pssv el	2018	-6.09	11.86	12.29
71	33.600	pssv el	2018	-5.73	12.20	11.56
72	33.400	pssv el	2018	-5.39	12.53	10.88
73	33.200	pssv el	2018	-5.07	12.87	10.23
74	33.000	pssv el	2557	-4.77	10.43	12.20
75	32.800	pssv el	3095	-4.49	8.83	13.90
76	32.600	pssv el	2321	-4.23	9.02	9.83
77	32.500	pssv el	1547	-4.11	9.16	6.36
78	32.400	pssv el	2321	-3.99	9.30	9.27
79	32.200	pssv el	3095	-3.77	9.49	11.68
80	32.000	pssv el	3095	-3.57	9.71	11.06
81	31.800	pssv el	3095	-3.39	9.93	10.48
82	31.600	pssv el	3095	-3.22	10.15	9.96
83	31.400	pssv el	3095	-3.06	10.37	9.47
84	31.200	pssv el	3095	-2.92	10.59	9.03
85	31.000	pssv el	3095	-2.78	10.81	8.61
86	30.800	pssv el	3095	-2.66	11.03	8.23

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
87	30.600	pssv el	3095	-2.54	11.25	7.86
88	30.400	pssv el	3095	-2.43	11.47	7.52
89	30.200	pssv el	3095	-2.32	11.68	7.18
90	30.000	pssv el	3095	-2.22	11.90	6.86
91	29.800	pssv el	3095	-2.11	12.12	6.54
92	29.600	pssv el	3095	-2.01	12.34	6.23
93	29.400	pssv el	3095	-1.91	12.56	5.92
94	29.200	pssv el	3095	-1.81	12.78	5.61
95	29.000	pssv el	4104	-1.71	9.80	7.03
96	28.800	pssv el	5113	-1.61	8.00	8.24
97	28.600	pssv el	3835	-1.51	8.12	5.80
98	28.500	pssv el	2557	-1.46	8.20	3.74
99	28.400	pssv el	3835	-1.41	8.28	5.42
100	28.200	pssv el	5113	-1.31	8.40	6.71
101	28.000	pssv el	2557	-1.21	8.50	3.10
Sum						695.53

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -187.80kN m/m(G.L. 42.000m)
max shear force Smax= 179.75kN m (G.L. 42.000m)
max displacement Del.xmax= -14.17mm (G.L. 38.000m)

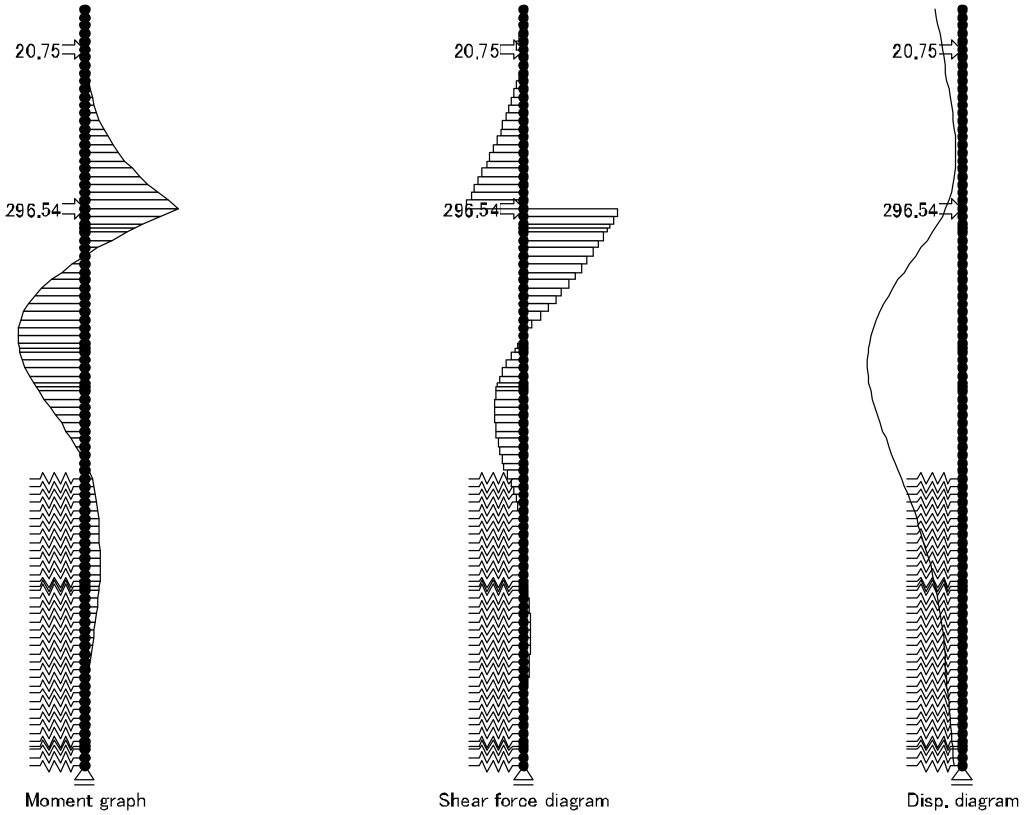
node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-1.20	-4.16	------------
2	46.800	-0.24	-0.24	-1.20	-3.77	-3.94	------------
3	46.600	-0.99	-0.99	-3.77	-6.58	-3.71	------------
4	46.400	-2.31	-2.31	-6.58	-9.64	-3.49	------------
5	46.200	-4.24	-4.24	-9.64	-12.93	-3.26	------------
6	46.000	-6.82	-6.82	-12.93	4.28	-3.04	* 20.75
7	45.800	-5.97	-5.97	4.28	0.51	-2.83	------------
8	45.600	-5.86	-5.86	0.51	-3.50	-2.61	------------
9	45.400	-6.57	-6.57	-3.50	-7.76	-2.41	------------
10	45.200	-8.12	-8.12	-7.76	-12.25	-2.20	------------
11	45.000	-10.57	-10.57	-12.25	-16.98	-2.00	------------
12	44.800	-13.96	-13.96	-16.98	-21.96	-1.81	------------
13	44.600	-18.36	-18.36	-21.96	-27.17	-1.63	------------
14	44.400	-23.79	-23.79	-27.17	-32.62	-1.46	------------
15	44.200	-30.31	-30.31	-32.62	-38.32	-1.31	------------
16	44.000	-37.98	-37.98	-38.32	-44.25	-1.17	------------
17	43.800	-46.83	-46.83	-44.25	-50.42	-1.06	------------
18	43.600	-56.91	-56.91	-50.42	-56.84	-0.98	------------
19	43.400	-68.28	-68.28	-56.84	-63.49	-0.94	------------
20	43.200	-80.98	-80.98	-63.49	-70.38	-0.94	------------
21	43.000	-95.05	-95.05	-70.38	-77.52	-1.00	------------
22	42.800	-110.56	-110.56	-77.52	-84.89	-1.11	------------
23	42.600	-127.54	-127.54	-84.89	-92.50	-1.30	------------
24	42.400	-146.04	-146.04	-92.50	-100.36	-1.57	------------
25	42.200	-166.11	-166.11	-100.36	-108.45	-1.94	------------
26	42.000	-187.80	-187.80	-108.45	179.75	-2.42	* 296.54
27	41.800	-151.85	-151.85	179.75	171.18	-3.01	------------
28	41.600	-117.61	-117.61	171.18	164.59	-3.70	------------
29	41.500	-101.15	-101.15	164.59	160.12	-4.07	------------
30	41.400	-85.14	-85.14	160.12	153.17	-4.46	------------
31	41.200	-54.51	-54.51	153.17	143.46	-5.29	------------
32	41.000	-25.81	-25.81	143.46	133.23	-6.14	------------
33	40.800	0.83	0.83	133.23	122.47	-7.02	------------
34	40.600	25.33	25.33	122.47	111.20	-7.89	------------
35	40.400	47.57	47.57	111.20	99.41	-8.75	------------
36	40.200	67.45	67.45	99.41	87.09	-9.58	------------
37	40.000	84.87	84.87	87.09	74.26	-10.36	------------
38	39.800	99.72	99.72	74.26	60.91	-11.09	------------
39	39.600	111.90	111.90	60.91	47.03	-11.76	------------
40	39.400	121.31	121.31	47.03	32.64	-12.35	------------
41	39.200	127.84	127.84	32.64	17.73	-12.86	------------
42	39.000	131.38	131.38	17.73	5.30	-13.29	------------
43	38.800	132.44	132.44	5.30	-3.71	-13.64	------------
44	38.600	131.70	131.70	-3.71	-10.01	-13.90	------------
45	38.500	130.70	130.70	-10.01	-14.55	-14.00	------------
46	38.400	129.24	129.24	-14.55	-21.91	-14.07	------------
47	38.200	124.86	124.86	-21.91	-31.15	-14.16	------------
48	38.000	118.63	118.63	-31.15	-39.05	-14.17	------------
49	37.800	110.82	110.82	-39.05	-45.51	-14.10	------------
50	37.600	101.72	101.72	-45.51	-49.83	-13.96	------------
51	37.500	96.74	96.74	-49.83	-51.80	-13.87	------------
52	37.400	91.56	91.56	-51.80	-53.39	-13.76	------------
53	37.200	80.88	80.88	-53.39	-54.78	-13.49	------------

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
54	37.000	69.92	69.92	-54.78	-55.34	-13.18	------------
55	36.800	58.86	58.86	-55.34	-55.06	-12.81	------------
56	36.600	47.84	47.84	-55.06	-53.96	-12.41	------------
57	36.400	37.05	37.05	-53.96	-52.02	-11.98	------------
58	36.200	26.65	26.65	-52.02	-49.25	-11.53	------------
59	36.000	16.80	16.80	-49.25	-45.65	-11.05	------------
60	35.800	7.67	7.67	-45.65	-41.22	-10.57	------------
61	35.600	-0.58	-0.58	-41.22	-35.95	-10.08	------------
62	35.400	-7.77	-7.77	-35.95	-29.86	-9.59	------------
63	35.200	-13.74	-13.74	-29.86	-23.74	-9.10	18.37
64	35.000	-18.49	-18.49	-23.74	-18.43	-8.63	17.41
65	34.800	-22.17	-22.17	-18.43	-13.90	-8.16	16.48
66	34.600	-24.95	-24.95	-13.90	-10.13	-7.71	15.57
67	34.400	-26.98	-26.98	-10.13	-7.08	-7.28	14.69
68	34.200	-28.39	-28.39	-7.08	-4.71	-6.86	13.86
69	34.000	-29.34	-29.34	-4.71	-3.00	-6.47	13.05
70	33.800	-29.94	-29.94	-3.00	-1.89	-6.09	12.29
71	33.600	-30.32	-30.32	-1.89	-1.36	-5.73	11.56
72	33.400	-30.59	-30.59	-1.36	-1.36	-5.39	10.88
73	33.200	-30.86	-30.86	-1.36	-1.86	-5.07	10.23
74	33.000	-31.23	-31.23	-1.86	-0.23	-4.77	12.20
75	32.800	-31.28	-31.28	-0.23	3.25	-4.49	13.90
76	32.600	-30.63	-30.63	3.25	5.35	-4.23	9.83
77	32.500	-30.09	-30.09	5.35	6.62	-4.11	6.36
78	32.400	-29.43	-29.43	6.62	8.32	-3.99	9.27
79	32.200	-27.77	-27.77	8.32	10.03	-3.77	11.68
80	32.000	-25.76	-25.76	10.03	11.28	-3.57	11.06
81	31.800	-23.51	-23.51	11.28	12.10	-3.39	10.48
82	31.600	-21.09	-21.09	12.10	12.55	-3.22	9.96
83	31.400	-18.58	-18.58	12.55	12.67	-3.06	9.47
84	31.200	-16.04	-16.04	12.67	12.50	-2.92	9.03
85	31.000	-13.54	-13.54	12.50	12.06	-2.78	8.61
86	30.800	-11.13	-11.13	12.06	11.39	-2.66	8.23
87	30.600	-8.85	-8.85	11.39	10.51	-2.54	7.86
88	30.400	-6.75	-6.75	10.51	9.43	-2.43	7.52
89	30.200	-4.87	-4.87	9.43	8.18	-2.32	7.18
90	30.000	-3.23	-3.23	8.18	6.75	-2.22	6.86
91	29.800	-1.88	-1.88	6.75	5.16	-2.11	6.54
92	29.600	-0.85	-0.85	5.16	3.42	-2.01	6.23
93	29.400	-0.16	-0.16	3.42	1.51	-1.91	5.92
94	29.200	0.14	0.14	1.51	-0.56	-1.81	5.61
95	29.000	0.03	0.03	-0.56	-1.05	-1.71	7.03
96	28.800	-0.18	-0.18	-1.05	-0.17	-1.61	8.24
97	28.600	-0.22	-0.22	-0.17	0.20	-1.51	5.80
98	28.500	-0.20	-0.20	0.20	0.37	-1.46	3.74
99	28.400	-0.16	-0.16	0.37	0.50	-1.41	5.42
100	28.200	-0.06	-0.06	0.50	0.30	-1.31	6.71
101	28.000	0.00	----------	0.30	----------	-1.21	3.10

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -187.80kN m/m (G.L. 42.000m)
max shear force Smax= 179.75kN m (G.L. 42.000m)
max displacement Del.xmax= -14.17mm (G.L. 38.000m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	187.80	0.00	179.75

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \le Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	104	216	OK

(4) shear stress

$$Tau = \frac{S}{A} \le Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	8	99	OK

4.4.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
20.75	3.600	74.69

3) stress

$$\mathrm{Sig.} = \frac{P^* \ 10^3}{n^* \ A} \ \ \text{<=Sig.a}$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
152	176	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,'£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
296.54	1.800	533.77

3) stress

$$\mathrm{Sig.} = \frac{P^* \ 10^3}{n^* \ A} \ \ \text{<=Sig.a}$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
121	176	OK

4.4.5 Waling member stress

(1) Upper stage Wailing check

1) member in use

steel material in use : H | 150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 3.600(m)

2) moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
74.69	3.600	26.89

3) stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \quad <= Sig.a$$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
62	140	OK

(2) Lower stage Wailing check

1) member in use

steel material in use : H | 200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2) moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
533.77	1.800	96.08

3) stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \quad <= Sig.a$$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
102	140	OK

5 Check case (earthquake time)

5.1 calculation of external forces

design seismicity during an earthquake : Kh= 0.04

design seismicity method: river standard equation

$$Kh' = \frac{Gam\ sat}{Gam\ sat - Gam\ w} * Kh$$

where,

Gam sat: soil saturated weight

Gam w : water unit weight

5.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1)water pressure table(riverside section: working external force)

H.W.L. 40.000(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	40.000 39.000	1.000	0.00 10.00
2	39.000 38.750	0.250	10.00 12.50
3	38.750 38.000	0.750	12.50 20.00
4	38.000 37.500	0.500	20.00 25.00
5	37.500 33.000	4.500	25.00 19.08
6	33.000 29.000	4.000	19.08 13.82
7	29.000 28.000	1.000	13.82 12.50

(2)active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h)+ q)- 2c*Sqrt(Ka)

$$Ka= \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1+ Sqrt\{\sin(Phi) * \sin(Phi - Theta)/ \cos(Theta)\}]^2}$$

in case of clay, Kh= 0 in 10m below GL and active earth pressure is linearly estimated

Kh = 0 for clay in 10m below GL.

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	39.000 38.750	0.250	9.0	20.00	10.0 10.0	0.00 2.25	0.0844 0.0844	4.83 4.83	0.555 0.555	0.00 0.00
2	38.750 38.000	0.750	9.0	20.00	10.0 10.0	2.25 9.00	0.0844 0.0844	4.83 4.83	0.555 0.555	0.00 0.00
3	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
4	37.500 35.739	1.761	9.0	25.00	10.0 10.0	13.50 29.35	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
5	35.739 33.000	2.739	9.0	25.00	10.0 10.0	29.35 54.00	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 11.44
6	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	0.0844 0.0844	4.83 4.83	0.464 0.464	11.44 28.16
7	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	0.0844 0.0844	4.83 4.83	0.464 0.464	28.16 61.59

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp= \frac{\cos^2(Phi- Theta)}{\cos^2(Theta)* [1- Sqrt(\{sin(Phi)* sin(Phi- Theta)/ cos(Theta)\}]^2}$$

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN m2)	srchg prsse Sum(rh)+q (kN m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN m2)
1	38.000 37.500	0.500	18.0	20.00	10.0 10.0	0.00 9.00	0.0400 0.0400	2.29 2.29	1.981 1.981	28.15 45.98
2	37.500 37.000	0.500	9.0	20.00	10.0 10.0	9.00 13.50	0.0844 0.0844	4.83 4.83	1.913 1.913	44.88 53.49
3	37.000 32.000	5.000	9.0	25.00	10.0 10.0	13.50 58.50	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 166.62
4	32.000 28.000	4.000	9.0	25.00	10.0 10.0	58.50 94.50	0.0844 0.0844	4.83 4.83	2.327 2.327	166.62 250.38
5	28.000 20.000	8.000	9.0	25.00	10.0 10.0	94.50 166.50	0.0844 0.0844	4.83 4.83	2.327 2.327	250.38 417.90

(4)active earth pressure intensity table(embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN m2)	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ka	active e-prss pa (kN m2)	e-prss in use pa (kN m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	0.00 90.00	0.333	0.00 30.00	0.00 30.00
2	42.000 40.000	2.000	18.0	30.00	0.0 0.0	90.00 126.00	0.333	30.00 42.00	30.00 42.00
3	40.000 38.750	1.250	18.0	30.00	0.0 0.0	126.00 148.50	0.333	42.00 49.50	42.00 49.50
4	38.750 38.500	0.250	9.0	30.00	0.0 0.0	148.50 150.75	0.333	49.50 50.25	49.50 50.25
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	150.75 159.75	0.490	59.91 64.32	59.91 64.32
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	159.75 204.75	0.406	52.09 70.36	52.09 70.36
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	204.75 240.75	0.406	70.36 84.97	70.36 84.97
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	240.75 312.75	0.406	84.97 114.19	84.97 114.19

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN m2)	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Kp	passive e-prss pp (kN m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	0.00 90.00	3.000	0.00 270.00
2	42.000 40.000	2.000	18.0	30.00	0.0 0.0	90.00 126.00	3.000	270.00 378.00
3	40.000 38.750	1.250	18.0	30.00	0.0 0.0	126.00 148.50	3.000	378.00 445.50
4	38.750 38.500	0.250	9.0	30.00	0.0 0.0	148.50 150.75	3.000	445.50 452.25
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	150.75 159.75	2.040	336.03 354.39
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	159.75 204.75	2.464	425.00 535.88
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	204.75 240.75	2.464	535.88 624.58
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	240.75 312.75	2.464	624.58 801.98

(6)passive earth pressure intensity table (out of embankment: passive resistant moment below)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 38.750	0.250	9.0	20.00	10.0 10.0	0.00 2.25	0.0844 0.0844	4.83 4.83	1.913 1.913	27.66 31.97
2	38.750 38.000	0.750	9.0	20.00	10.0 10.0	2.25 9.00	0.0844 0.0844	4.83 4.83	1.913 1.913	31.97 44.88
3	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	0.0844 0.0844	4.83 4.83	2.327 2.327	51.45 61.92
4	37.500 33.000	4.500	9.0	25.00	10.0 10.0	13.50 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 156.15
5	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	0.0844 0.0844	4.83 4.83	2.327 2.327	156.15 239.91
6	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	0.0844 0.0844	4.83 4.83	2.327 2.327	239.91 407.43

(7)seismicity for inertia force, H-force distribution table(embankment section: for inertia moment)

seismicity for inertia force is linearly distributed from GL to 10m depth, calculate with reducing seismicity. Regardless WT, design seismicity is considered using next equation. Basic design seismicity is applied with input design seismicity for the case of earthquake.

pe= Gam * B* Kh

where,

pe : inertia force intensity, H-force, for each layer (top and bottom)

Gam : wet weight of each layer

B : embankment width in use (8.000)m

Kh : design seismicity for each layer (top and bottom)

No	depth GL(m)	layer thick. h (m)	soil unit weight wet Gamt	sub Gam'	sat Gamsat	seis-micity Kh	inertia H-compo pe=Gam.B.Kh
1	47.000 42.000	5.000	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
2	42.000 40.000	2.000	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
3	40.000 38.750	1.250	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
4	38.750 38.500	0.250	18.0	9.0	19.0	0.0400 0.0400	5.76 5.76
5	38.500 37.500	1.000	18.0	9.0	19.0	0.0400 0.0360	* 5.76 * 5.18
6	37.500 32.500	5.000	18.0	9.0	19.0	0.0360 0.0160	* 5.18 * 2.30
7	32.500 28.500	4.000	18.0	9.0	19.0	0.0160 0.0000	* 2.30 * 0.00
8	28.500 20.500	8.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00

Note:* character shows a section where linearly reduced seismicity.

5.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 38.750(m)

L.W.L. 37.500(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	38.750 38.500	0.250	0.00 2.50
2	38.500 37.500	1.000	2.50 12.50
3	37.500 32.500	5.000	12.50 5.92
4	32.500 28.500	4.000	5.92 0.66
5	28.500 28.000	0.500	0.66 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	0.00 90.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 32.15
2	42.000 40.000	2.000	18.0	30.00	0.0 0.0	90.00 126.00	0.0400 0.0400	2.29 2.29	0.357 0.357	32.15 45.01
3	40.000 38.750	1.250	18.0	30.00	0.0 0.0	126.00 148.50	0.0400 0.0400	2.29 2.29	0.357 0.357	45.01 53.05
4	38.750 38.500	0.250	9.0	30.00	0.0 0.0	148.50 150.75	0.0844 0.0844	4.83 4.83	0.386 0.386	57.31 58.18
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	150.75 159.75	0.0844 0.0844	4.83 4.83	0.555 0.555	68.81 73.81
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	159.75 204.75	0.0844 0.0844	4.83 4.83	0.464 0.464	60.54 81.44
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	204.75 240.75	0.0844 0.0844	4.83 4.83	0.464 0.464	81.44 98.15
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	240.75 312.75	0.0844 0.0844	4.83 4.83	0.464 0.464	98.15 131.58

(3) passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	38.000 37.500	0.500	18.0	20.00	10.0 10.0	0.00 9.00	0.0400 0.0400	2.29 2.29	1.981 1.981	28.15 45.98
2	37.500 37.000	0.500	9.0	20.00	10.0 10.0	9.00 13.50	0.0844 0.0844	4.83 4.83	1.913 1.913	44.88 53.49
3	37.000 32.000	5.000	9.0	25.00	10.0 10.0	13.50 58.50	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 166.62
4	32.000 28.000	4.000	9.0	25.00	10.0 10.0	58.50 94.50	0.0844 0.0844	4.83 4.83	2.327 2.327	166.62 250.38
5	28.000 20.000	8.000	9.0	25.00	10.0 10.0	94.50 166.50	0.0844 0.0844	4.83 4.83	2.327 2.327	250.38 417.90

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	38.000 37.500	0.500	18.0	0.00 9.00	0.658	0.00 5.92
2	37.500 37.000	0.500	9.0	9.00 13.50	0.658	5.92 8.88
3	37.000 32.000	5.000	9.0	13.50 58.50	0.577	7.79 33.78
4	32.000 28.000	4.000	9.0	58.50 94.50	0.577	33.78 54.56
5	28.000 20.000	8.000	9.0	94.50 166.50	0.577	54.56 96.13

Note:is a layer without earth pressure in calculation.

5.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure table (embankment section)

H.W.L. 41.750(m)

L.W.L. 40.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	41.750 40.000	1.750	0.00 17.50
2	40.000 38.500	1.500	17.50 15.31
3	38.500 37.500	1.000	15.31 13.85
4	37.500 32.500	5.000	13.85 6.56
5	32.500 28.500	4.000	6.56 0.73
6	28.500 28.000	0.500	0.73 0.00

(2) active earth pressure magnitude table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 42.000	5.000	18.0	30.00	0.0 0.0	0.00 90.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 32.15
2	42.000 41.750	0.250	18.0	30.00	0.0 0.0	90.00 94.50	0.0400 0.0400	2.29 2.29	0.357 0.357	32.15 33.76
3	41.750 40.000	1.750	9.0	30.00	0.0 0.0	94.50 110.25	0.0844 0.0844	4.83 4.83	0.386 0.386	36.47 42.55
4	40.000 38.500	1.500	9.0	30.00	0.0 0.0	110.25 123.75	0.0844 0.0844	4.83 4.83	0.386 0.386	42.55 47.76
5	38.500 37.500	1.000	9.0	20.00	10.0 10.0	123.75 132.75	0.0844 0.0844	4.83 4.83	0.555 0.555	53.82 58.82
6	37.500 32.500	5.000	9.0	25.00	10.0 10.0	132.75 177.75	0.0844 0.0844	4.83 4.83	0.464 0.464	48.01 68.90
7	32.500 28.500	4.000	9.0	25.00	10.0 10.0	177.75 213.75	0.0844 0.0844	4.83 4.83	0.464 0.464	68.90 85.62
8	28.500 20.500	8.000	9.0	25.00	10.0 10.0	213.75 285.75	0.0844 0.0844	4.83 4.83	0.464 0.464	85.62 119.05

(3) passive earth pressure intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	39.000 38.000	1.000	9.0	20.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.913 1.913	27.66 44.88
2	38.000 37.500	0.500	9.0	25.00	10.0 10.0	9.00 13.50	0.0844 0.0844	4.83 4.83	2.327 2.327	51.45 61.92
3	37.500 33.000	4.500	9.0	25.00	10.0 10.0	13.50 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	61.92 156.15
4	33.000 29.000	4.000	9.0	25.00	10.0 10.0	54.00 90.00	0.0844 0.0844	4.83 4.83	2.327 2.327	156.15 239.91
5	29.000 21.000	8.000	9.0	25.00	10.0 10.0	90.00 162.00	0.0844 0.0844	4.83 4.83	2.327 2.327	239.91 407.43

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	39.000 38.000	1.000	9.0	0.00 9.00	0.658	0.00 5.92
2	38.000 37.500	0.500	9.0	9.00 13.50	0.577	5.20 7.79
3	37.500 33.000	4.500	9.0	13.50 54.00	0.577	7.79 31.18
4	33.000 29.000	4.000	9.0	54.00 90.00	0.577	31.18 51.96
5	29.000 21.000	8.000	9.0	90.00 162.00	0.577	51.96 93.54

Note: is a layer without earth pressure in calculation.

5.2 Stability analysis

5.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.00)

Md: shear deformation moment on check plane(kN* m/m)

Mr: shear resistant moment on check plane(kN* m/m)

$$Mr = Mro*\left(1+\frac{d}{H}\right)+Msp$$

$$Mro = \int_0^{yo}(pRP- pRA)ydy$$

where,

Mro: basic shear resistant moment of filling soil

d : depth from current ground surface to check level

H : wall height(from top of wall to ground level in embankment range)

pRP: passive earth pressure above check level with a distance y(kN/m2)

pRA: active earth pressure above check level with a distance y(kN/m2)

y : a distance from the location of pRP,pRA working(m)

yo : cross point coordinates of the failure plane in filling soil

Msp: resistant moment caused by two rows sheet piles

smaller resistance either landside or riverside and make double to evaluate

Msp= 2* (smaller value either Msp1 or Msp2)

Msp1: resistant moment derived from sheet pile

Msp1= Sig.a* Zsp

Sig.a: allowable stress of sheet pile in use(N/mm2)

Zsp : section modulus considering joint(splice) of sheet pile in use(mm^3/ m)

Msp2: resistant moment allowed by embedment deeper than check level.

Msp2= Ppu* hpu

Ppu: passive resultant force from check elevation to sheet pile tip

hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	28.000	10.500	0.00	7403.66	999.99>=1.00
Layer boundary surface	28.500	10.000	0.00	7140.73	999.99>=1.00
Layer boundary surface	32.500	6.000	0.00	5882.34	999.99>=1.00
Layer boundary surface	37.500	1.000	282.05	3487.77	12.37>=1.00
Current ground level	38.500	0.000	213.92	2949.14	13.79>=1.00

(2)check level(Embedment tip: G.L. 28.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	0.00
resistant moment	Mr(kN.m/m)	7403.66
factor of safety	Mr/ Md	999.99>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	1263.02
active earth-prss moment	Ma	322.78
pssv earth-prss moment	- Mp	5459.56
other load moment	Mc	0.00
inertia force moment	Me	928.56
dynamic hydraulic moment	Mwd	2.66
deformation moment	Md(kN.m/m)	0.00

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	40.000 39.000	1.000	0.00 10.00	5.00	11.333	56.67
2	39.000 38.750	0.250	10.00 12.50	2.81	10.870	30.57
3	38.750 38.000	0.750	12.50 20.00	12.19	10.346	126.09
4	38.000 37.500	0.500	20.00 25.00	11.25	9.741	109.58
5	37.500 33.000	4.500	25.00 19.08	99.18	7.351	729.03
6	33.000 29.000	4.000	19.08 13.82	65.79	3.107	204.39
7	29.000 28.000	1.000	13.82 12.50	13.16	0.508	6.69
Sum				209.38		1263.02

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.750	0.250	0.00 0.00	0.00	10.875	0.00
2	38.750 38.000	0.750	0.00 0.00	0.00	10.375	0.00
3	38.000 37.500	0.500	0.00 0.00	0.00	9.750	0.00
4	37.500 35.739	1.761	0.00 0.00	0.00	8.619	0.00
5	35.739 33.000	2.739	0.00 11.44	15.67	5.913	92.67
6	33.000 29.000	4.000	11.44 28.16	79.21	2.719	215.34
7	29.000 28.000	1.000	28.16 32.34	30.25	0.488	14.78
Sum				125.13		322.78

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.15 45.98	18.53	9.730	180.33
2	37.500 37.000	0.500	44.88 53.49	24.59	9.243	227.30
3	37.000 32.000	5.000	61.92 166.62	571.34	6.118	3495.61
4	32.000 28.000	4.000	166.62 250.38	834.00	1.866	1556.32
Sum				1448.47		5459.56

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 77.76(kN/m)

Me = Sum(Me) + Mew

= 928.56(kN.m/m)

* surcharge load

Pew = q * B * Kh

= 0.00(kN/m)

Mew = Pew * (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/3) * (2 * p1 + p2) / (p1 + p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 42.000	5.000	5.76 5.76	28.80	16.500	475.20
2	42.000 40.000	2.000	5.76 5.76	11.52	13.000	149.76
3	40.000 38.750	1.250	5.76 5.76	7.20	11.375	81.90
4	38.750 38.500	0.250	5.76 5.76	1.44	10.625	15.30
5	38.500 37.500	1.000	5.76 5.18	5.47	10.009	54.77
6	37.500 32.500	5.000	5.18 2.30	18.72	7.321	137.04
7	32.500 28.500	4.000	2.30 0.00	4.61	3.167	14.59
8	28.500 28.000	0.500	0.00 0.00	0.00	0.250	0.00
Sum				77.76		928.56

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd * (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 0.23(kN/m)

Mwd= 2.66(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
40.000	39.000	1.000	1.000	0.600	0.23	11.400	2.66

Note: Lwd is a distance from water level, resultant force works at G.L. 39.400(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	7403.66 0.00 583.20 0.00
rsst moment Mr(kN.m/m)	7403.66

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 3312.16* (1+ 1.235)= 7403.66(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	31.625 28.500	3.125	555.28 624.58	73.55 84.97	481.73 539.61	1595.84	2.033	3244.32
2	28.500 28.000	0.500	624.58 635.67	84.97 86.80	539.61 548.87	272.12	0.249	67.84
Sum						1867.97		3312.16

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	31.625	28.500	3.125	25.00	0.00	32.50	4.905	57.50	1.991	6.896
2	28.500	28.000	0.500	25.00	0.00	32.50	0.785	57.50	0.319	1.103
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

$xip= 90.0- \tan^{-1}(\cot(xip))$

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

$xia= 90.0- \tan^{-1}(\cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(583.20, 0.00)= 0.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level,

for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 28.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	0.00
resistant moment	Mr(kN.m/m)	7140.73
factor of safety	Mr/ Md	999.99>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	1159.92
active earth-prss moment	Ma	264.17
pssv earth-prss moment	- Mp	4766.18
other load moment	Mc	0.00
inertia force moment	Me	889.68
dynamic hydraulic moment	Mwd	2.54
deformation moment	Md(kN.m/m)	0.00

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	40.000 39.000	1.000	0.00 10.00	5.00	10.833	54.17
2	39.000 38.750	0.250	10.00 12.50	2.81	10.370	29.17
3	38.750 38.000	0.750	12.50 20.00	12.19	9.846	120.00
4	38.000 37.500	0.500	20.00 25.00	11.25	9.241	103.96
5	37.500 33.000	4.500	25.00 19.08	99.18	6.851	679.44
6	33.000 29.000	4.000	19.08 13.82	65.79	2.607	171.49
7	29.000 28.500	0.500	13.82 13.16	6.74	0.252	1.70
Sum				202.96		1159.92

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.750	0.250	0.00 0.00	0.00	10.375	0.00
2	38.750 38.000	0.750	0.00 0.00	0.00	9.875	0.00
3	38.000 37.500	0.500	0.00 0.00	0.00	9.250	0.00
4	37.500 35.739	1.761	0.00 0.00	0.00	8.119	0.00
5	35.739 33.000	2.739	0.00 11.44	15.67	5.413	84.83
6	33.000 29.000	4.000	11.44 28.16	79.21	2.219	175.73
7	29.000 28.500	0.500	28.16 30.25	14.60	0.247	3.61
Sum				109.48		264.17

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.15 45.98	18.53	9.230	171.06
2	37.500 37.000	0.500	44.88 53.49	24.59	8.743	215.01
3	37.000 32.000	5.000	61.92 166.62	571.34	5.618	3209.93
4	32.000 28.500	3.500	166.62 239.91	711.43	1.645	1170.18
Sum				1325.90		4766.18

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 77.76(kN/m)

Me = Sum(Me)+ Mew

= 889.68(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 42.000	5.000	5.76 5.76	28.80	16.000	460.80
2	42.000 40.000	2.000	5.76 5.76	11.52	12.500	144.00
3	40.000 38.750	1.250	5.76 5.76	7.20	10.875	78.30
4	38.750 38.500	0.250	5.76 5.76	1.44	10.125	14.58
5	38.500 37.500	1.000	5.76 5.18	5.47	9.509	52.03
6	37.500 32.500	5.000	5.18 2.30	18.72	6.821	127.68
7	32.500 28.500	4.000	2.30 0.00	4.61	2.667	12.29
Sum				77.76		889.68

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gamw: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 0.23(kN/m)

Mwd= 2.54(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
40.000	39.000	1.000	1.000	0.600	0.23	10.900	2.54

Note: Lwd is a distance from water level, resultant force works at G.L. 39.400(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	7076.39 64.34 583.20 32.17
rsst moment Mr(kN.m/m)	7140.73

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mfo* (1+ d/ H)= 3251.31* (1+ 1.176)= 7076.39(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mfo kN m/m
1	32.125 28.500	3.625	544.20 624.58	71.73 84.97	472.47 539.61	1834.39	1.772	3251.31
Sum						1834.39		3251.31

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	32.125	28.500	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane

$Bp= \cot(xip)* h$

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

$xip= 90.0- \tan^{-1} (\cot(xip))$

* active failure plane

$Ba= \cot(xia)* h$

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(Theta)\sin(Phi)}{\sin(Phi- Theta)}-)$$

$xia= 90.0- \tan^{-1} (\cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(583.20, 32.17)= 64.34(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m³/m - - - - - - - - $* 10^{-6}$ m³/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	28.500 28.000	0.500	250.38 260.85	127.81	0.252	32.17
Sum				127.81		32.17

(4) check level(Layer boundary surface: G.L. 32.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	0.00
resistant moment	Mr(kN.m/m)	5882.34
factor of safety	Mr/ Md	999.99>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	467.38
active earth-prss moment	Ma	23.66
pssv earth-prss moment	- Mp	1158.51
other load moment	Mc	0.00
inertia force moment	Me	584.78
dynamic hydraulic moment	Mwd	1.61
deformation moment	Md(kN.m/m)	0.00

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	40.000 39.000	1.000	0.00 10.00	5.00	6.833	34.17
2	39.000 38.750	0.250	10.00 12.50	2.81	6.370	17.92
3	38.750 38.000	0.750	12.50 20.00	12.19	5.846	71.25
4	38.000 37.500	0.500	20.00 25.00	11.25	5.241	58.96
5	37.500 33.000	4.500	25.00 19.08	99.18	2.851	282.73
6	33.000 32.500	0.500	19.08 18.42	9.38	0.251	2.36
Sum				139.80		467.38

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.750	0.250	0.00 0.00	0.00	6.375	0.00
2	38.750 38.000	0.750	0.00 0.00	0.00	5.875	0.00
3	38.000 37.500	0.500	0.00 0.00	0.00	5.250	0.00
4	37.500 35.739	1.761	0.00 0.00	0.00	4.119	0.00
5	35.739 33.000	2.739	0.00 11.44	15.67	1.413	22.14
6	33.000 32.500	0.500	11.44 13.53	6.24	0.243	1.52
Sum				21.92		23.66

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.15 45.98	18.53	5.230	96.93
2	37.500 37.000	0.500	44.88 53.49	24.59	4.743	116.64
3	37.000 32.500	4.500	61.92 156.15	490.65	1.926	944.95
Sum				533.78		1158.51

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 73.15(kN/m)

Me = Sum(Me) + Mew

= 584.78(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 42.000	5.000	5.76 5.76	28.80	12.000	345.60
2	42.000 40.000	2.000	5.76 5.76	11.52	8.500	97.92
3	40.000 38.750	1.250	5.76 5.76	7.20	6.875	49.50
4	38.750 38.500	0.250	5.76 5.76	1.44	6.125	8.82
5	38.500 37.500	1.000	5.76 5.18	5.47	5.509	30.14
6	37.500 32.500	5.000	5.18 2.30	18.72	2.821	52.80
Sum				73.15		584.78

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 0.23(kN/m)

Mwd= 1.61(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
40.000	39.000	1.000	1.000	0.600	0.23	6.900	1.61

Note: Lwd is a distance from water level, resultant force works at G.L. 39.400(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	4715.94 1166.40 583.20 2323.09
rsst moment Mr(kN.m/m)	5882.34

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2764.52* (1+ 0.706)= 4715.94(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	36.125 32.500	3.625	455.49 535.88	57.12 70.36	398.38 465.52	1565.82	1.766	2764.52
Sum						1565.82		2764.52

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	36.125	32.500	3.625	25.00	0.00	32.50	5.690	57.50	2.309	7.999
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(583.20, 2323.09)= 1166.40(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	32.500 29.000	3.500	166.62 239.91	711.43	1.855	1319.82
2	29.000 28.000	1.000	239.91 260.85	250.38	4.007	1003.27
Sum				961.81		2323.09

(5)check level(Layer boundary surface: G.L. 37.500m)

1)check result

item		value
deformation moment	Md(kN.m/m)	282.05
resistant moment	Mr(kN.m/m)	3487.77
factor of safety	Mr/ Md	12.37>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	26.04
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	4.26
other load moment	Mc	0.00
inertia force moment	Me	259.82
dynamic hydraulic moment	Mwd	0.44
deformation moment	Md(kN.m/m)	282.05

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	40.000 39.000	1.000	0.00 10.00	5.00	1.833	9.17
2	39.000 38.750	0.250	10.00 12.50	2.81	1.370	3.85
3	38.750 38.000	0.750	12.50 20.00	12.19	0.846	10.31
4	38.000 37.500	0.500	20.00 25.00	11.25	0.241	2.71
Sum				31.25		26.04

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.750	0.250	0.00 0.00	0.00	1.375	0.00
2	38.750 38.000	0.750	0.00 0.00	0.00	0.875	0.00
3	38.000 37.500	0.500	0.00 0.00	0.00	0.250	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.15 45.98	18.53	0.230	4.26
Sum				18.53		4.26

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew
 = 54.43(kN/m)

Me = Sum(Me) + Mew
 = 259.82(kN.m/m)

* surcharge load

Pew = q* B* Kh
 = 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)
 = 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 42.000	5.000	5.76 5.76	28.80	7.000	201.60
2	42.000 40.000	2.000	5.76 5.76	11.52	3.500	40.32
3	40.000 38.750	1.250	5.76 5.76	7.20	1.875	13.50
4	38.750 38.500	0.250	5.76 5.76	1.44	1.125	1.62
5	38.500 37.500	1.000	5.76 5.18	5.47	0.509	2.78
Sum				54.43		259.82

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 0.23(kN/m)

Mwd= 0.44(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
40.000	39.000	1.000	1.000	0.600	0.23	1.900	0.44

Note: Lwd is a distance from water level, resultant force works at G.L. 39.400(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H)	2321.37
Msp= 2* min(Msp1, Msp2)	1166.40
Msp1	583.20
Msp2	8778.63
rsst moment Mr(kN.m/m)	3487.77

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 2077.02* (1+ 0.118)= 2321.37(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.042 40.000	1.042	321.73 378.00	35.75 42.00	285.98 336.00	324.05	3.007	974.44
2	40.000 38.750	1.250	378.00 445.50	42.00 49.50	336.00 396.00	457.50	1.858	850.00
3	38.750 38.500	0.250	445.50 452.25	49.50 50.25	396.00 402.00	99.75	1.125	112.19
4	38.500 37.500	1.000	336.03 354.39	59.91 64.32	276.13 290.07	283.10	0.496	140.39
Sum						1164.40		2077.02

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	41.042	40.000	1.042	30.00	0.00	30.00	1.805	60.00	0.602	2.406
2	40.000	38.750	1.250	30.00	0.00	30.00	2.165	60.00	0.722	2.887
3	38.750	38.500	0.250	30.00	0.00	30.00	0.433	60.00	0.144	0.577
4	38.500	37.500	1.000	20.00	0.00	35.00	1.428	55.00	0.700	2.128

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
Interval Sum(Bp) + Ba										7.999

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan^{-1} (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(583.20, 8778.63)= 1166.40(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	324.0	324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	37.500 33.000	4.500	61.92 156.15	490.65	2.574	1262.98
2	33.000 29.000	4.000	156.15 239.91	792.12	6.641	5260.47
3	29.000 28.000	1.000	239.91 260.85	250.38	9.007	2255.18
Sum				1533.15		8778.63

(6) check level(Current ground level: G.L. 38.500m)

1) check result

item		value
deformation moment	Md(kN.m/m)	213.92
resistant moment	Mr(kN.m/m)	2949.14
factor of safety	Mr/ Md	13.79>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	5.62
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	0.00
other load moment	Mc	0.00
inertia force moment	Me	208.08
dynamic hydraulic moment	Mwd	0.21
deformation moment	Md(kN.m/m)	213.92

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	40.000 39.000	1.000	0.00 10.00	5.00	0.833	4.17
2	39.000 38.750	0.250	10.00 12.50	2.81	0.370	1.04
3	38.750 38.500	0.250	12.50 15.00	3.44	0.121	0.42
Sum				11.25		5.62

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	39.000 38.750	0.250	0.00 0.00	0.00	0.375	0.00
2	38.750 38.500	0.250	0.00 0.00	0.00	0.125	0.00
Sum				0.00		0.00

c.passive earth pressure moment

Sum(Pp) = 0.00kN/m   Sum(Mp) = 0.00kN.m/m

d.other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e.inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 48.96(kN/m)

Me = Sum(Me)+ Mew

= 208.08(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 42.000	5.000	5.76 5.76	28.80	6.000	172.80
2	42.000 40.000	2.000	5.76 5.76	11.52	2.500	28.80
3	40.000 38.750	1.250	5.76 5.76	7.20	0.875	6.30
4	38.750 38.500	0.250	5.76 5.76	1.44	0.125	0.18
Sum				48.96		208.08

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gamw: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 0.23(kN/m)

Mwd= 0.21(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
40.000	39.000	1.000	1.000	0.600	0.23	0.900	0.21

Note: Lwd is a distance from water level, resultant force works at G.L. 39.400(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1782.74 1166.40 583.20 10338.51
rsst moment Mr(kN.m/m)	2949.14

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mo* (1+ d/ H)= 1782.74* (1+ 0.000)= 1782.74(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mo kN m/m
1	41.964 40.000	1.964	271.94 378.00	30.22 42.00	241.73 336.00	567.33	2.429	1377.81
2	40.000 38.750	1.250	378.00 445.50	42.00 49.50	336.00 396.00	457.50	0.858	392.50
3	38.750 38.500	0.250	445.50 452.25	49.50 50.25	396.00 402.00	99.75	0.125	12.44
Sum						1124.58		1782.74

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth top GL(m)	depth bottom GL(m)	thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure angle xip	passive failure width Bp (m)	active failure angle xia	active failure width Ba (m)	failure W Bp+ Ba (m)
1	41.964	40.000	1.964	30.00	0.00	30.00	3.402	60.00	1.134	4.536
2	40.000	38.750	1.250	30.00	0.00	30.00	2.165	60.00	0.722	2.887
3	38.750	38.500	0.250	30.00	0.00	30.00	0.433	60.00	0.144	0.577
Interval Sum(Bp) + Ba										8.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(583.20, 10338.51)= 1166.40(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m3/m - - - - - - - - * 10^{-6} m3/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 324.0	PU28+1 3000 0.60 1800 324.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	583.20	583.20

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	38.500 38.000	0.500	36.27 44.88	20.29	0.259	5.25
2	38.000 37.500	0.500	51.45 61.92	28.34	0.758	21.47
3	37.500 33.000	4.500	61.92 156.15	490.65	3.574	1753.63
4	33.000 29.000	4.000	156.15 239.91	792.12	7.641	6052.59
5	29.000 28.000	1.000	239.91 260.85	250.38	10.007	2505.56
Sum				1581.78		10338.51

5.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 8.000, height H= 8.500(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.00)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	28.000	10.500	412.50	2443.37	5.92>=1.00

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item	value
sum of H force Fd(kN/m)	412.50
sum of rsst Fr(kN/m)	2443.37
factor of safety Fr/ Fd	5.92>=1.00

2)sum of horizontal force(Fd)

horizontal force in detail		H force
water pressure	Fw	209.38
active earth pressure	Fa	125.13
other load	Fc	0.00
inertia force	Fe	77.76
dynamic hydraulic prrs	Fwd	0.23
sum of H force Fd(kN/m)		412.50

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

d.inertia force

table of inertia force when shear deformation failures is check at tip of embedment.

e.dynamic hydraulic pressure

table of dynamic hydraulic press. when shear deform failures is checked at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail		H force
ground H resistance	Fs	994.90
passive earth pressure	Fp	1448.47
sum of resistance Fr(kN/m)		2443.37

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 8.000+ 1962.00* tan(25.00) Deg.

= 994.90(kN/m)

b. soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (245.25+ 0.00)* 8.000= 1962.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	42.000	5.000	18.0	90.00
2	42.000	40.000	2.000	18.0	36.00
3	40.000	38.750	1.250	18.0	22.50
4	38.750	38.500	0.250	9.0	2.25
5	38.500	37.500	1.000	9.0	9.00
6	37.500	32.500	5.000	9.0	45.00
7	32.500	28.500	4.000	9.0	36.00
8	28.500	28.000	0.500	9.0	4.50
Sum			19.000		245.25

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

5.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 8.000, height H= 8.500(m) using the next equation.

$$\frac{Qu}{V - Gam2 * Df * Be} >= FS$$

$$Qu = Be\{ k * c * Nc + k * Gam2 * Df * (Nq - 1) + \frac{1}{2} * Gam1 * Be * NGam \}$$

where,

FS : required factor of safety(1.00)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B- 2e

B: wall width

e: eccentricity(e= Mb/ V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/ V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	28.000	10.500	10955.61	1206.00	9.08>=1.00

(2)check level(embedment tip: G.L. 28.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	1962.00
	distance from ground to check level	Df	10.500
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	8.000
	v-compo sum V- Gam2.Df.Be (kN/m)		1206.00
Qu	moment on check level	Mb	0.00
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	0.000
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		10955.61
factor of safety			9.08>=1.00

2)summery of external force

external force detail		moment Mb(kN.m/m)	H-force Hb(kN/m)
water pressure	Mw(Fw)	1263.02	209.38
active earth pressure	Ma(Fa)	322.78	125.13
passive earth pressure-	Mp(Fp)	5459.56	1448.47
other load	Mc(Fc)	0.00	0.00
inertia force	Me(Fe)	928.56	77.76
dynamic water prss	Mwd(Fwd)	2.66	0.23
external force sum		0.00	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b. active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

e. inertia load

refer to inertia force in checking shear failure at embedment tip

f. dynamic water pressure

refer to dynamic water pressure in checking shear failure at embedment tip

3)weight of filling soil(V)

refer to 'b.weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 1962.00(kN/m)

4)eccentricity distance(e)calculation

e = Mb/ V

= 0.00/ 1962.00

= 0.000(m)

Be= B- 2e

= 8.000- 2.0* 0.000

= 8.000(m)

5)calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 1962.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\ 2 = \frac{Sum(Gam\ i\ hi)}{Sum(hi)}$$

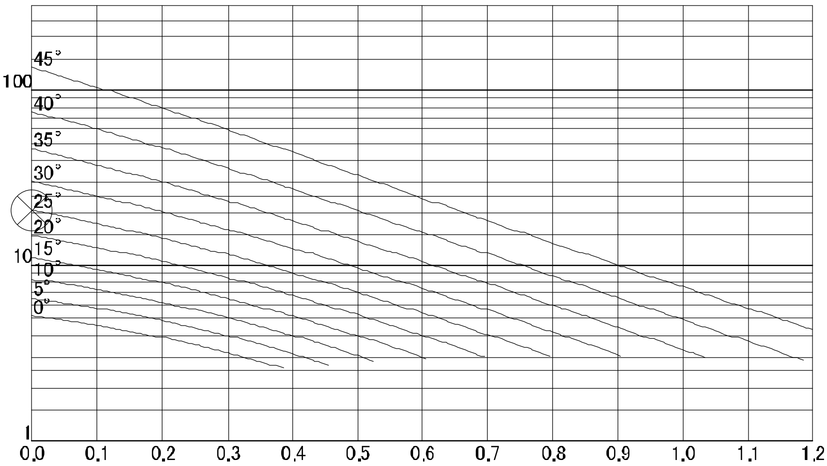
= 9.00(kN/m3)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	38.500	37.500	1.000	9.0	9.00
2	37.500	32.500	5.000	9.0	45.00
3	32.500	28.500	4.000	9.0	36.00
4	28.500	28.000	0.500	9.0	4.50
Sum			10.500		94.50

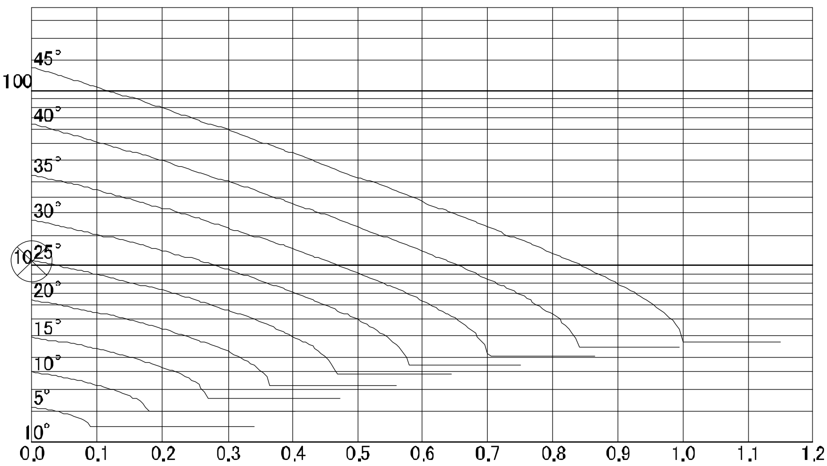
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

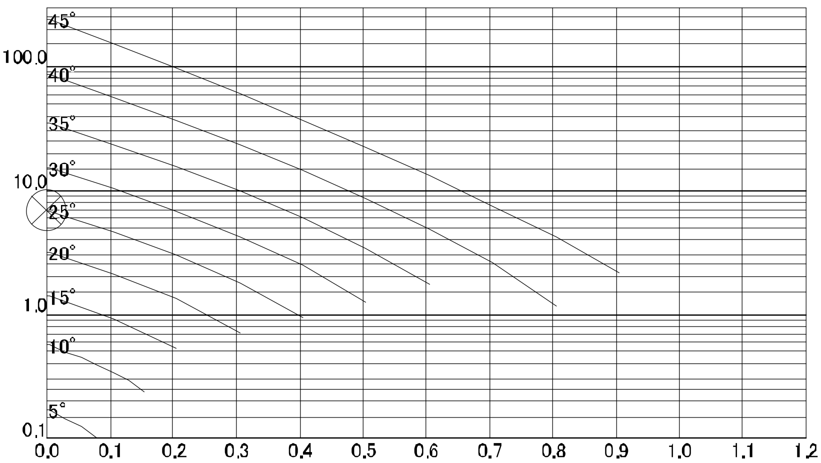
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



5.3 landside sheet pile

5.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 38.750(m)
L.WL : 37.500(m)

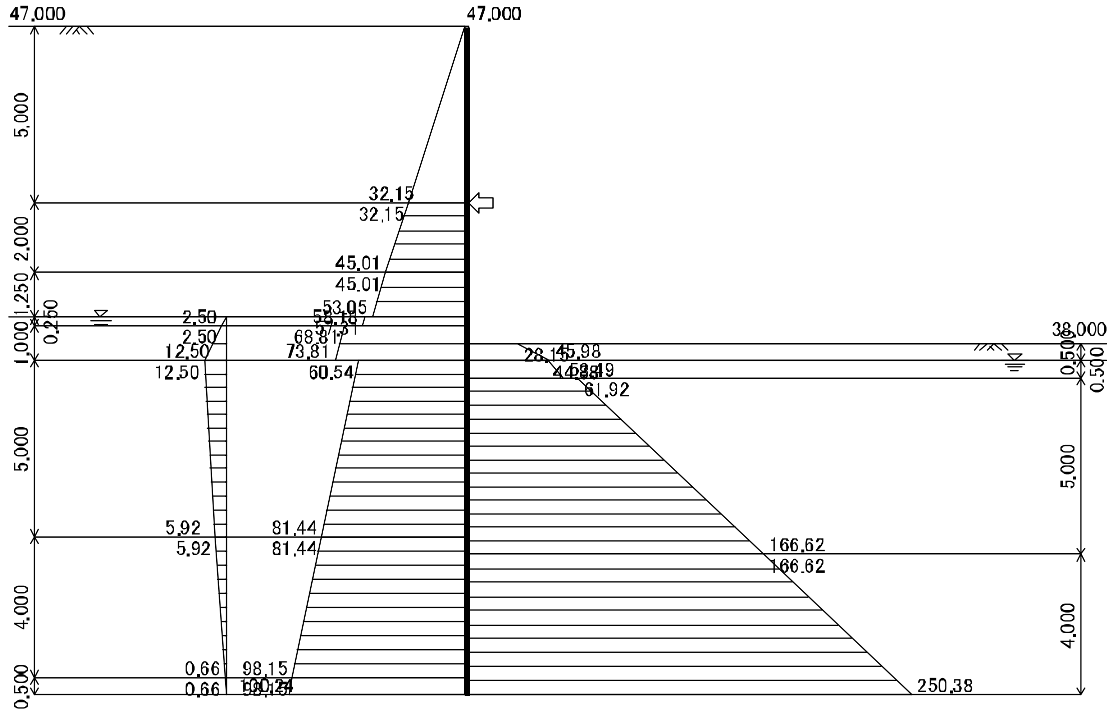
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	32.330	28.000
active sd	Ma+Mw+Mac(kN m/m)	3472.30	8428.07
passive sd	Mp+Mpc(kN m/m)	4169.72	14819.05
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.201>=1.20	1.758>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 40.000	2.000	32.15 45.01	77.17	1.056	81.45
2	40.000 38.750	1.250	45.01 53.05	61.29	2.642	161.94
3	38.750 38.500	0.250	57.31 58.18	14.44	3.375	48.73
4	38.500 37.500	1.000	68.81 73.81	71.31	4.006	285.67
5	37.500 32.500	5.000	60.54 81.44	354.96	7.123	2528.24
6	32.500 28.500	4.000	81.44 98.15	359.18	11.562	4152.90
7	28.500 28.000	0.500	98.15 100.24	49.60	13.751	682.03
Sum				987.95		7940.96

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	38.750 38.500	0.250	0.00 2.50	0.31	3.417	1.07
2	38.500 37.500	1.000	2.50 12.50	7.50	4.111	30.83
3	37.500 32.500	5.000	12.50 5.92	46.05	6.702	308.66
4	32.500 28.500	4.000	5.92 0.66	13.16	10.967	144.30
5	28.500 28.000	0.500	0.66 0.00	0.16	13.667	2.25
Sum				67.19		487.11

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	38.000 37.500	0.500	28.15 45.98	18.53	4.270	79.14
2	37.500 37.000	0.500	44.88 53.49	24.59	4.757	116.99
3	37.000 32.000	5.000	61.92 166.62	571.34	7.882	4503.21
4	32.000 28.000	4.000	166.62 250.38	834.00	12.134	10119.71
Sum				1448.47		14819.05

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

5.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN m/m)	-175.36	G.L. 38.400
max shear force Smax(kN/m)	-154.52	G.L. 42.000
upper tension mbr rct R1(kN/m)	0.00	G.L. 46.000
lower tension mbr rct R2(kN/m)	-238.15	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 42.000	0.00 32.15	0.00 0.00	---- ----	---- ----	0.00 32.15	---- ----
2	42.000 40.000	32.15 45.01	0.00 0.00	---- ----	---- ----	32.15 45.01	---- ----
3	40.000 38.750	45.01 53.05	0.00 0.00	---- ----	---- ----	45.01 53.05	---- ----
4	38.750 38.500	57.31 58.18	0.00 2.50	---- ----	---- ----	57.31 60.68	---- ----
5	38.500 38.000	68.81 71.31	2.50 7.50	---- ----	---- ----	71.31 78.81	---- ----
6	38.000 37.500	71.31 73.81	7.50 12.50	28.15 45.98	0.00 5.92	78.81 80.39	28.15 40.06
7	37.500 37.000	60.54 62.63	12.50 11.84	44.88 53.49	5.92 8.88	67.12 65.59	38.96 44.61
8	37.000 32.500	62.63 81.44	11.84 5.92	61.92 156.15	7.79 31.18	66.68 56.18	54.12 124.97
9	32.500 32.000	81.44 83.53	5.92 5.26	156.15 166.62	31.18 33.78	56.18 55.01	124.97 132.84
10	32.000 28.500	83.53 98.15	5.26 0.66	166.62 239.91	33.78 51.96	55.01 46.85	132.84 187.95
11	28.500 28.000	98.15 100.24	0.66 0.00	239.91 250.38	51.96 54.56	46.85 45.68	187.95 195.82

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	38.000	37.500	0.500	14000	6728
2	37.500	37.000	0.500	14000	6728
3	37.000	32.000	5.000	42000	20184
4	32.000	28.000	4.000	64400	30948
5	28.000	20.000	8.000	106400	51132

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp. * (2 * number * A * E)}{(L * s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [8.000]m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	6818
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	19.29	3.86	--------	--------	--------	--------
17	43.800	On excavation plane	20.58	20.58	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	21.86	21.86	4.37	--------	--------	--------	--------
19	43.400	On excavation plane	23.15	23.15	4.63	--------	--------	--------	--------
20	43.200	On excavation plane	24.44	24.44	4.89	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN m2	back side load below nd kN m2	back side load cntrt ld kN m2	excavation side load above nd kN m2	excavation side load below nd kN m2	excavation side load cntrt ld kN m2	soil spring kN m
21	43.000	On excavation plane	25.72	25.72	5.14	--------	--------	--------	--------
22	42.800	On excavation plane	27.01	27.01	5.40	--------	--------	--------	--------
23	42.600	On excavation plane	28.29	28.29	5.66	--------	--------	--------	--------
24	42.400	On excavation plane	29.58	29.58	5.92	--------	--------	--------	--------
25	42.200	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
26	42.000	Tensile member	32.15	32.15	6.43	--------	--------	--------	122718
27	41.800	On excavation plane	33.44	33.44	6.69	--------	--------	--------	--------
28	41.600	On excavation plane	34.73	34.73	6.95	--------	--------	--------	--------
29	41.400	On excavation plane	36.01	36.01	7.20	--------	--------	--------	--------
30	41.200	On excavation plane	37.30	37.30	7.46	--------	--------	--------	--------
31	41.000	On excavation plane	38.58	38.58	7.72	--------	--------	--------	--------
32	40.800	On excavation plane	39.87	39.87	7.97	--------	--------	--------	--------
33	40.600	On excavation plane	41.16	41.16	8.23	--------	--------	--------	--------
34	40.400	On excavation plane	42.44	42.44	8.49	--------	--------	--------	--------
35	40.200	On excavation plane	43.73	43.73	8.75	--------	--------	--------	--------
36	40.000	On excavation plane	45.01	45.01	9.00	--------	--------	--------	--------
37	39.800	On excavation plane	46.30	46.30	9.26	--------	--------	--------	--------
38	39.600	On excavation plane	47.59	47.59	9.52	--------	--------	--------	--------
39	39.400	On excavation plane	48.87	48.87	9.77	--------	--------	--------	--------
40	39.200	On excavation plane	50.16	50.16	10.03	--------	--------	--------	--------
41	39.000	On excavation plane	51.44	51.44	10.29	--------	--------	--------	--------
42	38.800	On excavation plane	52.73	52.73	6.56	--------	--------	--------	--------
43	38.750	On excavation plane	53.05	57.31	5.66	--------	--------	--------	--------
44	38.600	On excavation plane	59.33	59.33	7.40	--------	--------	--------	--------
45	38.500	On excavation plane	60.68	71.31	6.60	--------	--------	--------	--------
46	38.400	On excavation plane	72.81	72.81	10.98	--------	--------	--------	--------
47	38.200	On excavation plane	75.81	75.81	15.16	--------	--------	--------	--------
48	38.000	Pa plas.	78.81	78.81	15.70	0.00	28.15	2.93	--------
49	37.800	Pa plas.	79.44	79.44	15.89	32.92	32.92	6.58	--------
50	37.600	Pa plas.	80.07	80.07	12.00	37.68	37.68	5.56	--------
51	37.500	Pa plas.	80.39	67.12	7.37	40.06	38.96	3.94	--------
52	37.400	Pa plas.	66.82	66.82	10.01	40.09	40.09	6.06	--------
53	37.200	Pa plas.	66.21	66.21	13.24	42.35	42.35	8.47	--------
54	37.000	Pa plas.	65.59	66.68	13.23	44.61	54.12	9.90	--------
55	36.800	Pa plas.	66.21	66.21	13.24	57.27	57.27	11.45	--------
56	36.600	Pa plas.	65.75	65.75	13.15	60.42	60.42	12.08	--------
57	36.400	Pa plas.	65.28	65.28	13.06	63.57	63.57	12.71	--------
58	36.200	Pa plas.	64.81	64.81	12.96	66.72	66.72	13.34	--------
59	36.000	Pa plas.	64.35	64.35	12.87	69.87	69.87	13.97	--------
60	35.800	Pa plas.	63.88	63.88	12.78	73.02	73.02	14.60	--------
61	35.600	Pa plas.	63.41	63.41	12.68	76.16	76.16	15.23	--------
62	35.400	Pa plas.	62.95	62.95	12.59	79.31	79.31	15.86	--------
63	35.200	Pa plas.	62.48	62.48	12.50	82.46	82.46	16.49	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
64	35.000	Pa plas.	62.01	62.01	12.40	85.61	85.61	17.12	--------
65	34.800	Pa plas.	61.55	61.55	12.31	88.76	88.76	17.75	--------
66	34.600	Pa plas.	61.08	61.08	12.22	91.91	91.91	18.38	--------
67	34.400	Pa plas.	60.61	60.61	12.12	95.06	95.06	19.01	--------
68	34.200	Pa plas.	60.15	60.15	12.03	98.21	98.21	19.64	--------
69	34.000	Pa plas.	59.68	59.68	11.94	101.35	101.35	20.27	--------
70	33.800	Pa plas.	59.21	59.21	11.84	104.50	104.50	20.90	--------
71	33.600	Pas ela.	58.75	58.75	11.75	107.65	107.65	--------	4037
72	33.400	Pas ela.	58.28	58.28	11.66	110.80	110.80	--------	4037
73	33.200	Pas ela.	57.81	57.81	11.56	113.95	113.95	--------	4037
74	33.000	Pas ela.	57.35	57.35	11.47	117.10	117.10	--------	4037
75	32.800	Pas ela.	56.88	56.88	11.38	120.25	120.25	--------	4037
76	32.600	Pas ela.	56.41	56.41	8.47	123.40	123.40	--------	3028
77	32.500	Pas ela.	56.18	56.18	5.62	124.97	124.97	--------	2018
78	32.400	Pas ela.	55.95	55.95	8.38	126.55	126.55	--------	3028
79	32.200	Pas ela.	55.48	55.48	11.10	129.69	129.69	--------	4037
80	32.000	Pas ela.	55.01	55.01	11.00	132.84	132.84	--------	5113
81	31.800	Pas ela.	54.55	54.55	10.91	135.99	135.99	--------	6190
82	31.600	Pas ela.	54.08	54.08	10.82	139.14	139.14	--------	6190
83	31.400	Pas ela.	53.61	53.61	10.72	142.29	142.29	--------	6190
84	31.200	Pas ela.	53.15	53.15	10.63	145.44	145.44	--------	6190
85	31.000	Pas ela.	52.68	52.68	10.54	148.59	148.59	--------	6190
86	30.800	Pas ela.	52.21	52.21	10.44	151.74	151.74	--------	6190
87	30.600	Pas ela.	51.75	51.75	10.35	154.88	154.88	--------	6190
88	30.400	Pas ela.	51.28	51.28	10.26	158.03	158.03	--------	6190
89	30.200	Pas ela.	50.81	50.81	10.16	161.18	161.18	--------	6190
90	30.000	Pas ela.	50.35	50.35	10.07	164.33	164.33	--------	6190
91	29.800	Pas ela.	49.88	49.88	9.98	167.48	167.48	--------	6190
92	29.600	Pas ela.	49.41	49.41	9.88	170.63	170.63	--------	6190
93	29.400	Pas ela.	48.95	48.95	9.79	173.78	173.78	--------	6190
94	29.200	Pas ela.	48.48	48.48	9.70	176.93	176.93	--------	6190
95	29.000	Pas ela.	48.01	48.01	9.60	180.07	180.07	--------	6190
96	28.800	Pas ela.	47.55	47.55	9.51	183.22	183.22	--------	6190
97	28.600	Pas ela.	47.08	47.08	7.07	186.37	186.37	--------	4642
98	28.500	Pas ela.	46.85	46.85	4.68	187.95	187.95	--------	3095
99	28.400	Pas ela.	46.61	46.61	6.98	189.52	189.52	--------	4642
100	28.200	Pas ela.	46.15	46.15	9.23	192.67	192.67	--------	6190
101	28.000	Pas ela.	45.68	0.00	4.58	195.82	0.00	--------	3095
Sum					849.73			302.28	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= 18.45mm(G.L. 38.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-12.12	- - - -	- - - -
2	46.800	on exv	- - - -	-11.66	- - - -	- - - -
3	46.600	on exv	- - - -	-11.21	- - - -	- - - -
4	46.400	on exv	- - - -	-10.76	- - - -	- - - -
5	46.200	on exv	- - - -	-10.30	- - - -	- - - -
6	46.000	on exv	6818	-9.85	- - - -	Note: 0.00
7	45.800	on exv	- - - -	-9.39	- - - -	- - - -
8	45.600	on exv	- - - -	-8.94	- - - -	- - - -
9	45.400	on exv	- - - -	-8.48	- - - -	- - - -
10	45.200	on exv	- - - -	-8.02	- - - -	- - - -
11	45.000	on exv	- - - -	-7.56	- - - -	- - - -
12	44.800	on exv	- - - -	-7.09	- - - -	- - - -
13	44.600	on exv	- - - -	-6.61	- - - -	- - - -
14	44.400	on exv	- - - -	-6.12	- - - -	- - - -
15	44.200	on exv	- - - -	-5.62	- - - -	- - - -
16	44.000	on exv	- - - -	-5.10	- - - -	- - - -
17	43.800	on exv	- - - -	-4.57	- - - -	- - - -
18	43.600	on exv	- - - -	-4.01	- - - -	- - - -
19	43.400	on exv	- - - -	-3.43	- - - -	- - - -
20	43.200	on exv	- - - -	-2.81	- - - -	- - - -
21	43.000	on exv	- - - -	-2.16	- - - -	- - - -
22	42.800	on exv	- - - -	-1.46	- - - -	- - - -
23	42.600	on exv	- - - -	-0.71	- - - -	- - - -
24	42.400	on exv	- - - -	0.11	- - - -	- - - -
25	42.200	on exv	- - - -	0.98	- - - -	- - - -
26	42.000	on exv	122718	1.94	- - - -	Note: -238.15
27	41.800	on exv	- - - -	2.98	- - - -	- - - -
28	41.600	on exv	- - - -	4.08	- - - -	- - - -
29	41.400	on exv	- - - -	5.24	- - - -	- - - -
30	41.200	on exv	- - - -	6.42	- - - -	- - - -
31	41.000	on exv	- - - -	7.61	- - - -	- - - -
32	40.800	on exv	- - - -	8.81	- - - -	- - - -
33	40.600	on exv	- - - -	9.98	- - - -	- - - -
34	40.400	on exv	- - - -	11.11	- - - -	- - - -
35	40.200	on exv	- - - -	12.20	- - - -	- - - -
36	40.000	on exv	- - - -	13.23	- - - -	- - - -
37	39.800	on exv	- - - -	14.19	- - - -	- - - -
38	39.600	on exv	- - - -	15.07	- - - -	- - - -
39	39.400	on exv	- - - -	15.86	- - - -	- - - -
40	39.200	on exv	- - - -	16.56	- - - -	- - - -
41	39.000	on exv	- - - -	17.15	- - - -	- - - -
42	38.800	on exv	- - - -	17.63	- - - -	- - - -
43	38.750	on exv	- - - -	17.74	- - - -	- - - -
44	38.600	on exv	- - - -	18.01	- - - -	- - - -
45	38.500	on exv	- - - -	18.15	- - - -	- - - -
46	38.400	on exv	- - - -	18.27	- - - -	- - - -
47	38.200	on exv	- - - -	18.41	- - - -	- - - -
48	38.000	pssv pl	- - - -	18.45	4.36	- - - -
49	37.800	pssv pl	- - - -	18.37	4.89	- - - -
50	37.600	pssv pl	- - - -	18.19	5.51	- - - -
51	37.500	pssv pl	- - - -	18.06	5.85	- - - -
52	37.400	pssv pl	- - - -	17.91	6.00	- - - -
53	37.200	pssv pl	- - - -	17.54	6.29	- - - -
54	37.000	pssv pl	- - - -	17.09	3.68	- - - -
55	36.800	pssv pl	- - - -	16.56	2.84	- - - -
56	36.600	pssv pl	- - - -	15.97	2.99	- - - -
57	36.400	pssv pl	- - - -	15.32	3.15	- - - -
58	36.200	pssv pl	- - - -	14.63	3.31	- - - -
59	36.000	pssv pl	- - - -	13.89	3.46	- - - -
60	35.800	pssv pl	- - - -	13.13	3.62	- - - -
61	35.600	pssv pl	- - - -	12.35	3.77	- - - -
62	35.400	pssv pl	- - - -	11.56	3.93	- - - -
63	35.200	pssv pl	- - - -	10.77	4.09	- - - -
64	35.000	pssv pl	- - - -	9.98	4.24	- - - -
65	34.800	pssv pl	- - - -	9.21	4.40	- - - -
66	34.600	pssv pl	- - - -	8.46	4.55	- - - -
67	34.400	pssv pl	- - - -	7.74	4.71	- - - -
68	34.200	pssv pl	- - - -	7.05	4.87	- - - -
69	34.000	pssv pl	- - - -	6.40	5.02	- - - -
70	33.800	pssv pl	- - - -	5.79	5.18	- - - -
71	33.600	pssv el	4037	5.22	5.33	-21.09
72	33.400	pssv el	4037	4.70	5.49	-18.99
73	33.200	pssv el	4037	4.23	5.65	-17.08
74	33.000	pssv el	4037	3.80	5.80	-15.36
75	32.800	pssv el	4037	3.42	5.96	-13.81
76	32.600	pssv el	3028	3.08	6.09	-9.32
77	32.500	pssv el	2018	2.92	6.19	-5.90
78	32.400	pssv el	3028	2.78	6.29	-8.40
79	32.200	pssv el	4037	2.51	6.43	-10.14
80	32.000	pssv el	5113	2.28	5.20	-11.66
81	31.800	pssv el	6190	2.08	4.39	-12.90
82	31.600	pssv el	6190	1.92	4.50	-11.86
83	31.400	pssv el	6190	1.78	4.60	-11.00
84	31.200	pssv el	6190	1.66	4.70	-10.29
85	31.000	pssv el	6190	1.57	4.80	-9.72
86	30.800	pssv el	6190	1.50	4.90	-9.26

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
87	30.600	pssv el	6190	1.44	5.00	-8.91
88	30.400	pssv el	6190	1.40	5.11	-8.64
89	30.200	pssv el	6190	1.37	5.21	-8.45
90	30.000	pssv el	6190	1.34	5.31	-8.32
91	29.800	pssv el	6190	1.33	5.41	-8.23
92	29.600	pssv el	6190	1.32	5.51	-8.19
93	29.400	pssv el	6190	1.32	5.62	-8.17
94	29.200	pssv el	6190	1.32	5.72	-8.17
95	29.000	pssv el	6190	1.32	5.82	-8.19
96	28.800	pssv el	6190	1.33	5.92	-8.22
97	28.600	pssv el	4642	1.33	6.01	-6.19
98	28.500	pssv el	3095	1.34	6.07	-4.14
99	28.400	pssv el	4642	1.34	6.14	-6.22
100	28.200	pssv el	6190	1.35	6.23	-8.33
101	28.000	pssv el	3095	1.35	6.30	-4.18
Sum						-547.45

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -175.36kN m/m(G.L. 38.400m)
max shear force Smax= -154.52kN/m (G.L. 42.000m)
max displacement Del.xmax= 18.45mm (G.L. 38.000m)

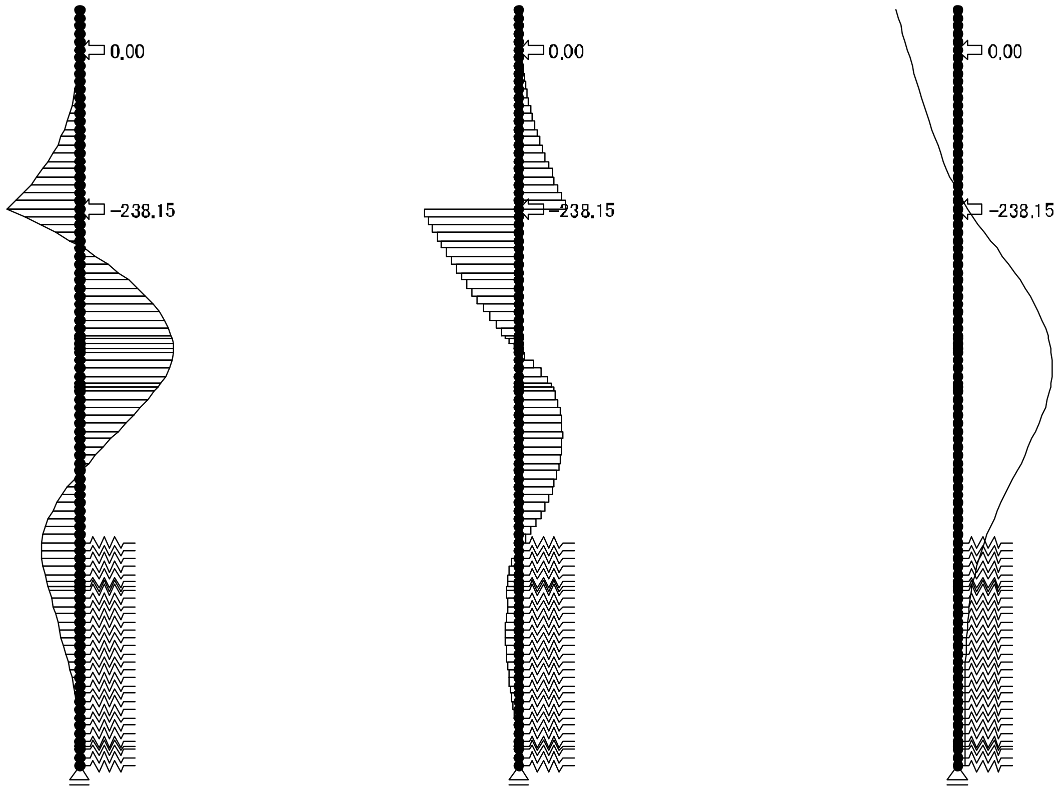
node No	Y co GL(m)	moment kN m/m top	moment kN m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	0.03	-12.12	------------
2	46.800	0.01	0.01	0.03	0.29	-11.66	------------
3	46.600	0.06	0.06	0.29	0.80	-11.21	------------
4	46.400	0.23	0.23	0.80	1.58	-10.76	------------
5	46.200	0.54	0.54	1.58	2.60	-10.30	------------
6	46.000	1.06	1.06	2.60	3.89	-9.85	* 0.00
7	45.800	1.84	1.84	3.89	5.43	-9.39	------------
8	45.600	2.93	2.93	5.43	7.23	-8.94	------------
9	45.400	4.37	4.37	7.23	9.29	-8.48	------------
10	45.200	6.23	6.23	9.29	11.61	-8.02	------------
11	45.000	8.55	8.55	11.61	14.18	-7.56	------------
12	44.800	11.39	11.39	14.18	17.01	-7.09	------------
13	44.600	14.79	14.79	17.01	20.10	-6.61	------------
14	44.400	18.81	18.81	20.10	23.44	-6.12	------------
15	44.200	23.50	23.50	23.44	27.04	-5.62	------------
16	44.000	28.91	28.91	27.04	30.90	-5.10	------------
17	43.800	35.09	35.09	30.90	35.01	-4.57	------------
18	43.600	42.09	42.09	35.01	39.39	-4.01	------------
19	43.400	49.97	49.97	39.39	44.02	-3.43	------------
20	43.200	58.77	58.77	44.02	48.90	-2.81	------------
21	43.000	68.55	68.55	48.90	54.05	-2.16	------------
22	42.800	79.36	79.36	54.05	59.45	-1.46	------------
23	42.600	91.25	91.25	59.45	65.11	-0.71	------------
24	42.400	104.27	104.27	65.11	71.03	0.11	------------
25	42.200	118.48	118.48	71.03	77.20	0.98	------------
26	42.000	133.92	133.92	77.20	-154.52	1.94	* -238.15
27	41.800	103.01	103.01	-154.52	-147.83	2.98	------------
28	41.600	73.45	73.45	-147.83	-140.89	4.08	------------
29	41.400	45.27	45.27	-140.89	-133.68	5.24	------------
30	41.200	18.53	18.53	-133.68	-126.22	6.42	------------
31	41.000	-6.71	-6.71	-126.22	-118.51	7.61	------------
32	40.800	-30.41	-30.41	-118.51	-110.53	8.81	------------
33	40.600	-52.52	-52.52	-110.53	-102.30	9.98	------------
34	40.400	-72.98	-72.98	-102.30	-93.81	11.11	------------
35	40.200	-91.74	-91.74	-93.81	-85.07	12.20	------------
36	40.000	-108.76	-108.76	-85.07	-76.06	13.23	------------
37	39.800	-123.97	-123.97	-76.06	-66.80	14.19	------------
38	39.600	-137.33	-137.33	-66.80	-57.29	15.07	------------
39	39.400	-148.79	-148.79	-57.29	-47.51	15.86	------------
40	39.200	-158.29	-158.29	-47.51	-37.48	16.56	------------
41	39.000	-165.79	-165.79	-37.48	-27.19	17.15	------------
42	38.800	-171.22	-171.22	-27.19	-20.63	17.63	------------
43	38.750	-172.26	-172.26	-20.63	-14.97	17.74	------------
44	38.600	-174.50	-174.50	-14.97	-7.57	18.01	------------
45	38.500	-175.26	-175.26	-7.57	-0.97	18.15	------------
46	38.400	-175.36	-175.36	-0.97	10.01	18.27	------------
47	38.200	-173.35	-173.35	10.01	25.17	18.41	------------
48	38.000	-168.32	-168.32	25.17	37.94	18.45	------------
49	37.800	-160.73	-160.73	37.94	47.24	18.37	------------
50	37.600	-151.28	-151.28	47.24	53.68	18.19	------------
51	37.500	-145.92	-145.92	53.68	57.11	18.06	------------
52	37.400	-140.21	-140.21	57.11	61.07	17.91	------------
53	37.200	-127.99	-127.99	61.07	65.84	17.54	------------

node No	Y co GL(m)	moment kN.m/m top	bottom	shear force kN/m top	bottom	disp Del.x mm	reaction Q kN/m
54	37.000	-114.82	-114.82	65.84	69.17	17.09	------------
55	36.800	-100.99	-100.99	69.17	70.96	16.56	------------
56	36.600	-86.80	-86.80	70.96	72.03	15.97	------------
57	36.400	-72.39	-72.39	72.03	72.37	15.32	------------
58	36.200	-57.92	-57.92	72.37	71.99	14.63	------------
59	36.000	-43.52	-43.52	71.99	70.89	13.89	------------
60	35.800	-29.34	-29.34	70.89	69.06	13.13	------------
61	35.600	-15.53	-15.53	69.06	66.51	12.35	------------
62	35.400	-2.23	-2.23	66.51	63.24	11.56	------------
63	35.200	10.42	10.42	63.24	59.24	10.77	------------
64	35.000	22.27	22.27	59.24	54.52	9.98	------------
65	34.800	33.17	33.17	54.52	49.08	9.21	------------
66	34.600	42.99	42.99	49.08	42.91	8.46	------------
67	34.400	51.57	51.57	42.91	36.03	7.74	------------
68	34.200	58.78	58.78	36.03	28.41	7.05	------------
69	34.000	64.46	64.46	28.41	20.08	6.40	------------
70	33.800	68.47	68.47	20.08	11.02	5.79	------------
71	33.600	70.68	70.68	11.02	1.68	5.22	-21.09
72	33.400	71.01	71.01	1.68	-5.65	4.70	-18.99
73	33.200	69.88	69.88	-5.65	-11.17	4.23	-17.08
74	33.000	67.65	67.65	-11.17	-15.06	3.80	-15.36
75	32.800	64.64	64.64	-15.06	-17.49	3.42	-13.81
76	32.600	61.14	61.14	-17.49	-18.34	3.08	-9.32
77	32.500	59.31	59.31	-18.34	-18.62	2.92	-5.90
78	32.400	57.44	57.44	-18.62	-18.64	2.78	-8.40
79	32.200	53.72	53.72	-18.64	-17.68	2.51	-10.14
80	32.000	50.18	50.18	-17.68	-18.34	2.28	-11.66
81	31.800	46.51	46.51	-18.34	-20.33	2.08	-12.90
82	31.600	42.45	42.45	-20.33	-21.38	1.92	-11.86
83	31.400	38.17	38.17	-21.38	-21.65	1.78	-11.00
84	31.200	33.84	33.84	-21.65	-21.31	1.66	-10.29
85	31.000	29.58	29.58	-21.31	-20.49	1.57	-9.72
86	30.800	25.48	25.48	-20.49	-19.31	1.50	-9.26
87	30.600	21.62	21.62	-19.31	-17.87	1.44	-8.91
88	30.400	18.04	18.04	-17.87	-16.26	1.40	-8.64
89	30.200	14.79	14.79	-16.26	-14.54	1.37	-8.45
90	30.000	11.88	11.88	-14.54	-12.79	1.34	-8.32
91	29.800	9.33	9.33	-12.79	-11.05	1.33	-8.23
92	29.600	7.12	7.12	-11.05	-9.35	1.32	-8.19
93	29.400	5.25	5.25	-9.35	-7.73	1.32	-8.17
94	29.200	3.70	3.70	-7.73	-6.20	1.32	-8.17
95	29.000	2.46	2.46	-6.20	-4.79	1.32	-8.19
96	28.800	1.50	1.50	-4.79	-3.49	1.33	-8.22
97	28.600	0.81	0.81	-3.49	-2.61	1.33	-6.19
98	28.500	0.54	0.54	-2.61	-2.06	1.34	-4.14
99	28.400	0.34	0.34	-2.06	-1.30	1.34	-6.22
100	28.200	0.08	0.08	-1.30	-0.40	1.35	-8.33
101	28.000	0.00	----------	-0.40	----------	1.35	-4.18

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -175.36kN m/m (G.L. 38.400m)
max shear force Smax= -154.52kN m (G.L. 42.000m)
max displacement Del.xmax= 18.45mm (G.L. 38.000m)



Moment graph Shear force diagram Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/mm)

FORUM8

5.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	175.36	0.00	154.52

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \le Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	97	324	OK

(4) shear stress

$$Tau = \frac{S}{A} \le Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	7	150	OK

5.3.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,’£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
0.00	3.600	0.00

3) stress

$$Sig. = \frac{P^* \ 10^3}{n^* \ A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
0	264	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,’£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
238.15	1.800	428.67

3) stress

$$Sig. = \frac{P^* \ 10^3}{n^* \ A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
97	264	OK

5.3.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$$M= \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
0.00	3.600	0.00

3)stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <=Sig.a$$

Z: section modulus (= 216* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
0	210	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M= \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
428.67	1.800	77.16

3)stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <=Sig.a$$

Z: section modulus (= 472* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
82	210	OK

5.4 riverside sheet pile

5.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 19.000(m)
position of tensile member G.L. : 42.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 41.750(m)
L.WL : 40.000(m)

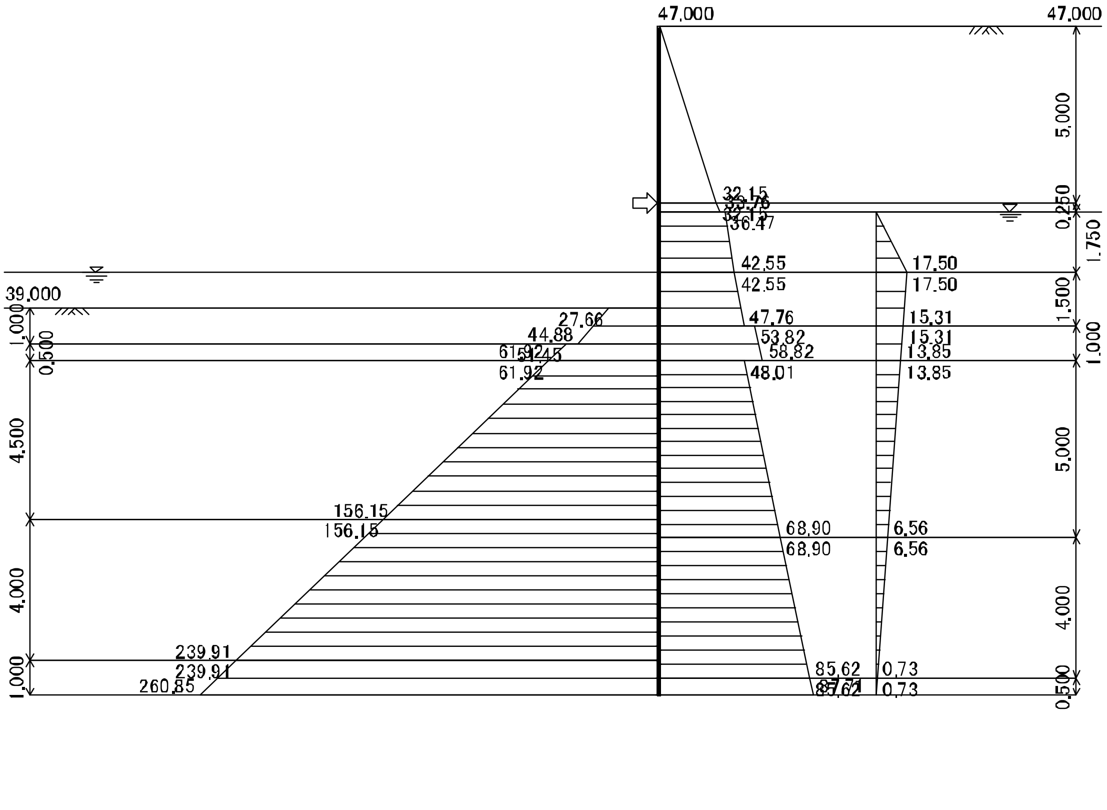
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	34.360	28.000
active sd	Ma+Mw+Mac(kN m/m)	1757.34	7406.55
passive sd	Mp+Mpc(kN m/m)	2109.84	15926.88
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.201>=1.20	2.150>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	42.000 41.750	0.250	32.15 33.76	8.24	0.126	1.04
2	41.750 40.000	1.750	36.47 42.55	69.14	1.147	79.34
3	40.000 38.500	1.500	42.55 47.76	67.73	2.764	187.24
4	38.500 37.500	1.000	53.82 58.82	56.32	4.007	225.69
5	37.500 32.500	5.000	48.01 68.90	292.28	7.149	2089.47
6	32.500 28.500	4.000	68.90 85.62	309.04	11.572	3576.24
7	28.500 28.000	0.500	85.62 87.71	43.33	13.751	595.84
Sum				846.08		6754.86

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	41.750 40.000	1.750	0.00 17.50	15.31	1.417	21.69
2	40.000 38.500	1.500	17.50 15.31	24.61	2.733	67.27
3	38.500 37.500	1.000	15.31 13.85	14.58	3.992	58.21
4	37.500 32.500	5.000	13.85 6.56	51.04	6.702	342.10
5	32.500 28.500	4.000	6.56 0.73	14.58	10.967	159.93
6	28.500 28.000	0.500	0.73 0.00	0.18	13.667	2.49
Sum				120.31		651.69

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	27.66 44.88	36.27	3.540	128.39
2	38.000 37.500	0.500	51.45 61.92	28.34	4.258	120.67
3	37.500 33.000	4.500	61.92 156.15	490.65	7.074	3470.91
4	33.000 29.000	4.000	156.15 239.91	792.12	11.141	8825.02
5	29.000 28.000	1.000	239.91 260.85	250.38	13.507	3381.89
Sum				1597.77		15926.88

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

5.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-117.59	G.L. 42.000
max shear force Smax(kN/m)	137.92	G.L. 42.000
upper tension mbr rct R1(kN/m)	4.08	G.L. 46.000
lower tension mbr rct R2(kN/m)	217.47	G.L. 42.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 42.000	0.00 32.15	0.00 0.00	---- ----	---- ----	0.00 32.15	---- ----
2	42.000 41.750	32.15 33.76	0.00 0.00	---- ----	---- ----	32.15 33.76	---- ----
3	41.750 40.000	36.47 42.55	0.00 17.50	---- ----	---- ----	36.47 60.05	---- ----
4	40.000 39.000	42.55 46.02	17.50 16.04	---- ----	---- ----	60.05 62.07	---- ----
5	39.000 38.500	46.02 47.76	16.04 15.31	27.66 36.27	0.00 2.96	62.07 60.11	27.66 33.31
6	38.500 38.000	53.82 56.32	15.31 14.58	36.27 44.88	2.96 5.92	66.17 64.98	33.31 38.96
7	38.000 37.500	56.32 58.82	14.58 13.85	51.45 61.92	5.20 7.79	65.71 64.88	46.25 54.12
8	37.500 33.000	48.01 66.81	13.85 7.29	61.92 156.15	7.79 31.18	54.07 42.93	54.12 124.97
9	33.000 32.500	66.81 68.90	7.29 6.56	156.15 166.62	31.18 33.78	42.93 41.69	124.97 132.84
10	32.500 29.000	68.90 83.53	6.56 1.46	166.62 239.91	33.78 51.96	41.69 33.02	132.84 187.95
11	29.000 28.500	83.53 85.62	1.46 0.73	239.91 250.38	51.96 54.56	33.02 31.78	187.95 195.82
12	28.500 28.000	85.62 87.71	0.73 0.00	250.38 260.85	54.56 57.16	31.78 30.55	195.82 203.69

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH= Eta*\frac{1}{0.3}*Alpha\ Eo*\left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	39.000	38.000	1.000	14000	6728
2	38.000	37.500	0.500	42000	20184
3	37.500	33.000	4.500	42000	20184
4	33.000	29.000	4.000	64400	30948
5	29.000	21.000	8.000	106400	51132

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp. * (2* number* A* E)}{(L* s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]

L : tensile member set length(wall width) [8.000] m

s : tensile member horizontal pitch(spacing)

A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	25	0.000491	200000000.0	3.600	6818
2	1	75	0.004418	200000000.0	1.800	122718

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	6818
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	19.29	3.86	--------	--------	--------	--------
17	43.800	On excavation plane	20.58	20.58	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	21.86	21.86	4.37	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
19	43.400	On excavation plane	23.15	23.15	4.63	--------	--------	--------	--------
20	43.200	On excavation plane	24.44	24.44	4.89	--------	--------	--------	--------
21	43.000	On excavation plane	25.72	25.72	5.14	--------	--------	--------	--------
22	42.800	On excavation plane	27.01	27.01	5.40	--------	--------	--------	--------
23	42.600	On excavation plane	28.29	28.29	5.66	--------	--------	--------	--------
24	42.400	On excavation plane	29.58	29.58	5.92	--------	--------	--------	--------
25	42.200	On excavation plane	30.87	30.87	6.17	--------	--------	--------	--------
26	42.000	Tensile member	32.15	32.15	6.43	--------	--------	--------	122718
27	41.800	On excavation plane	33.44	33.44	4.15	--------	--------	--------	--------
28	41.750	On excavation plane	33.76	36.47	3.62	--------	--------	--------	--------
29	41.600	On excavation plane	38.49	38.49	6.77	--------	--------	--------	--------
30	41.400	On excavation plane	41.19	41.19	8.24	--------	--------	--------	--------
31	41.200	On excavation plane	43.88	43.88	8.78	--------	--------	--------	--------
32	41.000	On excavation plane	46.58	46.58	9.32	--------	--------	--------	--------
33	40.800	On excavation plane	49.27	49.27	9.85	--------	--------	--------	--------
34	40.600	On excavation plane	51.97	51.97	10.39	--------	--------	--------	--------
35	40.400	On excavation plane	54.66	54.66	10.93	--------	--------	--------	--------
36	40.200	On excavation plane	57.36	57.36	11.47	--------	--------	--------	--------
37	40.000	On excavation plane	60.05	60.05	11.95	--------	--------	--------	--------
38	39.800	On excavation plane	60.45	60.45	12.09	--------	--------	--------	--------
39	39.600	On excavation plane	60.86	60.86	12.17	--------	--------	--------	--------
40	39.400	On excavation plane	61.26	61.26	12.25	--------	--------	--------	--------
41	39.200	On excavation plane	61.66	61.66	12.33	--------	--------	--------	--------
42	39.000	Pa plas.	62.07	62.07	12.38	0.00	27.66	2.82	--------
43	38.800	Pa plas.	61.28	61.28	12.26	29.92	29.92	5.98	--------
44	38.600	Pa plas.	60.50	60.50	9.09	32.18	32.18	4.78	--------
45	38.500	Pa plas.	60.11	66.17	6.32	33.31	33.31	3.33	--------
46	38.400	Pa plas.	65.93	65.93	9.88	34.44	34.44	5.21	--------
47	38.200	Pa plas.	65.46	65.46	13.09	36.70	36.70	7.34	--------
48	38.000	Pa plas.	64.98	65.71	13.07	38.96	46.25	8.54	--------
49	37.800	Pa plas.	65.37	65.37	13.07	49.40	49.40	9.88	--------
50	37.600	Pa plas.	65.04	65.04	9.76	52.55	52.55	7.82	--------
51	37.500	Pa plas.	64.88	54.07	5.95	54.12	54.12	5.41	--------
52	37.400	Pa plas.	53.82	53.82	8.06	55.70	55.70	8.41	--------
53	37.200	Pa plas.	53.33	53.33	10.67	58.85	58.85	11.77	--------
54	37.000	Pa plas.	52.83	52.83	10.57	62.00	62.00	12.40	--------
55	36.800	Pa plas.	52.33	52.33	10.47	65.14	65.14	13.03	--------
56	36.600	Pa plas.	51.84	51.84	10.37	68.29	68.29	13.66	--------
57	36.400	Pa plas.	51.34	51.34	10.27	71.44	71.44	14.29	--------
58	36.200	Pa plas.	50.85	50.85	10.17	74.59	74.59	14.92	--------
59	36.000	Pa plas.	50.35	50.35	10.07	77.74	77.74	15.55	--------
60	35.800	Pa plas.	49.86	49.86	9.97	80.89	80.89	16.18	--------
61	35.600	Pa plas.	49.36	49.36	9.87	84.04	84.04	16.81	--------

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN m
			above nd kN m2	below nd kN m2	cntrt ld kN m2	above nd kN m2	below nd kN m2	cntrt ld kN m2	
62	35.400	Pas ela.	48.87	48.87	9.77	87.19	87.19	--------	4037
63	35.200	Pas ela.	48.37	48.37	9.67	90.33	90.33	--------	4037
64	35.000	Pas ela.	47.88	47.88	9.58	93.48	93.48	--------	4037
65	34.800	Pas ela.	47.38	47.38	9.48	96.63	96.63	--------	4037
66	34.600	Pas ela.	46.89	46.89	9.38	99.78	99.78	--------	4037
67	34.400	Pas ela.	46.39	46.39	9.28	102.93	102.93	--------	4037
68	34.200	Pas ela.	45.90	45.90	9.18	106.08	106.08	--------	4037
69	34.000	Pas ela.	45.40	45.40	9.08	109.23	109.23	--------	4037
70	33.800	Pas ela.	44.91	44.91	8.98	112.38	112.38	--------	4037
71	33.600	Pas ela.	44.41	44.41	8.88	115.52	115.52	--------	4037
72	33.400	Pas ela.	43.92	43.92	8.78	118.67	118.67	--------	4037
73	33.200	Pas ela.	43.42	43.42	8.68	121.82	121.82	--------	4037
74	33.000	Pas ela.	42.93	42.93	8.59	124.97	124.97	--------	5113
75	32.800	Pas ela.	42.43	42.43	8.49	128.12	128.12	--------	6190
76	32.600	Pas ela.	41.94	41.94	6.30	131.27	131.27	--------	4642
77	32.500	Pas ela.	41.69	41.69	4.17	132.84	132.84	--------	3095
78	32.400	Pas ela.	41.44	41.44	6.21	134.42	134.42	--------	4642
79	32.200	Pas ela.	40.95	40.95	8.19	137.57	137.57	--------	6190
80	32.000	Pas ela.	40.45	40.45	8.09	140.71	140.71	--------	6190
81	31.800	Pas ela.	39.95	39.95	7.99	143.86	143.86	--------	6190
82	31.600	Pas ela.	39.46	39.46	7.89	147.01	147.01	--------	6190
83	31.400	Pas ela.	38.96	38.96	7.79	150.16	150.16	--------	6190
84	31.200	Pas ela.	38.47	38.47	7.69	153.31	153.31	--------	6190
85	31.000	Pas ela.	37.97	37.97	7.59	156.46	156.46	--------	6190
86	30.800	Pas ela.	37.48	37.48	7.50	159.61	159.61	--------	6190
87	30.600	Pas ela.	36.98	36.98	7.40	162.76	162.76	--------	6190
88	30.400	Pas ela.	36.49	36.49	7.30	165.91	165.91	--------	6190
89	30.200	Pas ela.	35.99	35.99	7.20	169.05	169.05	--------	6190
90	30.000	Pas ela.	35.50	35.50	7.10	172.20	172.20	--------	6190
91	29.800	Pas ela.	35.00	35.00	7.00	175.35	175.35	--------	6190
92	29.600	Pas ela.	34.51	34.51	6.90	178.50	178.50	--------	6190
93	29.400	Pas ela.	34.01	34.01	6.80	181.65	181.65	--------	6190
94	29.200	Pas ela.	33.52	33.52	6.70	184.80	184.80	--------	6190
95	29.000	Pas ela.	33.02	33.02	6.60	187.95	187.95	--------	8208
96	28.800	Pas ela.	32.53	32.53	6.51	191.10	191.10	--------	10226
97	28.600	Pas ela.	32.03	32.03	4.81	194.24	194.24	--------	7670
98	28.500	Pas ela.	31.78	31.78	3.18	195.82	195.82	--------	5113
99	28.400	Pas ela.	31.54	31.54	4.72	197.39	197.39	--------	7670
100	28.200	Pas ela.	31.04	31.04	6.21	200.54	200.54	--------	10226
101	28.000	Pas ela.	30.55	0.00	3.07	203.69	0.00	--------	5113
Sum					732.03			198.14	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= -8.31mm(G.L. 38.600m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	----	-0.81	----	----
2	46.800	on exv	----	-0.77	----	----
3	46.600	on exv	----	-0.72	----	----
4	46.400	on exv	----	-0.68	----	----
5	46.200	on exv	----	-0.64	----	----
6	46.000	on exv	6818	-0.60	----	Note: 4.08
7	45.800	on exv	----	-0.56	----	----
8	45.600	on exv	----	-0.52	----	----
9	45.400	on exv	----	-0.48	----	----
10	45.200	on exv	----	-0.44	----	----
11	45.000	on exv	----	-0.40	----	----
12	44.800	on exv	----	-0.37	----	----
13	44.600	on exv	----	-0.34	----	----
14	44.400	on exv	----	-0.32	----	----
15	44.200	on exv	----	-0.30	----	----
16	44.000	on exv	----	-0.30	----	----
17	43.800	on exv	----	-0.31	----	----
18	43.600	on exv	----	-0.34	----	----
19	43.400	on exv	----	-0.38	----	----
20	43.200	on exv	----	-0.46	----	----
21	43.000	on exv	----	-0.56	----	----
22	42.800	on exv	----	-0.70	----	----
23	42.600	on exv	----	-0.89	----	----
24	42.400	on exv	----	-1.12	----	----
25	42.200	on exv	----	-1.41	----	----
26	42.000	on exv	122718	-1.77	----	Note: 217.47
27	41.800	on exv	----	-2.20	----	----
28	41.750	on exv	----	-2.32	----	----
29	41.600	on exv	----	-2.69	----	----
30	41.400	on exv	----	-3.23	----	----
31	41.200	on exv	----	-3.78	----	----
32	41.000	on exv	----	-4.35	----	----
33	40.800	on exv	----	-4.92	----	----
34	40.600	on exv	----	-5.47	----	----
35	40.400	on exv	----	-5.99	----	----
36	40.200	on exv	----	-6.47	----	----
37	40.000	on exv	----	-6.91	----	----
38	39.800	on exv	----	-7.30	----	----
39	39.600	on exv	----	-7.63	----	----
40	39.400	on exv	----	-7.89	----	----
41	39.200	on exv	----	-8.10	----	----
42	39.000	pssv pl	----	-8.23	4.20	----
43	38.800	pssv pl	----	-8.30	4.45	----
44	38.600	pssv pl	----	-8.31	4.74	----
45	38.500	pssv pl	----	-8.30	4.95	----
46	38.400	pssv pl	----	-8.26	5.16	----
47	38.200	pssv pl	----	-8.16	5.45	----
48	38.000	pssv pl	----	-8.00	3.17	----
49	37.800	pssv pl	----	-7.80	2.45	----
50	37.600	pssv pl	----	-7.55	2.58	----
51	37.500	pssv pl	----	-7.41	2.68	----
52	37.400	pssv pl	----	-7.27	2.78	----
53	37.200	pssv pl	----	-6.96	2.92	----
54	37.000	pssv pl	----	-6.64	3.07	----
55	36.800	pssv pl	----	-6.29	3.23	----
56	36.600	pssv pl	----	-5.94	3.38	----
57	36.400	pssv pl	----	-5.58	3.54	----
58	36.200	pssv pl	----	-5.23	3.70	----
59	36.000	pssv pl	----	-4.88	3.85	----
60	35.800	pssv pl	----	-4.54	4.01	----
61	35.600	pssv pl	----	-4.22	4.16	----
62	35.400	pssv el	4037	-3.91	4.32	15.78
63	35.200	pssv el	4037	-3.62	4.48	14.62
64	35.000	pssv el	4037	-3.35	4.63	13.54
65	34.800	pssv el	4037	-3.11	4.79	12.54
66	34.600	pssv el	4037	-2.88	4.94	11.62
67	34.400	pssv el	4037	-2.67	5.10	10.78
68	34.200	pssv el	4037	-2.48	5.26	10.01
69	34.000	pssv el	4037	-2.31	5.41	9.32
70	33.800	pssv el	4037	-2.15	5.57	8.69
71	33.600	pssv el	4037	-2.01	5.72	8.12
72	33.400	pssv el	4037	-1.88	5.88	7.61
73	33.200	pssv el	4037	-1.77	6.04	7.15
74	33.000	pssv el	5113	-1.67	4.89	8.53
75	32.800	pssv el	6190	-1.58	4.14	9.77
76	32.600	pssv el	4642	-1.50	4.23	6.95
77	32.500	pssv el	3095	-1.46	4.29	4.52
78	32.400	pssv el	4642	-1.43	4.36	6.63
79	32.200	pssv el	6190	-1.37	4.45	8.46
80	32.000	pssv el	6190	-1.31	4.55	8.12
81	31.800	pssv el	6190	-1.27	4.65	7.83
82	31.600	pssv el	6190	-1.22	4.75	7.57
83	31.400	pssv el	6190	-1.19	4.85	7.35

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
84	31.200	pssv el	6190	-1.15	4.95	7.14
85	31.000	pssv el	6190	-1.12	5.06	6.95
86	30.800	pssv el	6190	-1.09	5.16	6.76
87	30.600	pssv el	6190	-1.06	5.26	6.59
88	30.400	pssv el	6190	-1.04	5.36	6.41
89	30.200	pssv el	6190	-1.01	5.46	6.23
90	30.000	pssv el	6190	-0.98	5.56	6.05
91	29.800	pssv el	6190	-0.95	5.67	5.85
92	29.600	pssv el	6190	-0.91	5.77	5.65
93	29.400	pssv el	6190	-0.88	5.87	5.43
94	29.200	pssv el	6190	-0.84	5.97	5.21
95	29.000	pssv el	8208	-0.80	4.58	6.59
96	28.800	pssv el	10226	-0.76	3.74	7.82
97	28.600	pssv el	7670	-0.73	3.79	5.56
98	28.500	pssv el	5113	-0.71	3.83	3.61
99	28.400	pssv el	7670	-0.69	3.87	5.26
100	28.200	pssv el	10226	-0.65	3.92	6.61
101	28.000	pssv el	5113	-0.61	3.97	3.10
Sum						533.89

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -117.59kN m/m(G.L. 42.000m)
max shear force Smax= 137.92kN/m (G.L. 42.000m)
max displacement Del.xmax= -8.31mm (G.L. 38.600m)

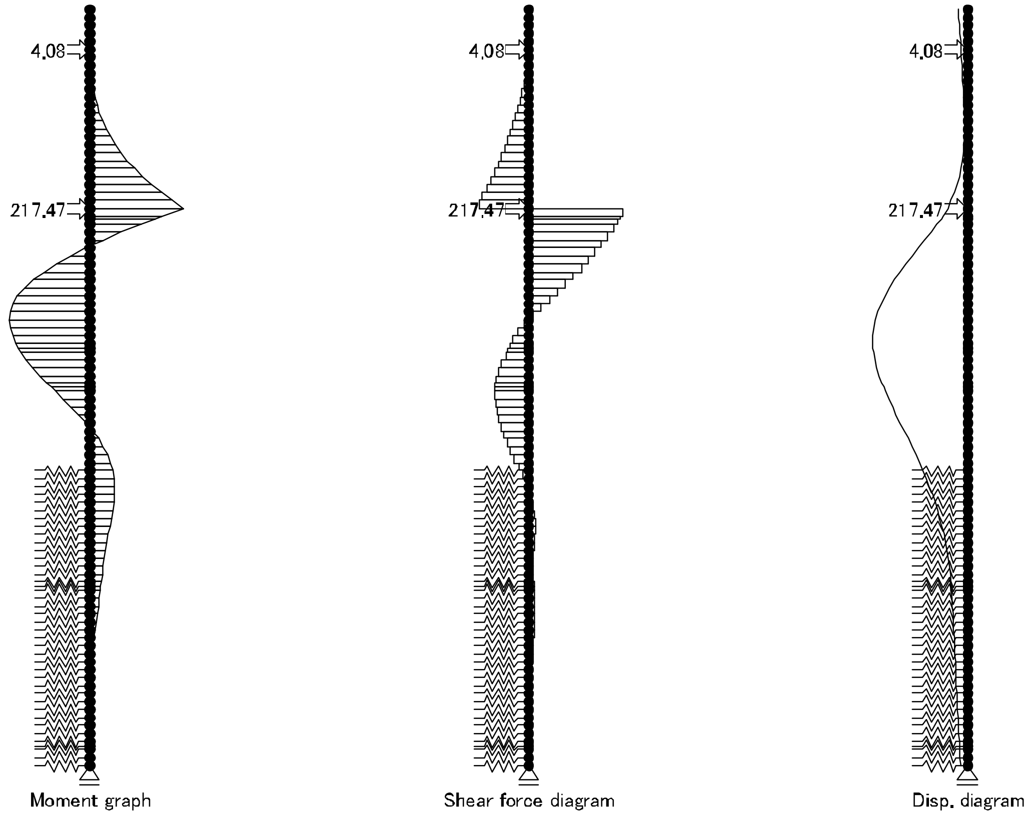
node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-0.03	-0.81	------------
2	46.800	-0.01	-0.01	-0.03	-0.29	-0.77	------------
3	46.600	-0.06	-0.06	-0.29	-0.80	-0.72	------------
4	46.400	-0.23	-0.23	-0.80	-1.58	-0.68	------------
5	46.200	-0.54	-0.54	-1.58	-2.60	-0.64	------------
6	46.000	-1.06	-1.06	-2.60	0.19	-0.60	* 4.08
7	45.800	-1.02	-1.02	0.19	-1.35	-0.56	------------
8	45.600	-1.29	-1.29	-1.35	-3.15	-0.52	------------
9	45.400	-1.92	-1.92	-3.15	-5.21	-0.48	------------
10	45.200	-2.97	-2.97	-5.21	-7.53	-0.44	------------
11	45.000	-4.47	-4.47	-7.53	-10.10	-0.40	------------
12	44.800	-6.49	-6.49	-10.10	-12.93	-0.37	------------
13	44.600	-9.08	-9.08	-12.93	-16.01	-0.34	------------
14	44.400	-12.28	-12.28	-16.01	-19.36	-0.32	------------
15	44.200	-16.15	-16.15	-19.36	-22.96	-0.30	------------
16	44.000	-20.74	-20.74	-22.96	-26.82	-0.30	------------
17	43.800	-26.11	-26.11	-26.82	-30.93	-0.31	------------
18	43.600	-32.29	-32.29	-30.93	-35.31	-0.34	------------
19	43.400	-39.36	-39.36	-35.31	-39.94	-0.38	------------
20	43.200	-47.34	-47.34	-39.94	-44.82	-0.46	------------
21	43.000	-56.31	-56.31	-44.82	-49.97	-0.56	------------
22	42.800	-66.30	-66.30	-49.97	-55.37	-0.70	------------
23	42.600	-77.38	-77.38	-55.37	-61.03	-0.89	------------
24	42.400	-89.58	-89.58	-61.03	-66.95	-1.12	------------
25	42.200	-102.97	-102.97	-66.95	-73.12	-1.41	------------
26	42.000	-117.59	-117.59	-73.12	137.92	-1.77	* 217.47
27	41.800	-90.01	-90.01	137.92	133.77	-2.20	------------
28	41.750	-83.32	-83.32	133.77	130.16	-2.32	------------
29	41.600	-63.80	-63.80	130.16	123.39	-2.69	------------
30	41.400	-39.12	-39.12	123.39	115.16	-3.23	------------
31	41.200	-16.09	-16.09	115.16	106.38	-3.78	------------
32	41.000	5.19	5.19	106.38	97.06	-4.35	------------
33	40.800	24.60	24.60	97.06	87.21	-4.92	------------
34	40.600	42.04	42.04	87.21	76.82	-5.47	------------
35	40.400	57.41	57.41	76.82	65.89	-5.99	------------
36	40.200	70.58	70.58	65.89	54.41	-6.47	------------
37	40.000	81.47	81.47	54.41	42.46	-6.91	------------
38	39.800	89.96	89.96	42.46	30.37	-7.30	------------
39	39.600	96.03	96.03	30.37	18.20	-7.63	------------
40	39.400	99.67	99.67	18.20	5.95	-7.89	------------
41	39.200	100.86	100.86	5.95	-6.38	-8.10	------------
42	39.000	99.59	99.59	-6.38	-15.95	-8.23	------------
43	38.800	96.40	96.40	-15.95	-22.22	-8.30	------------
44	38.600	91.95	91.95	-22.22	-26.52	-8.31	------------
45	38.500	89.30	89.30	-26.52	-29.51	-8.30	------------
46	38.400	86.35	86.35	-29.51	-34.18	-8.26	------------
47	38.200	79.51	79.51	-34.18	-39.93	-8.16	------------
48	38.000	71.53	71.53	-39.93	-44.46	-8.00	------------
49	37.800	62.64	62.64	-44.46	-47.66	-7.80	------------
50	37.600	53.11	53.11	-47.66	-49.59	-7.55	------------

node No	Y co GL(m)	moment kN.m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
51	37.500	48.15	48.15	-49.59	-50.13	-7.41	------------
52	37.400	43.13	43.13	-50.13	-49.78	-7.27	------------
53	37.200	33.18	33.18	-49.78	-48.67	-6.96	------------
54	37.000	23.44	23.44	-48.67	-46.84	-6.64	------------
55	36.800	14.07	14.07	-46.84	-44.28	-6.29	------------
56	36.600	5.22	5.22	-44.28	-40.99	-5.94	------------
57	36.400	-2.98	-2.98	-40.99	-36.97	-5.58	------------
58	36.200	-10.37	-10.37	-36.97	-32.22	-5.23	------------
59	36.000	-16.82	-16.82	-32.22	-26.74	-4.88	------------
60	35.800	-22.17	-22.17	-26.74	-20.54	-4.54	------------
61	35.600	-26.27	-26.27	-20.54	-13.60	-4.22	------------
62	35.400	-28.99	-28.99	-13.60	-7.59	-3.91	15.78
63	35.200	-30.51	-30.51	-7.59	-2.64	-3.62	14.62
64	35.000	-31.04	-31.04	-2.64	1.32	-3.35	13.54
65	34.800	-30.78	-30.78	1.32	4.39	-3.11	12.54
66	34.600	-29.90	-29.90	4.39	6.63	-2.88	11.62
67	34.400	-28.57	-28.57	6.63	8.13	-2.67	10.78
68	34.200	-26.95	-26.95	8.13	8.97	-2.48	10.01
69	34.000	-25.16	-25.16	8.97	9.20	-2.31	9.32
70	33.800	-23.31	-23.31	9.20	8.91	-2.15	8.69
71	33.600	-21.53	-21.53	8.91	8.14	-2.01	8.12
72	33.400	-19.90	-19.90	8.14	6.97	-1.88	7.61
73	33.200	-18.51	-18.51	6.97	5.43	-1.77	7.15
74	33.000	-17.42	-17.42	5.43	5.37	-1.67	8.53
75	32.800	-16.35	-16.35	5.37	6.65	-1.58	9.77
76	32.600	-15.02	-15.02	6.65	7.31	-1.50	6.95
77	32.500	-14.29	-14.29	7.31	7.66	-1.46	4.52
78	32.400	-13.52	-13.52	7.66	8.08	-1.43	6.63
79	32.200	-11.91	-11.91	8.08	8.35	-1.37	8.46
80	32.000	-10.24	-10.24	8.35	8.38	-1.31	8.12
81	31.800	-8.56	-8.56	8.38	8.22	-1.27	7.83
82	31.600	-6.92	-6.92	8.22	7.90	-1.22	7.57
83	31.400	-5.34	-5.34	7.90	7.46	-1.19	7.35
84	31.200	-3.84	-3.84	7.46	6.90	-1.15	7.14
85	31.000	-2.46	-2.46	6.90	6.25	-1.12	6.95
86	30.800	-1.21	-1.21	6.25	5.52	-1.09	6.76
87	30.600	-0.11	-0.11	5.52	4.71	-1.06	6.59
88	30.400	0.84	0.84	4.71	3.83	-1.04	6.41
89	30.200	1.60	1.60	3.83	2.86	-1.01	6.23
90	30.000	2.17	2.17	2.86	1.81	-0.98	6.05
91	29.800	2.53	2.53	1.81	0.66	-0.95	5.85
92	29.600	2.67	2.67	0.66	-0.60	-0.91	5.65
93	29.400	2.55	2.55	-0.60	-1.97	-0.88	5.43
94	29.200	2.15	2.15	-1.97	-3.46	-0.84	5.21
95	29.000	1.46	1.46	-3.46	-3.47	-0.80	6.59
96	28.800	0.77	0.77	-3.47	-2.16	-0.76	7.82
97	28.600	0.33	0.33	-2.16	-1.41	-0.73	5.56
98	28.500	0.19	0.19	-1.41	-0.98	-0.71	3.61
99	28.400	0.10	0.10	-0.98	-0.44	-0.69	5.26
100	28.200	0.01	0.01	-0.44	-0.04	-0.65	6.61
101	28.000	0.00	----------	-0.04	----------	-0.61	3.10

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -117.59kN m/m (G.L. 42.000m)
max shear force Smax= 137.92kN m (G.L. 42.000m)
max displacement Del.xmax= -8.31mm (G.L. 38.600m)



* in figure, number in arrow shows tensile reaction (kN/m)

5.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	117.59	0.00	137.92

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	65	324	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	6	150	OK

5.4.4 Tensile member stress

(1) Upper stage check on tensile member

1) member in use

diameter in use : Phi 25(mm)
material in use : ,'£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 3.600(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 25^2 * (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
4.08	3.600	14.69

3) stress

$$Sig. = \frac{P* 10^3}{n* A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
30	264	OK

(2) Lower stage check on tensile member

1) member in use

diameter in use : Phi 75(mm)
material in use : ,'£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 75^2 * (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
217.47	1.800	391.45

3) stress

$$Sig. = \frac{P* 10^3}{n* A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
89	264	OK

5.4.5 Waling member stress

(1)Upper stage Wailing check

1)member in use

steel material in use : H |150 ~150 ~ 7 ~10
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 3.600(m)

2)moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
14.69	3.600	5.29

3)stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \leq Sig.a$$

Z: section modulus (= 216* 2cm³)
Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
12	210	OK

(2)Lower stage Wailing check

1)member in use

steel material in use : H |200 ~200 ~ 8 ~12
material in use : SS400
allowable stress : 210(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
391.45	1.800	70.46

3)stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \leq Sig.a$$

Z: section modulus (= 472* 2cm³)
Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
75	210	OK

6 Calculation on impermeability

(1)check method

impermeability effect (seepage pass) is checked through two passes.

water level condition is ordinary case for stability (and landside sheet pile as well).

1)seepage pass part 1 (along sheet pile)

$$F1= \frac{L1}{h1} >= FS$$

2)seepage pass part 2(pass through excavation bottom in land side: omit if no shape)

$$F2= \frac{L2}{h2} >= FS$$

where,

FS: required factor of safety(Sandy foundation: 3.25)

Fi : factor of safety

L1: seepage pass part 1(along sheet pile)

h1: water level difference part 1(from ordinal H.W.L. to landside ground surface)

L2: seepage pass part 2(pass through landside excavation bottom)

h2: water level difference part 2(from ordinal H.W.L. to landside ground surface)

(2)calculation result summery

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
nomal time	29.000	8.000	3.63>=3.25

(3)seepage pass part 1(along sheet pile)

L1= D1+ Lb+ D2

where,

D1: sheet pile embedment length on riverside(m)

D2: sheet pile embedment length on landside(m)

Lb: distance between sheet piles(m)

Lb= Sqrt(B^2+ Del.L^2)

B : embankment width (8.000m)

Del.L: difference of sheet pile between riverside and landside(0.000m)

L1= 11.000+ 8.000+ 10.000

= 29.000(m)

(4)seepage pass part 2(pass through landside excavation bottom)

Because of no excavation shape, omit calculation.

Cover

(3)Abo Gabal Canal

Contents

1 Design condition

File name:AboGabal 2

1.1 Properties

(1)wall scale

final wall width : 6.000(m)
length of landside final sheet pile : 9.000(m)
length of riverside final sheet pile : 9.000(m)

(2)basic data

title : Ibrahimia 1
comment :
wall type : Steel sheet pile
influence of water level : Yes consider
water unit weight Gamw : 10.00(kN/m³)
check earthquake case : Yes
check liquefaction case : No
check riverside sheet pile : Yes
tensile member installation position

No	position G.L.(m)
1	46.000

1.2 shape

(1)plane

wall extension

wall No	inter wl len.(m)	angle (deg)	object wall
1	18.400	----.---	
2	21.000	120.000	
3	8.400	140.000	OK

wall direction: Hor.

(2)side

top of filling soil : G.L. 47.000(m)
top of landside sheet pile : G.L. 47.000(m)
top of riverside sheet pile : G.L. 47.000(m)

(3)tensile member planar layout

tensile member adjusting installation method : Equally layout

wall 1

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

wall 2

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

wall 3

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

1.3 Method

(1)check points
Check 4* C > Sum(Gam h) : No check
Check shielding effect : check sand ground
Check discharge : No
Check circle slope : No
Check, change of bearing capacity : No

(2)design method
shear deformation failure check points
search the position of min FS : Yes
ditto searching pitch : 1.00(m)
calculation of self-weight : Conforming design manual
consider external force above tensile member with the limit equivalent method : No consider
elasto-plastic analysis and calculation condition member force in liquefaction
coefficient of allowance when tensile member spring is calculated Alp. : 1.0
equivalent loading width for calculation BH : 10.0m
deformation coefficient in earthquake : 2.00 of ordinary time (input)
wall tip bearing condition : Free
calculation pitch : 0.20(m)
check elastic zone in elasto-plastic calculation :No
required elastic zone rate as above : 50.0%
design of residual water level
residual water level setting(riverside water level - landside water level)* ratio: 0.500

1.4 Strata data

(1)soil character of filling soil

filled soil	soil unit weight			inter fric angle (deg)	cohesion	
	wet kN/m3	submrg kN/m3	satur. kN/m3		Co kN/m2	increment k kN/m3
Sandy soil	18.0	9.0	19.0	30.0	0.0	0.0

(2)River side section(current ground level G.L. 43.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m³		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
3	2.000	Sandy	25.0	18.0	9.0	19.0	25.0	10.0	0.0	70000
4	2.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
5	2.000	Sandy	5.0	18.0	9.0	19.0	10.0	10.0	0.0	14000
6	1.000	Sandy	17.0	18.0	9.0	19.0	20.0	10.0	0.0	47600
7	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200
8	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200
9	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
10	1.000	Sandy	49.0	18.0	9.0	19.0	30.0	10.0	0.0	137200
11	1.000	Sandy	59.0	18.0	9.0	19.0	35.0	10.0	0.0	165200
12	1.000	Sandy	24.0	18.0	9.0	19.0	25.0	10.0	0.0	67200
13	1.000	Sandy	38.0	18.0	9.0	19.0	30.0	10.0	0.0	106400
14	1.000	Sandy	44.0	18.0	9.0	19.0	35.0	10.0	0.0	123200
15	1.000	Sandy	38.0	18.0	9.0	19.0	35.0	10.0	0.0	106400

(3)Embankment body section(current ground level G.L. 43.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m²
				Wet kN/m3	Submerged kN/m3	Saturation kN/m³		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
3	2.000	Sandy	25.0	18.0	9.0	19.0	25.0	10.0	0.0	70000
4	2.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
5	2.000	Sandy	5.0	18.0	9.0	19.0	10.0	10.0	0.0	14000
6	1.000	Sandy	17.0	18.0	9.0	19.0	20.0	10.0	0.0	47600
7	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
8	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200
9	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
10	1.000	Sandy	49.0	18.0	9.0	19.0	30.0	10.0	0.0	137200
11	1.000	Sandy	59.0	18.0	9.0	19.0	35.0	10.0	0.0	165200
12	1.000	Sandy	24.0	18.0	9.0	19.0	25.0	10.0	0.0	67200
13	1.000	Sandy	38.0	18.0	9.0	19.0	30.0	10.0	0.0	106400
14	1.000	Sandy	44.0	18.0	9.0	19.0	35.0	10.0	0.0	123200
15	1.000	Sandy	38.0	18.0	9.0	19.0	35.0	10.0	0.0	106400

(4)Land side section(current ground level G.L. 42.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
3	2.000	Sandy	25.0	18.0	9.0	19.0	25.0	10.0	0.0	70000
4	2.000	Sandy	23.0	18.0	9.0	19.0	25.0	10.0	0.0	64400
5	2.000	Sandy	5.0	18.0	9.0	19.0	10.0	10.0	0.0	14000
6	1.000	Sandy	17.0	18.0	9.0	19.0	20.0	10.0	0.0	47600
7	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200
8	1.000	Sandy	19.0	18.0	9.0	19.0	20.0	10.0	0.0	53200
9	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
10	1.000	Sandy	49.0	18.0	9.0	19.0	30.0	10.0	0.0	137200
11	1.000	Sandy	59.0	18.0	9.0	19.0	35.0	10.0	0.0	165200
12	1.000	Sandy	24.0	18.0	9.0	19.0	25.0	10.0	0.0	67200
13	1.000	Sandy	38.0	18.0	9.0	19.0	30.0	10.0	0.0	106400
14	1.000	Sandy	44.0	18.0	9.0	19.0	35.0	10.0	0.0	123200
15	1.000	Sandy	38.0	18.0	9.0	19.0	35.0	10.0	0.0	106400

1.5 members

(1)wall data

effective rate of sheet pile

moment of inertia (stress deformation calculation) : 0.45

modulus of section : 0.60

landside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

riverside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

(2)tensile member, wailing data

tensile member

No	position G.L.(m)	tns mbr spring tns	tns mbr H-pitch m	tns mbr dia mm	tns mbr mat	tns mbr number	tns mbr direct iput	tns spring sprg cost. kN/m/m	wailing material
1	46.000	Use	1.800	32.0	7	1	No	----------	SS400

waling member

wailing member : Channel steel

wailing check equation : TL/10

1.5 Study case data

(1)check case [deal Normal time]

check case name : ｲ7ｽ

internal setting

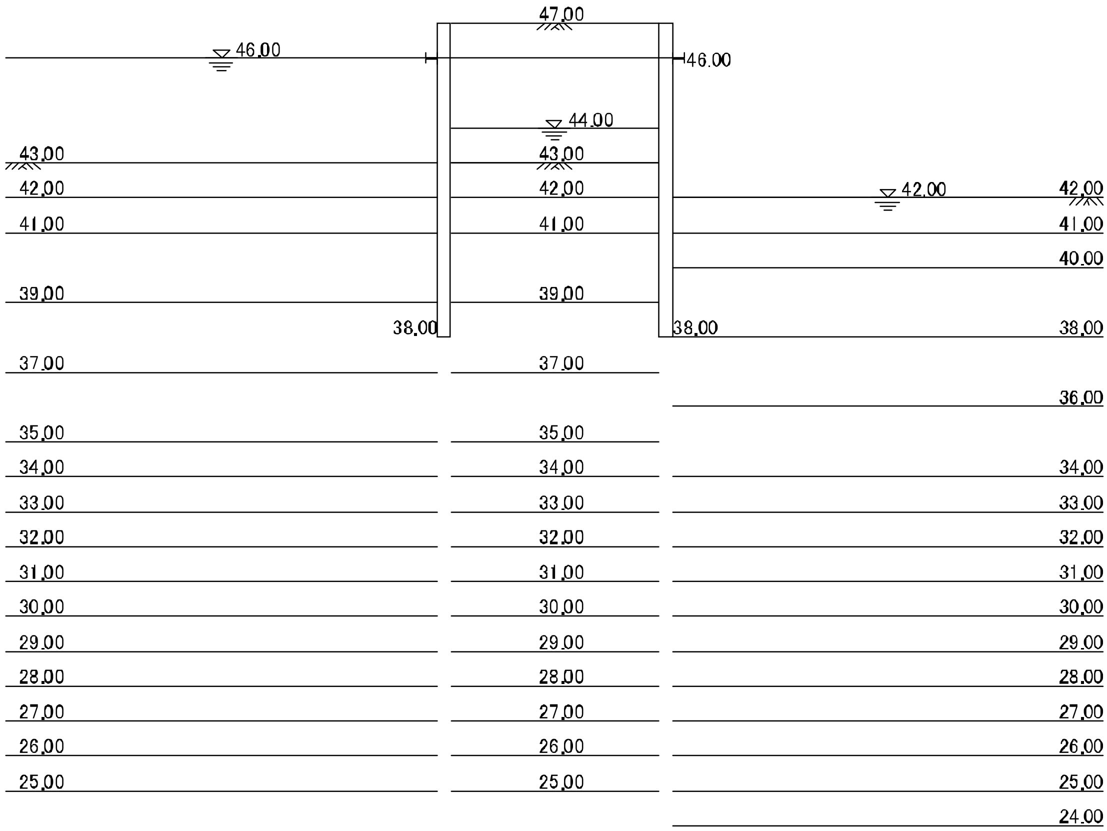
e-prss	soil spring	allowable
Normal time	Normal time	Normal time

water level condition
* stability calculation and check of landside sheet pile
  riverside water level : G.L. 46.000(m)
  landside water level : G.L. 42.000(m)
* check of riverside sheet pile
  wall residual water level : G.L. 44.000(m)
  riverside water level : G.L. 43.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	10.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



(2)check case [deal Earthquake time]
check case name : 'n kŽž
internal setting

e-prss	soil spring	allowable
Earthquake time	Earthquake time	Earthquake time

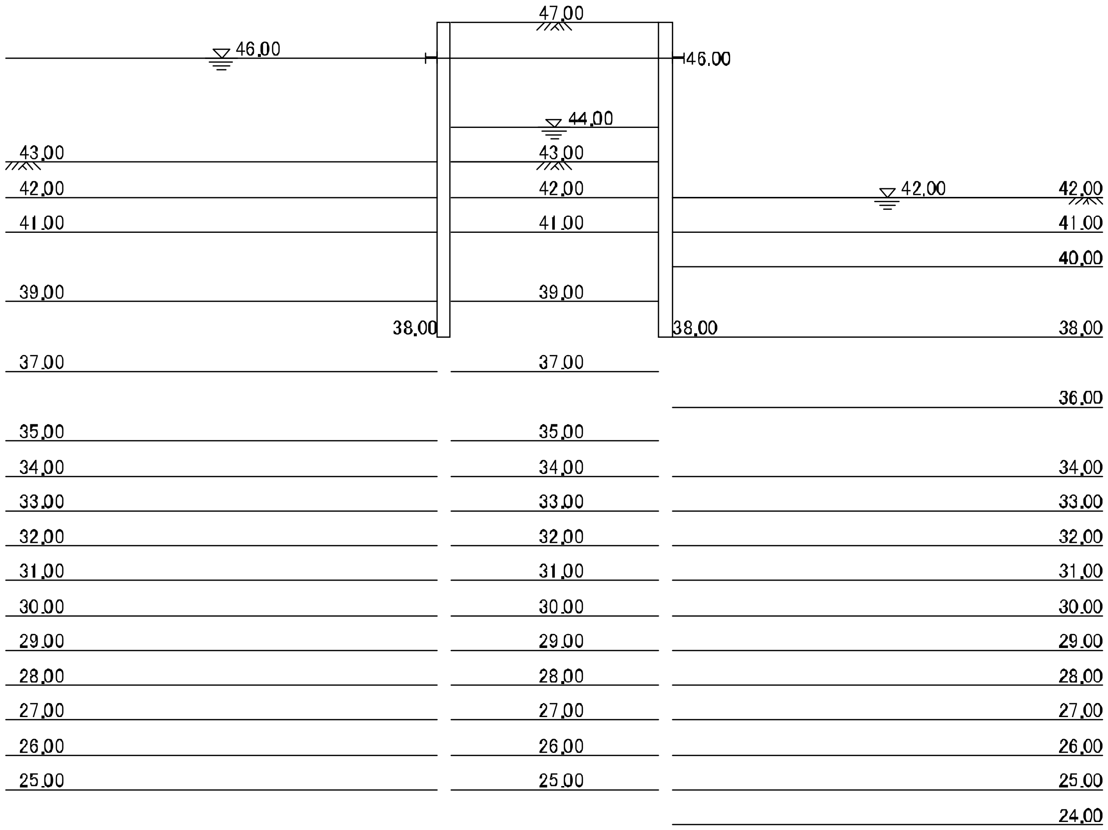
design seismicity
* design seismicity : 0.04
* seismic assumption : River standard method
resistant moment above shear deformation check level : Normal time
water level condition

* stability calculation and check of landside sheet pile
riverside water level : G.L. 46.000(m)
landside water level : G.L. 42.000(m)
* check of riverside sheet pile
wall residual water level : G.L. 44.000(m)
riverside water level : G.L. 43.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



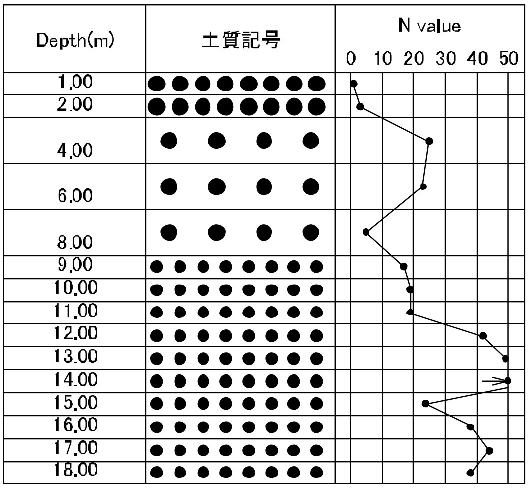
1.7 circular failure

Not calculate circular failure

1.8 discharge data

not check discharge

1. 9 Drillhole log



1.10 Steel data

steel sheet pile

No	steel name	w (mm)	h (mm)	W (kg/m2)	A (cm2/m)	I (cm4/m)	Z (cm3/m)
1	IIŒ^	400	100	48.0	153.00	8740	874
2	IIIŒ^	400	125	60.0	191.00	16800	1340
3	IIIŒ^	400	130	60.0	191.00	17400	1340
4	IVŒ^	400	170	76.1	242.50	38600	2270
5	VLŒ^	500	200	105.0	267.60	63000	3150
6	PU28+1	600	228	106.2	226.00	68380	3000

wailing(steel trench)

No	steel name	h (mm)	B (mm)	t_1 (mm)	t_2 (mm)	A (cm2)	w (kg/m)	Zx (cm^3)
1	m150 ~75 ~6.5 ~10	150	75	6.5	10.0	23.71	18.6	115
2	m150 ~75 ~9 ~12.5	150	75	9.0	12.5	30.59	24.0	140
3	m180 ~75 ~7 ~10.5	180	75	7.0	10.5	27.20	21.4	153
4	m200 ~80 ~7.5 ~11	200	80	7.5	11.0	31.33	24.6	195
5	m200 ~90 ~8 ~13.5	200	90	8.0	13.5	38.65	30.3	249
6	m250 ~90 ~9 ~13	250	90	9.0	13.0	44.07	34.6	334
7	m250 ~90 ~11 ~14.5	250	90	11.0	14.5	51.17	40.2	374
8	m300 ~90 ~9 ~13	300	90	9.0	13.0	48.57	38.1	429
9	m300 ~90 ~10 ~15.5	300	90	10.0	15.5	55.74	43.8	494
10	m300 ~90 ~12 ~16	300	90	12.0	16.0	61.90	48.6	525
11	m380 ~100 ~10.5 ~16	380	100	10.5	16.0	69.39	54.5	763
12	m380 ~100 ~13 ~16.5	380	100	13.0	16.5	78.96	62.0	823
13	m380 ~100 ~13 ~20	380	100	13.0	20.0	85.71	67.3	926
14	[125 ~65 ~6 ~8	125	65	6.0	8.0	17.11	13.4	67

Note:Two sheets makes one set for stress check, doubly count in calculation process.

1.11 material data

steel sheet pile material

Young's modulus : 2.00* 10^5 N/mm2

unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SY295		SY390	
	normal	earthq.	normal	earthq.
allw bending str	180	270	235	353
allw shear str	83	125	110	165

Material of steel pipe pile

Young's modulus : 2.00* 10^5 N/mm2

Unit weight : 77.0 kN/m3

allowable stress (unit: N/mm2)	SKY400		SY490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	278
allw shear str	80	120	106	160

material of wailing member

Young's modulus : 2.00* 10^5 N/mm2

allowable stress (unit: N/mm2)	SS400		SM490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	280

material of tensile member

Young's modulus : 2.00* 10^5 N/mm2

No	type	allw M stress (unit: N/mm2)	
		normal	earthq.
1	SS400 i ƒ40mm j	94	141
2	SS400 i „40mm j	86	129
3	SS490 i ƒ40mm j	110	165
4	SS490 i „40mm j	102	153
5	,'£–Í |490	125	195
6	,'£–Í |590	155	235
7	,'£–Í |690	176	264

1.12 standard value

(1)factor of safety

check items	requrie FS	
	normal	earthq.
check shear deform failure check slide check bear cap of found grnd check circular slope	1.20 1.20 1.20 1.20	1.00 1.00 1.00 1.00
chk embedment (sand grnd) chk embedment (clay grnd)	1.50 1.20	1.20 1.20
chk shielding (sand grnd) chk shielding (clay grnd)	3.25 3.00	------ ------

(2)design method for liquefaction

1)seismicity for evaluating liquefaction

region	strong	middle	weak
earthq.	0.18	0.15	0.12

2)soil layer classification according to FL

FL range	class
<= 1.00 1.00<= and <=1.30 >= 1.30	liquefied semi-liquefied non-liquefied

3)classification

internally fixed

classifi- cation	increment vibration	active passive
liquefied semi-liq non-liq	consider not not	not not ordinary

4)minimum embedment length to non-liquefied layer at tip: 1.000(m)

5)evaluation method of embedment length : suppose both front and back side of wall satisfied

2 Abbreviation Table

No	Abbreviation	Standard nomenclature
1	actv	active
2	agl	angle
3	bear cap. fac	bearing capacity factor
4	bf	before
5	bt	between
6	cntrt	concentrated
7	co. coord.	coordinate
8	coeff	coefficient
9	coh	cohesion, cohesive
10	comb	combination
11	coord	coordinate
12	crs area	cross section area
13	cs	case
14	dfr	deformation
15	dia	diameter
16	earthq.	earthquake
17	ecc	eccentricity
18	effsrchg	effective surcharge
19	el	elastic
20	embd L	embedment length
21	e-prss	earth pressure
22	exv	excavation
23	frc	force
24	freq compo	frequency component
25	fric	friction
26	Fs	safety factor
27	H	horizontal
28	inc	increment
29	inrt	inertia force
30	inter	internal, inner
31	ld	load
32	LEM	limit equilibrium method
33	liq	liquefaction
34	lv	level
35	ly	layer
36	lyr thck	layer thickness
37	mat	material
38	max	maximum
39	mbr	member
40	min	minimum
41	mt	moment
42	mthd	method
43	nd	node

No	Abbreviation	Standard nomenclature
44	non-liq	non-liquefaction
45	num	number
46	pl	plastic
47	prss	pressure
48	pssv	passive
49	rct	reaction (force)
50	rdc fcr	reduction factor
51	relstiff	relative stiffness
52	rfrm	reinforcement force, deterrent force
53	rsd	residual
54	rslt frc	resultant force
55	rsst	resistance
56	satur	saturation
57	sd	side
58	semi-liq	semi-liquefaction
59	stbl	stability
60	stffns	stiffness, deformation modulus(coeff.)
61	stnd	standard
62	str	stress
63	submrg	submerge, under water
64	Sum	summation
65	tns	tension, tensile
66	w/	with consideration
67	wl	wall
68	wt	weight
69	WT	water, water line, water level
70	wtr prss	water pressure

3 Result table

3.1 table of stability calculation result

Results of wall width B= 6.000(m), L of sheet pile landside LR= 9.000(m), riverside LL= 9.000(m)

(1)check result on shear deformation failure

*)check case: íŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m/m/m)	rsst moment Mr(kN.m/m/m)	Factor of safety F
Embedment tip	38.000	5.000	314.22	1935.14	6.16 >= 1.20
Layer boundary surface	39.000	4.000	328.71	1410.62	4.29 >= 1.20
Layer boundary surface	41.000	2.000	191.89	1397.22	7.28 >= 1.20
Layer boundary surface	42.000	1.000	106.67	1259.47	11.81 >= 1.20
Min safety factor	39.000	4.000	328.71	1410.62	4.29 >= 1.20
Current ground level	43.000	0.000	45.00	1011.39	22.48 >= 1.20

*)check case: 'n kŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m/m/m)	rsst moment Mr(kN.m/m/m)	Factor of safety F
Embedment tip	38.000	5.000	503.47	1935.14	3.84 >= 1.00
Layer boundary surface	39.000	4.000	478.72	1379.34	2.88 >= 1.00
Layer boundary surface	41.000	2.000	276.35	1721.22	6.23 >= 1.00
Layer boundary surface	42.000	1.000	165.21	1583.47	9.58 >= 1.00
Min safety factor	39.000	4.000	478.72	1379.34	2.88 >= 1.00
Current ground level	43.000	0.000	82.08	1335.39	16.27 >= 1.00

(2)check result for slide

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	H-frc sum Fd(kN/m)	rsst sum Fr(kN/m)	Factor of safety F
íŽž	38.000	5.000	213.24	631.24	2.96 >= 1.20
'n kŽž	38.000	5.000	241.90	618.04	2.55 >= 1.00

(3)check result on bearing capacity of foundational ground

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
´Ž½	38.000	5.000	4017.48	421.64	9.53>=1.20
'n kŽž	38.000	5.000	3470.07	447.93	7.75>=1.00

* check result on embedment

(1)check result based on the limit equilibrium method

*)landside sheet pile

total length= 9.000m(G.L. 38.000m)

check case	required length (m)	final length (m)	active moment (kN.m/m/m)	passive moment (kN.m/m/m)	Factor of safety F
íŽž	8.900	9.000	1140.18	1760.35	1.54 >= 1.50
'n kŽž	8.710	9.000	1282.97	1674.46	1.31 >= 1.20

*)riverside sheet pile

total length= 9.000 m(G.L. 38.000m)

check case	required length (m)	final length (m)	active moment (kN.m/m/m)	passive moment (kN.m/m/m)	Factor of safety F
íŽž	6.530	9.000	990.18	3071.08	3.10 >= 1.50
'n kŽž	7.010	9.000	1132.97	2355.87	2.08 >= 1.20

(2)check result on water shielding effect

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
íŽž	15.000	4.000	3.75>=3.25

(3) check about 4c > Sum(Gam h)

Not check about 4c > Sum(Gam h)

3.2 table of member force check result

(1) bending, shear, displacement results

*) landside sheet pile

Total length = 9.000m(G.L. 38.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
ˊŽž	-158.60	42.400	-69.13	46.000	15.31	42.400
′n kŽž	-164.99	42.600	-73.05	46.000	15.73	42.400

*) riverside sheet pile

Total length = 9.000m(G.L. 38.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
ˊŽž	72.05	43.200	-44.16	41.200	-5.71	43.000
′n kŽž	81.14	43.200	-56.36	41.200	-6.19	43.000

(2) result of tensile member reaction

*) landside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
ˊŽž	-72.76	--------
′n kŽž	-76.94	--------

*) riverside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
ˊŽž	45.53	--------
′n kŽž	50.36	--------

(3) table of check result on length of elastic state

Not check for elastic state

3.3 table of member force calculation result (wall, tensile member, wailing)

(1) wall

section type: Steel sheet pile

unit(N/mm^2)

	Landside sheet pile		River side sheet pile	
Steel name Steel name	PU28+1 SY295		PU28+1 SY295	
Examined case	Bending stress	Shear stress	Bending stress	Shear stress
ˆŽž 'n kŽž	88.1<= 180.0 91.7<= 270.0	3.1<= 83.0 3.2<= 125.0	40.0<= 180.0 45.1<= 270.0	2.0<= 83.0 2.5<= 125.0

(2) tensile member

1) upper tensile member

diameter : Phi 32(mm)

material : ,'f. Ť |690

installing pitch : 1.800(m)

number in use : 1

unit(N/mm^2)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ˆŽž 'n kŽž	162.9<= 176.0 172.2<= 264.0	101.9<= 176.0 112.7<= 264.0

(3) wailing member

1) upper wiling member

steel material : m150 ~75 ~6.5 ~10

material in use : SS400

unit(N/mm^2)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ˆŽž 'n kŽž	102.5<= 140.0 108.4<= 210.0	64.1<= 140.0 70.9<= 210.0

4 Check case (nomal time)

4.1 calculation of external forces

4.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1) water pressure table (riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 44.000	2.000	0.00 20.00
2	44.000 43.000	1.000	20.00 30.00
3	43.000 42.000	1.000	30.00 40.00
4	42.000 41.000	1.000	40.00 35.00
5	41.000 39.000	2.000	35.00 25.00
6	39.000 38.000	1.000	25.00 20.00

(2)active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h) + q)- 2c*Sqrt(Ka)

$$Ka=\frac{\cos^2(Phi-Theta)}{\cos^2(Theta)*[1+Sqrt\{\sin(Phi)*\sin(Phi-Theta)/\cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN m2)	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ka	active e-prss pa (kN m2)	e-prss in use pa (kN m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	0.704	-9.74 -3.40	0.00 0.00
2	42.000 41.463	0.537	9.0	10.00	10.0 10.0	19.00 23.84	0.704	-3.40 0.00	0.00 0.00
3	41.463 41.000	0.463	9.0	10.00	10.0 10.0	23.84 28.00	0.704	0.00 2.93	0.00 2.93
4	41.000 40.623	0.377	9.0	25.00	10.0 10.0	28.00 31.39	0.406	-1.38 0.00	0.00 0.00
5	40.623 39.000	1.623	9.0	25.00	10.0 10.0	31.39 46.00	0.406	0.00 5.93	0.00 5.93
6	39.000 37.000	2.000	9.0	25.00	10.0 10.0	46.00 64.00	0.406	5.93 13.23	5.93 13.23
7	37.000 35.000	2.000	9.0	10.00	10.0 10.0	64.00 82.00	0.704	28.28 40.95	28.28 40.95
8	35.000 34.000	1.000	9.0	20.00	10.0 10.0	82.00 91.00	0.490	26.20 30.61	26.20 30.61
9	34.000 33.000	1.000	9.0	20.00	10.0 10.0	91.00 100.00	0.490	30.61 35.02	30.61 35.02
10	33.000 32.000	1.000	9.0	20.00	10.0 10.0	100.00 109.00	0.490	35.02 39.44	35.02 39.44
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	0.333	24.79 27.79	24.79 27.79
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	0.333	27.79 30.79	27.79 30.79
13	30.000 29.000	1.000	9.0	35.00	10.0 10.0	127.00 136.00	0.271	24.00 26.44	24.00 26.44
14	29.000 28.000	1.000	9.0	25.00	10.0 10.0	136.00 145.00	0.406	42.46 46.11	42.46 46.11
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	0.333	36.79 39.79	36.79 39.79
16	27.000 26.000	1.000	9.0	35.00	10.0 10.0	154.00 163.00	0.271	31.32 33.76	31.32 33.76
17	26.000 25.000	1.000	9.0	35.00	10.0 10.0	163.00 172.00	0.271	33.76 36.20	33.76 36.20

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp=\frac{\cos^2(Phi-Theta)}{\cos^2(Theta)*[1-Sqrt\{\sin(Phi)*\sin(Phi-Theta)/\cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	42.000 41.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	1.420	23.84 36.62
2	41.000 40.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	1.420	36.62 49.40
3	40.000 38.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	2.464	75.74 120.09
4	38.000 36.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	2.464	120.09 164.45
5	36.000 34.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	1.420	100.53 126.09
6	34.000 33.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	2.040	175.41 193.77
7	33.000 32.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	2.040	193.77 212.13
8	32.000 31.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	2.040	212.13 230.48
9	31.000 30.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	3.000	331.64 358.64
10	30.000 29.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	3.000	358.64 385.64
11	29.000 28.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	3.690	470.17 503.38
12	28.000 27.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	2.464	341.85 364.02
13	27.000 26.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	3.000	439.64 466.64
14	26.000 25.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	3.690	569.80 603.02
15	25.000 24.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	3.690	603.02 636.23

(4) active earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.406	20.13 27.44	20.13 27.44
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.406	27.44 34.74	27.44 34.74
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.704	65.60 78.27	65.60 78.27
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.490	52.19 56.60	52.19 56.60
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.490	56.60 61.01	56.60 61.01
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.490	61.01 65.42	61.01 65.42
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.271	38.37 40.81	38.37 40.81
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.406	63.97 67.62	63.97 67.62
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.271	45.68 48.12	45.68 48.12
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.271	48.12 50.56	48.12 50.56

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	3.000	0.00 54.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	3.000	54.00 162.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	3.000	162.00 189.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	1.420	113.31 126.09
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	1.420	126.09 138.88
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	2.464	230.97 275.32
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	2.464	275.32 319.67
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	1.420	190.01 215.57
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	2.040	303.91 322.27
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	2.040	322.27 340.62
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	2.040	340.62 358.98
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	3.000	520.64 547.64
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	3.000	547.64 574.64
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	3.690	702.65 735.86
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	2.464	497.07 519.25
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	3.000	628.64 655.64
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	3.690	802.29 835.50
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	3.690	835.50 868.71

(6)passive earth pressure intensity table (out of embankment: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	1.420	38.04 50.82
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	19.00 28.00	1.420	50.82 63.60
3	41.000 39.000	2.000	9.0	25.00	10.0 10.0	28.00 46.00	2.464	100.38 144.73
4	39.000 37.000	2.000	9.0	25.00	10.0 10.0	46.00 64.00	2.464	144.73 189.08
5	37.000 35.000	2.000	9.0	10.00	10.0 10.0	64.00 82.00	1.420	114.73 140.30
6	35.000 34.000	1.000	9.0	20.00	10.0 10.0	82.00 91.00	2.040	195.81 214.17
7	34.000 33.000	1.000	9.0	20.00	10.0 10.0	91.00 100.00	2.040	214.17 232.52
8	33.000 32.000	1.000	9.0	20.00	10.0 10.0	100.00 109.00	2.040	232.52 250.88
9	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	3.000	361.64 388.64
10	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	3.000	388.64 415.64
11	30.000 29.000	1.000	9.0	35.00	10.0 10.0	127.00 136.00	3.690	507.07 540.28
12	29.000 28.000	1.000	9.0	25.00	10.0 10.0	136.00 145.00	2.464	366.49 388.66
13	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	3.000	469.64 496.64
14	27.000 26.000	1.000	9.0	35.00	10.0 10.0	154.00 163.00	3.690	606.71 639.92
15	26.000 25.000	1.000	9.0	35.00	10.0 10.0	163.00 172.00	3.690	639.92 673.13

4.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 20.00
3	42.000 41.000	1.000	20.00 15.00
4	41.000 39.000	2.000	15.00 5.00
5	39.000 38.000	1.000	5.00 0.00

(2) active earth pressure intensity table (embankment section: working external force)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.406	20.13 27.44	20.13 27.44
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.406	27.44 34.74	27.44 34.74
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.704	65.60 78.27	65.60 78.27
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.490	52.19 56.60	52.19 56.60
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.490	56.60 61.01	56.60 61.01
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.490	61.01 65.42	61.01 65.42
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.271	38.37 40.81	38.37 40.81
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.406	63.97 67.62	63.97 67.62
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.271	45.68 48.12	45.68 48.12
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.271	48.12 50.56	48.12 50.56

(3)passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	42.000 41.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	1.420	23.84 36.62
2	41.000 40.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	1.420	36.62 49.40
3	40.000 38.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	2.464	75.74 120.09
4	38.000 36.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	2.464	120.09 164.45
5	36.000 34.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	1.420	100.53 126.09
6	34.000 33.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	2.040	175.41 193.77
7	33.000 32.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	2.040	193.77 212.13
8	32.000 31.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	2.040	212.13 230.48
9	31.000 30.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	3.000	331.64 358.64
10	30.000 29.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	3.000	358.64 385.64
11	29.000 28.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	3.690	470.17 503.38
12	28.000 27.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	2.464	341.85 364.02
13	27.000 26.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	3.000	439.64 466.64
14	26.000 25.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	3.690	569.80 603.02
15	25.000 24.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	3.690	603.02 636.23

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

po= Ko(Sum(Gam h)+ q)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ko	active e-prss po (kN m2)
1	42.000 41.000	1.000	9.0	0.00 9.00	0.826	0.00 7.44
2	41.000 40.000	1.000	9.0	9.00 18.00	0.826	7.44 14.87
3	40.000 38.000	2.000	9.0	18.00 36.00	0.577	10.39 20.79
4	38.000 36.000	2.000	9.0	36.00 54.00	0.577	20.79 31.18
5	36.000 34.000	2.000	9.0	54.00 72.00	0.826	44.62 59.50
6	34.000 33.000	1.000	9.0	72.00 81.00	0.658	47.37 53.30
7	33.000 32.000	1.000	9.0	81.00 90.00	0.658	53.30 59.22
8	32.000 31.000	1.000	9.0	90.00 99.00	0.658	59.22 65.14
9	31.000 30.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
10	30.000 29.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
11	29.000 28.000	1.000	9.0	117.00 126.00	0.426	49.89 53.73
12	28.000 27.000	1.000	9.0	126.00 135.00	0.577	72.75 77.95
13	27.000 26.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00
14	26.000 25.000	1.000	9.0	144.00 153.00	0.426	61.40 65.24
15	25.000 24.000	1.000	9.0	153.00 162.00	0.426	65.24 69.08

Note: is a layer without earth pressure in calculation.

4.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)

L.W.L. 43.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 8.00
3	42.000 41.000	1.000	8.00 6.00
4	41.000 39.000	2.000	6.00 2.00
5	39.000 38.000	1.000	2.00 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.406	20.13 27.44	20.13 27.44
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.406	27.44 34.74	27.44 34.74
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.704	65.60 78.27	65.60 78.27
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.490	52.19 56.60	52.19 56.60
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.490	56.60 61.01	56.60 61.01
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.490	61.01 65.42	61.01 65.42
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.271	38.37 40.81	38.37 40.81
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.406	63.97 67.62	63.97 67.62
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.271	45.68 48.12	45.68 48.12
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.271	48.12 50.56	48.12 50.56

(3)passive earth pressure intensity table(out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	1.420	38.04 50.82
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	19.00 28.00	1.420	50.82 63.60
3	41.000 39.000	2.000	9.0	25.00	10.0 10.0	28.00 46.00	2.464	100.38 144.73
4	39.000 37.000	2.000	9.0	25.00	10.0 10.0	46.00 64.00	2.464	144.73 189.08
5	37.000 35.000	2.000	9.0	10.00	10.0 10.0	64.00 82.00	1.420	114.73 140.30
6	35.000 34.000	1.000	9.0	20.00	10.0 10.0	82.00 91.00	2.040	195.81 214.17
7	34.000 33.000	1.000	9.0	20.00	10.0 10.0	91.00 100.00	2.040	214.17 232.52
8	33.000 32.000	1.000	9.0	20.00	10.0 10.0	100.00 109.00	2.040	232.52 250.88
9	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	3.000	361.64 388.64
10	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	3.000	388.64 415.64
11	30.000 29.000	1.000	9.0	35.00	10.0 10.0	127.00 136.00	3.690	507.07 540.28
12	29.000 28.000	1.000	9.0	25.00	10.0 10.0	136.00 145.00	2.464	366.49 388.66
13	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	3.000	469.64 496.64
14	27.000 26.000	1.000	9.0	35.00	10.0 10.0	154.00 163.00	3.690	606.71 639.92
15	26.000 25.000	1.000	9.0	35.00	10.0 10.0	163.00 172.00	3.690	639.92 673.13

Note:is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	43.000 42.000	1.000	9.0	10.00 19.00	0.826	8.26 15.70
2	42.000 41.000	1.000	9.0	19.00 28.00	0.826	15.70 23.14
3	41.000 39.000	2.000	9.0	28.00 46.00	0.577	16.17 26.56
4	39.000 37.000	2.000	9.0	46.00 64.00	0.577	26.56 36.95
5	37.000 35.000	2.000	9.0	64.00 82.00	0.826	52.89 67.76
6	35.000 34.000	1.000	9.0	82.00 91.00	0.658	53.95 59.88
7	34.000 33.000	1.000	9.0	91.00 100.00	0.658	59.88 65.80
8	33.000 32.000	1.000	9.0	100.00 109.00	0.658	65.80 71.72
9	32.000 31.000	1.000	9.0	109.00 118.00	0.500	54.50 59.00
10	31.000 30.000	1.000	9.0	118.00 127.00	0.500	59.00 63.50
11	30.000 29.000	1.000	9.0	127.00 136.00	0.426	54.16 57.99
12	29.000 28.000	1.000	9.0	136.00 145.00	0.577	78.52 83.72
13	28.000 27.000	1.000	9.0	145.00 154.00	0.500	72.50 77.00
14	27.000 26.000	1.000	9.0	154.00 163.00	0.426	65.67 69.51
15	26.000 25.000	1.000	9.0	163.00 172.00	0.426	69.51 73.34

Note: is a layer without earth pressure in calculation.

4.2 Stability analysis

4.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.20)

Md: shear deformation moment on check plane(kN* m/m)

Mr: shear resistant moment on check plane(kN* m/m)

$$Mr = Mro * \left(1 + \frac{d}{H}\right) + Msp$$

$$Mro = \int_{0}^{yo} (pRP - pRA)\, y\, dy$$

where,

Mro: basic shear resistant moment of filling soil

d : depth from current ground surface to check level

H : wall height(from top of wall to ground level in embankment range)

pRP: passive earth pressure above check level with a distance y(kN/m2)

pRA: active earth pressure above check level with a distance y(kN/m2)

y : a distance from the location of pRP, pRA working(m)

yo : cross point coordinates of the failure plane in filling soil

Msp: resistant moment caused by two rows sheet piles

smaller resistance either landside or riverside and make double to evaluate

Msp= 2* (smaller value either Msp1 or Msp2)

Msp1: resistant moment derived from sheet pile

Msp1= Sig.a* Zsp

Sig.a: allowable stress of sheet pile in use(N/mm2)

Zsp : section modulus considering joint(splice) of sheet pile in use(mm³/ m)

Msp2: resistant moment allowed by embedment deeper than check level.

Msp2= Ppu* hpu

Ppu: passive resultant force from check elevation to sheet pile tip

hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	38.000	5.000	314.22	1935.14	6.16>=1.20
Layer boundary surface	39.000	4.000	328.71	1410.62	4.29>=1.20
Layer boundary surface	41.000	2.000	191.89	1397.22	7.28>=1.20
Layer boundary surface	42.000	1.000	106.67	1259.47	11.81>=1.20
Min safety factor	39.000	4.000	328.71	1410.62	4.29>=1.20
Current ground level	43.000	0.000	45.00	1011.39	22.48>=1.20

(2)check level(Embedment tip: G.L. 38.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	314.22
resistant moment	Mr(kN.m/m)	1935.14
factor of safety	Mr/ Md	6.16>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	693.33
active earth-prss moment	Ma	13.13
pssv earth-prss moment	- Mp	392.24
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	314.22

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	6.667	133.33
2	44.000 43.000	1.000	20.00 30.00	25.00	5.467	136.67
3	43.000 42.000	1.000	30.00 40.00	35.00	4.476	156.67
4	42.000 41.000	1.000	40.00 35.00	37.50	3.511	131.67
5	41.000 39.000	2.000	35.00 25.00	60.00	2.056	123.33
6	39.000 38.000	1.000	25.00 20.00	22.50	0.519	11.67
Sum				200.00		693.33

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	4.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	3.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	3.154	2.14
4	41.000 40.623	0.377	0.00 0.00	0.00	2.811	0.00
5	40.623 39.000	1.623	0.00 5.93	4.81	1.541	7.41
6	39.000 38.000	1.000	5.93 9.58	7.75	0.461	3.57
Sum				13.24		13.13

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	42.000 41.000	1.000	23.84 36.62	30.23	3.465	104.73
2	41.000 40.000	1.000	36.62 49.40	43.01	2.475	106.46
3	40.000 38.000	2.000	75.74 120.09	195.84	0.925	181.06
Sum				269.07		392.24

d. other load moment

* Sum(Pc)= 0.00(kN m/m)

* Sum(Mc)= 0.00(kN m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1935.14 0.00 324.00 0.00
rsst moment Mr(kN m/m)	1935.14

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mfo* (1+ d/ H)= 860.06* (1+ 1.250)= 1935.14(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mfo kN m/m
1	40.718 39.000	1.718	237.22 275.32	21.16 27.44	216.06 247.88	398.53	1.839	733.04
2	39.000 38.000	1.000	275.32 297.50	27.44 31.09	247.88 266.40	257.14	0.494	127.03
Sum						655.67		860.06

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth top GL(m)	depth bottom GL(m)	thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure angle xip	passive failure width Bp (m)	active failure angle xia	active failure width Ba (m)	failure W Bp+ Ba (m)
1	40.718	39.000	1.718	25.00	0.00	32.50	2.697	57.50	1.094	3.791
2	39.000	38.000	1.000	25.00	0.00	32.50	1.570	57.50	0.637	2.207
Interval Sum(Bp) + Ba										5.998

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 0.00)= 0.00(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3) check level(Layer boundary surface: G.L. 39.000m)

1) check result

item		value
deformation moment	MH(kN.m/m)	328.71
resistant moment	Mr(kN.m/m)	1410.62
factor of safety	Mr/ MH	4.29>=1.20

2)deformation moment(MH)calculation

deformation moment in detail		moment
water pressure moment	Mw	504.17
active earth-prss moment	Ma	4.06
pssv earth-prss moment	- Mp	179.52
other load moment	Mc	0.00
deformation moment	MH(kN.m/m)	328.71

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	5.667	113.33
2	44.000 43.000	1.000	20.00 30.00	25.00	4.467	111.67
3	43.000 42.000	1.000	30.00 40.00	35.00	3.476	121.67
4	42.000 41.000	1.000	40.00 35.00	37.50	2.511	94.17
5	41.000 39.000	2.000	35.00 25.00	60.00	1.056	63.33
Sum				177.50		504.17

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	3.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	2.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	2.154	1.46
4	41.000 40.623	0.377	0.00 0.00	0.00	1.811	0.00
5	40.623 39.000	1.623	0.00 5.93	4.81	0.541	2.60
Sum				5.49		4.06

c.passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	23.84 36.62	30.23	2.465	74.50
2	41.000 40.000	1.000	36.62 49.40	43.01	1.475	63.45
3	40.000 39.000	1.000	75.74 97.92	86.83	0.479	41.57
Sum				160.07		179.52

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1251.11 159.52 324.00 79.76
rsst moment Mr(kN.m/m)	1410.62

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H) = 625.55* (1+ 1.000) = 1251.11(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.781 41.000	0.781	128.89 138.88	35.30 40.25	93.59 98.63	75.06	2.387	179.18
2	41.000 39.000	2.000	230.97 275.32	20.13 27.44	210.84 247.88	458.72	0.973	446.37
Sum						533.78		625.55

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	41.781 41.000	41.000 39.000	0.781 2.000	10.00 25.00	0.00 0.00	40.00 32.50	0.931 3.139	50.00 57.50	0.655 1.274	1.586 4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip) = tan(Phi) + sec(Phi) * Sqrt(\frac{cos(-Theta) sin(Phi)}{sin(Phi - Theta)})$$

$xip = 90.0 - tan^{-1} (cot(xip))$

* active failure plane

Ba= cot(xia)* h

$$cot(xia) = - tan(Phi) + sec(Phi) * Sqrt(\frac{cos(Theta) sin(Phi)}{sin(Phi - Theta)})$$

$xia = 90.0 - tan^{-1} (cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip) = cot(xia) = tan(Phi) +sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 79.76) = 159.52(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - $* 10^{-6} m^3/m$ - - - - - - - - $* 10^{-6} m^3/m$ $* 10^3$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	144.73 166.91	155.82	0.512	79.76
Sum				155.82		79.76

(4) check level(Layer boundary surface: G.L. 41.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	191.89
resistant moment	Mr(kN.m/m)	1397.22
factor of safety	Mr/ Md	7.28>=1.20

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	205.83 0.10 14.05 0.00
deformation moment	Md(kN.m/m)	191.89

a. water pressure moment
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	3.667	73.33
2	44.000 43.000	1.000	20.00 30.00	25.00	2.467	61.67
3	43.000 42.000	1.000	30.00 40.00	35.00	1.476	51.67
4	42.000 41.000	1.000	40.00 35.00	37.50	0.511	19.17
Sum				117.50		205.83

b. active earth pressure moment
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	1.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	0.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	0.154	0.10
Sum				0.68		0.10

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	23.84 36.62	30.23	0.465	14.05
Sum				30.23		14.05

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	749.22 648.00 324.00 651.30
rsst moment Mr(kN.m/m)	1397.22

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 499.48* (1+ 0.500)= 749.22(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	43.839 43.000	0.839	166.35 189.00	18.48 21.00	147.86 168.00	132.50	2.411	319.41
2	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	1.494	132.90
3	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	0.494	47.17
Sum						316.87		499.48

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2 3	43.839 43.000 42.000	43.000 42.000 41.000	0.839 1.000 1.000	30.00 10.00 10.00	0.00 0.00 0.00	30.00 40.00 40.00	1.453 1.192 1.192	60.00 50.00 50.00	0.484 0.839 0.839	1.938 2.031 2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

  Bp= cot(xip)* h

  $$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

  xip= 90.0- tan^{-1} (cot(xip))

* active failure plane

  Ba= cot(xia)* h

  $$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

  xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)
= 2* min(324.00, 651.30) = 648.00(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m³/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m³/m	1800	1800
allowable stress Sig.a	* 10^{3} kN/m2	180.0	180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	41.000 39.000	2.000	100.38 144.73	245.12	1.060	259.90
2	39.000 38.000	1.000	144.73 166.91	155.82	2.512	391.40
Sum				400.94		651.30

(5) check level(Layer boundary surface: G.L. 42.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	106.67
resistant moment	Mr(kN.m/m)	1259.47
factor of safety	Mr/ Md	11.81>=1.20

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	106.67
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	0.00
other load moment	Me	0.00
deformation moment	Md(kN.m/m)	106.67

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	2.667	53.33
2	44.000 43.000	1.000	20.00 30.00	25.00	1.467	36.67
3	43.000 42.000	1.000	30.00 40.00	35.00	0.476	16.67
Sum				80.00		106.67

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	611.47 648.00 324.00 1081.91
rsst moment Mr(kN.m/m)	1259.47

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 489.18* (1+ 0.250)= 611.47(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	44.718 44.000	0.718	123.23 162.00	13.69 18.00	109.54 144.00	91.02	2.343	213.23
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	1.487	232.00
3	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	0.494	43.94
Sum						335.98		489.18

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2 3	44.718 44.000 43.000	44.000 43.000 42.000	0.718 1.000 1.000	30.00 30.00 10.00	0.00 0.00 0.00	30.00 30.00 40.00	1.244 1.732 1.192	60.00 60.00 50.00	0.415 0.577 0.839	1.658 2.309 2.031
Interval Sum(Bp) + Ba										5.998

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi - Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 1081.91)= 648.00(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	$*10^{-6}$ m³/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	$*10^{-6}$ m³/m	1800	1800
allowable stress Sig.a	$*10^{3}$ kN/m2	180.0	180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	50.82 63.60	57.21	0.519	29.67
2	41.000 39.000	2.000	100.38 144.73	245.12	2.060	505.02
3	39.000 38.000	1.000	144.73 166.91	155.82	3.512	547.22
Sum				458.15		1081.91

(6) check level(Min safety factor: G.L. 39.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	328.71
resistant moment	Mr(kN.m/m)	1410.62
factor of safety	Mr/ Md	4.29>=1.20

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	504.17
active earth-prss moment	Ma	4.06
pssv earth-prss moment	- Mp	179.52
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	328.71

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	5.667	113.33
2	44.000 43.000	1.000	20.00 30.00	25.00	4.467	111.67
3	43.000 42.000	1.000	30.00 40.00	35.00	3.476	121.67
4	42.000 41.000	1.000	40.00 35.00	37.50	2.511	94.17
5	41.000 39.000	2.000	35.00 25.00	60.00	1.056	63.33
Sum				177.50		504.17

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	3.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	2.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	2.154	1.46
4	41.000 40.623	0.377	0.00 0.00	0.00	1.811	0.00
5	40.623 39.000	1.623	0.00 5.93	4.81	0.541	2.60
Sum				5.49		4.06

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	23.84 36.62	30.23	2.465	74.50
2	41.000 40.000	1.000	36.62 49.40	43.01	1.475	63.45
3	40.000 39.000	1.000	75.74 97.92	86.83	0.479	41.57
Sum				160.07		179.52

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1251.11 159.52 324.00 79.76
rsst moment Mr(kN.m/m)	1410.62

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H) = 625.55* (1+ 1.000) = 1251.11(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.781 41.000	0.781	128.89 138.88	35.30 40.25	93.59 98.63	75.06	2.387	179.18
2	41.000 39.000	2.000	230.97 275.32	20.13 27.44	210.84 247.88	458.72	0.973	446.37
Sum						533.78		625.55

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	41.781 41.000	41.000 39.000	0.781 2.000	10.00 25.00	0.00 0.00	40.00 32.50	0.931 3.139	50.00 57.50	0.655 1.274	1.586 4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 79.76) = 159.52(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m³/m - - - - - - - - $* 10^{-6}$ m³/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	144.73 166.91	155.82	0.512	79.76

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
Sum				155.82		79.76

(7)check level(Current ground level: G.L. 43.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	45.00
resistant moment	Mr(kN.m/m)	1011.39
factor of safety	Mr/ Md	22.48>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	45.00
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	0.00
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	45.00

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	1.667	33.33
2	44.000 43.000	1.000	20.00 30.00	25.00	0.467	11.67
Sum				45.00		45.00

b.active earth pressure moment

Sum(Pa) = 0.00kN/m Sum(Ma) = 0.00kN.m/m

c.passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d.other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H)	363.39
Msp= 2* min(Msp1, Msp2)	648.00
Msp1	324.00
Msp2	1563.34
rsst moment Mr(kN.m/m)	1011.39

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 363.39* (1+ 0.000)= 363.39(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	45.598 44.000	1.598	75.71 162.00	8.41 18.00	67.30 144.00	168.83	1.702	287.39
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	0.487	76.00
Sum						324.83		363.39

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	45.598	44.000	1.598	30.00	0.00	30.00	2.768	60.00	0.923	3.690
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)
= 2* min(324.00, 1563.34)= 648.00(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	180.0	180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	38.04 50.82	44.43	0.524	23.28
2	42.000 41.000	1.000	50.82 63.60	57.21	1.519	86.88
3	41.000 39.000	2.000	100.38 144.73	245.12	3.060	750.13
4	39.000 38.000	1.000	144.73 166.91	155.82	4.512	703.04
Sum				502.58		1563.34

4.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.20)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H-frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	38.000	5.000	213.24	631.24	2.96>=1.20

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item	value
sum of H-force Fd(kN/m)	213.24
sum of rsst Fr(kN/m)	631.24
factor of safety Fr/ Fd	2.96>=1.20

2)sum of horizontal force(Fd)

horizontal force in detail	H-force
water pressure Fw	200.00
active earth pressure Fa	13.24
other load Fc	0.00
sum of H-force Fd(kN/m)	213.24

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail	H-force
ground H resistance Fs	362.17
passive earth pressure Fp	269.07
sum of resistance Fr(kN/m)	631.24

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 6.000+ 648.00* tan(25.00) Deg.

= 362.17(kN/m)

b.soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (108.00+ 0.00)* 6.000= 648.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	44.000	2.000	18.0	36.00
3	44.000	43.000	1.000	9.0	9.00
4	43.000	42.000	1.000	9.0	9.00
5	42.000	41.000	1.000	9.0	9.00
6	41.000	39.000	2.000	9.0	18.00
7	39.000	38.000	1.000	9.0	9.00
Sum			9.000		108.00

c.passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

4.2.3 Check bearing capacity of foundation ground

(1) result summery

1) check equation

Examined wall width B= 6.000, height H= 4.000(m) using the next equation.

$$\frac{Qu}{V - Gam2 * Df * Be} >= FS$$

$$Qu = Be\{ k * c * Nc + k * Gam2 * Df * (Nq - 1) + \frac{1}{2} * Gam1 * Be * NGam \}$$

where,

FS : required factor of safety(1.20)
Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)
V : vertical component on check level(weight inside wall above the level)(kN/m)
Be : effective loading width considering eccentricity (m)
Be= B- 2e
B: wall width
e: eccentricity(e= Mb/ V)
Mb : moment working on check level
k : overdesign coefficient for embedment effect(= 1.0)
c : cohesion below check level
Df : distance from ground level to check level
Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.
Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.
Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)
tan(Alpha) = Hb/ V
Hb: horizontal component of resultant force on check level

2) check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	38.000	5.000	4017.48	421.64	9.53>=1.20

(2) check level(embedment tip: G.L. 38.000m)

1) check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	648.00
	distance from ground to check level	Df	5.000
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	5.030
	v-compo sum V- Gam2.Df.Be (kN/m)		421.64
Qu	moment on check level	Mb	314.22
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	0.485
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		4017.48
factor of safety			9.53>=1.20

2) summery of external force

external force detail		moment Mb(kN.m/m)	H-force Hb(kN/m)
water pressure	Mw(Fw)	693.33	200.00
active earth pressure	Ma(Fa)	13.13	13.24
passive earth pressure-	Mp(Fp)	392.24	269.07
other load	Mc(Fc)	0.00	0.00
external force sum		314.22	0.00

a. water pressure

refer to water pressure in checking shear failure at embedment tip

b. active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c.passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d.other load

refer to other load in checking shear failure at embedment tip

3)weight of filling soil(V)

refer to 'b.weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 648.00(kN/m)

4)eccentricity distance(e)calculation

e = Mb/ V

= 314.22/ 648.00

= 0.485(m)

Be= B- 2e

= 6.000- 2.0* 0.485

= 5.030(m)

5)calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 648.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\,2 = \frac{Sum(Gam\,i\,hi)}{Sum(hi)}$$

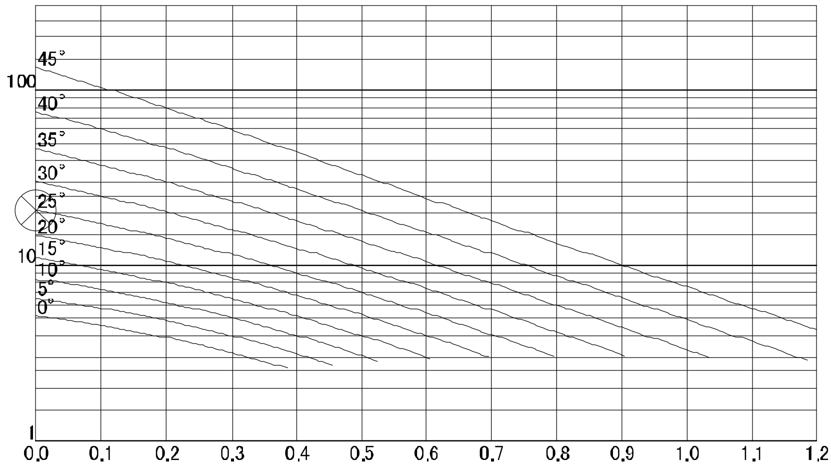
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	43.000	42.000	1.000	9.0	9.00
2	42.000	41.000	1.000	9.0	9.00
3	41.000	39.000	2.000	9.0	18.00
4	39.000	38.000	1.000	9.0	9.00
Sum			5.000		45.00

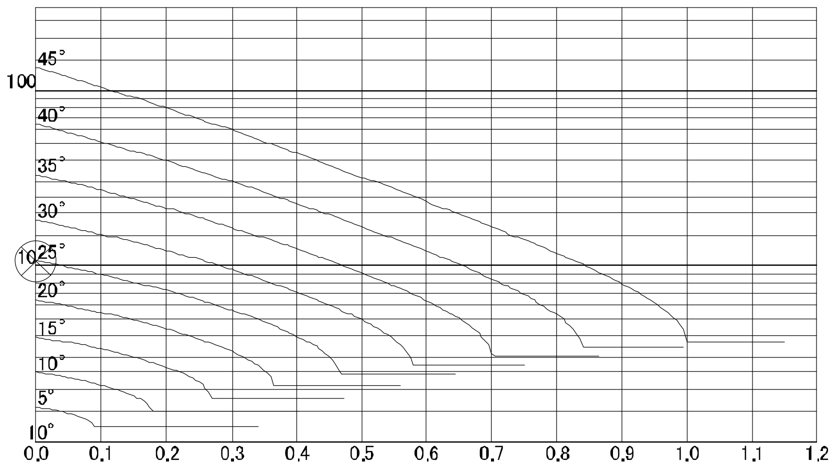
(3)bearing capacity factor calculation diagram

inclination of resultant force(Mb/ Hb)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

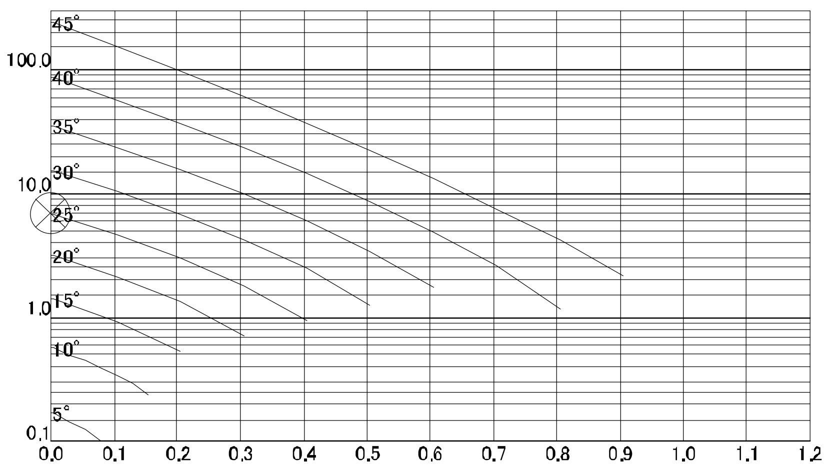
1)Nc calculation diagram



2)Nq calculation diagram



3)NGam calculation diagram



4.3 landside sheet pile

4.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 42.000(m)

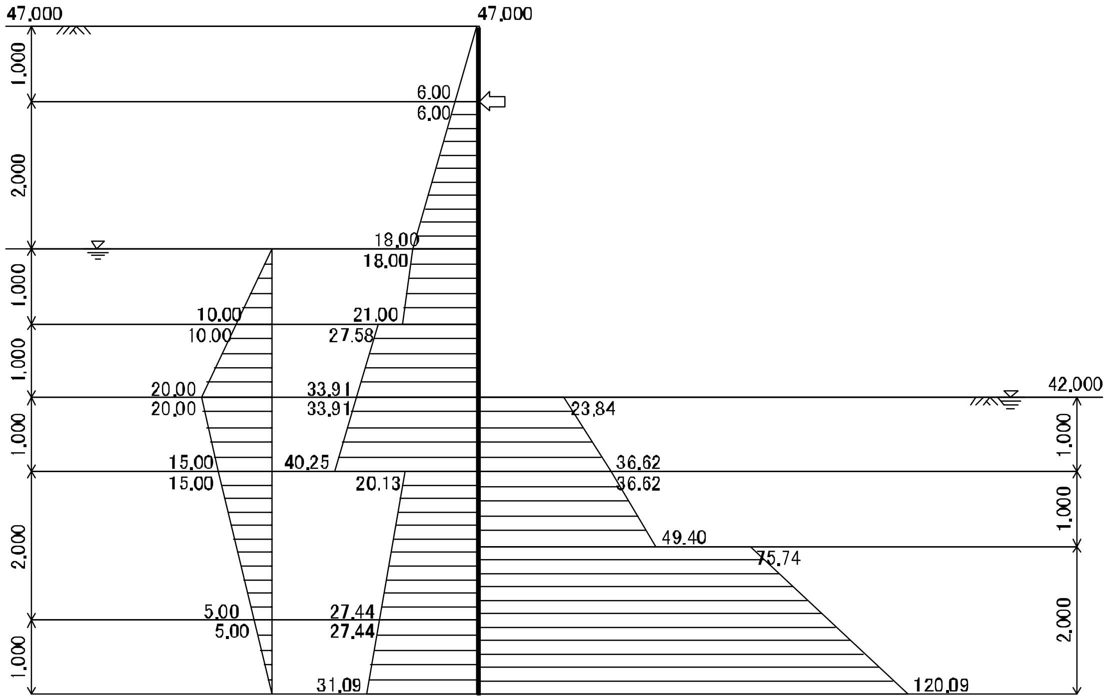
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	38.100	38.000
active sd	Ma+Mw+Mac(kN.m/m)	1108.97	1140.18
passive sd	Mp+Mpc(kN.m/m)	1665.76	1760.35
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.502>=1.50	1.544>=1.50



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.00 18.00	24.00	1.167	28.00
2	44.000 43.000	1.000	18.00 21.00	19.50	2.513	49.00
3	43.000 42.000	1.000	27.58 33.91	30.74	3.517	108.13
4	42.000 41.000	1.000	33.91 40.25	37.08	4.514	167.39
5	41.000 39.000	2.000	20.13 27.44	47.57	6.051	287.87
6	39.000 38.000	1.000	27.44 31.09	29.26	7.510	219.79
Sum				188.16		860.18

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 20.00	15.00	3.556	53.33
3	42.000 41.000	1.000	20.00 15.00	17.50	4.476	78.33
4	41.000 39.000	2.000	15.00 5.00	20.00	5.833	116.67
5	39.000 38.000	1.000	5.00 0.00	2.50	7.333	18.33
Sum				60.00		280.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	23.84 36.62	30.23	4.535	137.08
2	41.000 40.000	1.000	36.62 49.40	43.01	5.525	237.61
3	40.000 38.000	2.000	75.74 120.09	195.84	7.075	1385.65
Sum				269.07		1760.35

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

4.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-158.60	G.L. 42.400
max shear force Smax(kN/m)	-69.13	G.L. 46.000
upper tension mbr rct R1(kN/m)	-72.76	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 46.000	0.00 6.00	0.00 0.00	---- ----	---- ----	0.00 6.00	---- ----
2	46.000 44.000	6.00 18.00	0.00 0.00	---- ----	---- ----	6.00 18.00	---- ----
3	44.000 43.000	18.00 21.00	0.00 10.00	---- ----	---- ----	18.00 31.00	---- ----
4	43.000 42.000	27.58 33.91	10.00 20.00	---- ----	---- ----	37.58 53.91	---- ----
5	42.000 41.000	33.91 40.25	20.00 15.00	23.84 36.62	0.00 7.44	53.91 47.81	23.84 29.18
6	41.000 40.000	20.13 23.79	15.00 10.00	36.62 49.40	7.44 14.87	27.70 18.91	29.18 34.53
7	40.000 39.000	23.79 27.44	10.00 5.00	75.74 97.92	10.39 15.59	23.39 16.85	65.35 82.33
8	39.000 38.000	27.44 31.09	5.00 0.00	97.92 120.09	15.59 20.79	16.85 10.31	82.33 99.31

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	42.000	41.000	1.000	2800	673
2	41.000	40.000	1.000	8400	2018
3	40.000	38.000	2.000	70000	16820
4	38.000	36.000	2.000	64400	15474
5	36.000	34.000	2.000	14000	3364
6	34.000	33.000	1.000	47600	11437
7	33.000	32.000	1.000	53200	12783
8	32.000	31.000	1.000	53200	12783
9	31.000	30.000	1.000	117600	28257
10	30.000	29.000	1.000	137200	32967
11	29.000	28.000	1.000	165200	39694
12	28.000	27.000	1.000	67200	16147
13	27.000	26.000	1.000	106400	25566
14	26.000	25.000	1.000	123200	29603
15	25.000	24.000	1.000	106400	25566

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp. * (2 * number * A * E)}{(L * s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [6.000]m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.20	1.20	0.24	--------	--------	--------	--------
3	46.600	On excavation plane	2.40	2.40	0.48	--------	--------	--------	--------
4	46.400	On excavation plane	3.60	3.60	0.72	--------	--------	--------	--------
5	46.200	On excavation plane	4.80	4.80	0.96	--------	--------	--------	--------
6	46.000	Tensile member	6.00	6.00	1.20	--------	--------	--------	29787
7	45.800	On excavation plane	7.20	7.20	1.44	--------	--------	--------	--------
8	45.600	On excavation plane	8.40	8.40	1.68	--------	--------	--------	--------
9	45.400	On excavation plane	9.60	9.60	1.92	--------	--------	--------	--------
10	45.200	On excavation plane	10.80	10.80	2.16	--------	--------	--------	--------
11	45.000	On excavation plane	12.00	12.00	2.40	--------	--------	--------	--------
12	44.800	On excavation plane	13.20	13.20	2.64	--------	--------	--------	--------
13	44.600	On excavation plane	14.40	14.40	2.88	--------	--------	--------	--------
14	44.400	On excavation plane	15.60	15.60	3.12	--------	--------	--------	--------
15	44.200	On excavation plane	16.80	16.80	3.36	--------	--------	--------	--------
16	44.000	On excavation plane	18.00	18.00	3.64	--------	--------	--------	--------
17	43.800	On excavation plane	20.60	20.60	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	23.20	23.20	4.64	--------	--------	--------	--------
19	43.400	On excavation plane	25.80	25.80	5.16	--------	--------	--------	--------
20	43.200	On excavation plane	28.40	28.40	5.68	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
21	43.000	On excavation plane	31.00	37.58	6.87	--------	--------	--------	--------
22	42.800	On excavation plane	40.84	40.84	8.17	--------	--------	--------	--------
23	42.600	On excavation plane	44.11	44.11	8.82	--------	--------	--------	--------
24	42.400	On excavation plane	47.38	47.38	9.48	--------	--------	--------	--------
25	42.200	On excavation plane	50.64	50.64	10.13	--------	--------	--------	--------
26	42.000	Pas ela.	53.91	53.91	10.67	0.00	23.84	--------	67
27	41.800	Pas ela.	52.69	52.69	10.54	24.90	24.90	--------	135
28	41.600	Pas ela.	51.47	51.47	10.29	25.97	25.97	--------	135
29	41.400	Pas ela.	50.25	50.25	10.05	27.04	27.04	--------	135
30	41.200	Pas ela.	49.03	49.03	9.81	28.11	28.11	--------	135
31	41.000	Pas ela.	47.81	27.70	7.54	29.18	29.18	--------	269
32	40.800	Pas ela.	25.94	25.94	5.19	30.25	30.25	--------	404
33	40.600	Pas ela.	24.18	24.18	4.84	31.32	31.32	--------	404
34	40.400	Pas ela.	22.43	22.43	4.49	32.39	32.39	--------	404
35	40.200	Pas ela.	20.67	20.67	4.13	33.46	33.46	--------	404
36	40.000	Pa plas.	18.91	23.39	4.24	34.53	65.35	10.05	--------
37	39.800	Pa plas.	22.08	22.08	4.42	68.75	68.75	13.75	--------
38	39.600	Pa plas.	20.78	20.78	4.16	72.14	72.14	14.43	--------
39	39.400	Pa plas.	19.47	19.47	3.89	75.54	75.54	15.11	--------
40	39.200	Pa plas.	18.16	18.16	3.63	78.93	78.93	15.79	--------
41	39.000	Pas ela.	16.85	16.85	3.37	82.33	82.33	--------	3364
42	38.800	Pas ela.	15.54	15.54	3.11	85.73	85.73	--------	3364
43	38.600	Pas ela.	14.23	14.23	2.85	89.12	89.12	--------	3364
44	38.400	Pas ela.	12.92	12.92	2.58	92.52	92.52	--------	3364
45	38.200	Pas ela.	11.61	11.61	2.32	95.91	95.91	--------	3364
46	38.000	Act ela.	10.31	0.00	1.06	99.31	0.00	--------	1682
Sum					205.11			69.12	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= 15.31mm(G.L. 42.400m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-3.22	- - - -	- - - -
2	46.800	on exv	- - - -	-2.09	- - - -	- - - -
3	46.600	on exv	- - - -	-0.95	- - - -	- - - -
4	46.400	on exv	- - - -	0.18	- - - -	- - - -
5	46.200	on exv	- - - -	1.31	- - - -	- - - -
6	46.000	on exv	29787	2.44	- - - -	Note: -72.76
7	45.800	on exv	- - - -	3.57	- - - -	- - - -
8	45.600	on exv	- - - -	4.70	- - - -	- - - -
9	45.400	on exv	- - - -	5.80	- - - -	- - - -
10	45.200	on exv	- - - -	6.88	- - - -	- - - -
11	45.000	on exv	- - - -	7.93	- - - -	- - - -
12	44.800	on exv	- - - -	8.94	- - - -	- - - -
13	44.600	on exv	- - - -	9.89	- - - -	- - - -
14	44.400	on exv	- - - -	10.79	- - - -	- - - -
15	44.200	on exv	- - - -	11.62	- - - -	- - - -
16	44.000	on exv	- - - -	12.38	- - - -	- - - -
17	43.800	on exv	- - - -	13.07	- - - -	- - - -
18	43.600	on exv	- - - -	13.67	- - - -	- - - -
19	43.400	on exv	- - - -	14.19	- - - -	- - - -
20	43.200	on exv	- - - -	14.61	- - - -	- - - -

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
21	43.000	on exv	- - - -	14.94	- - - -	- - - -
22	42.800	on exv	- - - -	15.16	- - - -	- - - -
23	42.600	on exv	- - - -	15.29	- - - -	- - - -
24	42.400	on exv	- - - -	15.31	- - - -	- - - -
25	42.200	on exv	- - - -	15.23	- - - -	- - - -
26	42.000	pssv el	67	15.05	35.82	-1.01
27	41.800	pssv el	135	14.77	37.02	-1.99
28	41.600	pssv el	135	14.39	38.61	-1.94
29	41.400	pssv el	135	13.92	40.19	-1.87
30	41.200	pssv el	135	13.37	41.78	-1.80
31	41.000	pssv el	269	12.74	21.69	-3.43
32	40.800	pssv el	404	12.04	14.99	-4.86
33	40.600	pssv el	404	11.28	15.52	-4.55
34	40.400	pssv el	404	10.47	16.05	-4.23
35	40.200	pssv el	404	9.61	16.58	-3.88
36	40.000	pssv pl	- - - -	8.72	5.33	- - - -
37	39.800	pssv pl	- - - -	7.80	4.09	- - - -
38	39.600	pssv pl	- - - -	6.86	4.29	- - - -
39	39.400	pssv pl	- - - -	5.91	4.49	- - - -
40	39.200	pssv pl	- - - -	4.96	4.69	- - - -
41	39.000	pssv el	3364	4.00	4.89	-13.45
42	38.800	pssv el	3364	3.04	5.10	-10.22
43	38.600	pssv el	3364	2.08	5.30	-7.00
44	38.400	pssv el	3364	1.12	5.50	-3.78
45	38.200	pssv el	3364	0.17	5.70	-0.56
46	38.000	actv el	1682	-0.79	5.85	1.33
Sum						-135.99

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -158.60kN m/m(G.L. 42.400m)

max shear force Smax= -69.13kN/m (G.L. 46.000m)

max displacement Del.xmax= 15.31mm (G.L. 42.400m)

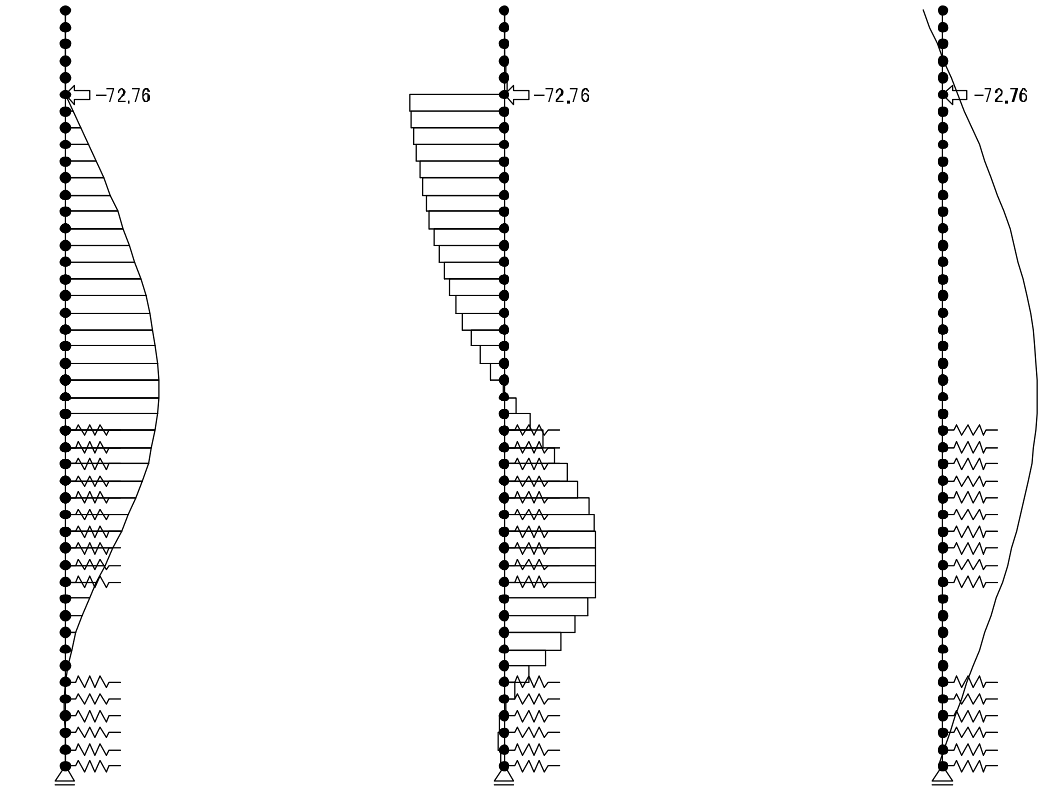
node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	0.03	-3.22	------------
2	46.800	0.01	0.01	0.03	0.27	-2.09	------------
3	46.600	0.06	0.06	0.27	0.75	-0.95	------------
4	46.400	0.21	0.21	0.75	1.47	0.18	------------
5	46.200	0.50	0.50	1.47	2.43	1.31	------------
6	46.000	0.99	0.99	2.43	-69.13	2.44	* -72.76
7	45.800	-12.84	-12.84	-69.13	-67.69	3.57	------------
8	45.600	-26.38	-26.38	-67.69	-66.01	4.70	------------
9	45.400	-39.58	-39.58	-66.01	-64.09	5.80	------------
10	45.200	-52.40	-52.40	-64.09	-61.93	6.88	------------
11	45.000	-64.78	-64.78	-61.93	-59.53	7.93	------------
12	44.800	-76.69	-76.69	-59.53	-56.89	8.94	------------
13	44.600	-88.07	-88.07	-56.89	-54.01	9.89	------------
14	44.400	-98.87	-98.87	-54.01	-50.89	10.79	------------
15	44.200	-109.05	-109.05	-50.89	-47.53	11.62	------------
16	44.000	-118.56	-118.56	-47.53	-43.90	12.38	------------
17	43.800	-127.34	-127.34	-43.90	-39.78	13.07	------------
18	43.600	-135.30	-135.30	-39.78	-35.14	13.67	------------
19	43.400	-142.32	-142.32	-35.14	-29.98	14.19	------------
20	43.200	-148.32	-148.32	-29.98	-24.30	14.61	------------
21	43.000	-153.18	-153.18	-24.30	-17.43	14.94	------------
22	42.800	-156.66	-156.66	-17.43	-9.26	15.16	------------
23	42.600	-158.52	-158.52	-9.26	-0.43	15.29	------------
24	42.400	-158.60	-158.60	-0.43	9.04	15.31	------------
25	42.200	-156.79	-156.79	9.04	19.17	15.23	------------
26	42.000	-152.96	-152.96	19.17	28.83	15.05	-1.01
27	41.800	-147.19	-147.19	28.83	37.38	14.77	-1.99
28	41.600	-139.72	-139.72	37.38	45.74	14.39	-1.94
29	41.400	-130.57	-130.57	45.74	53.91	13.92	-1.87
30	41.200	-119.79	-119.79	53.91	61.92	13.37	-1.80
31	41.000	-107.40	-107.40	61.92	66.03	12.74	-3.43
32	40.800	-94.20	-94.20	66.03	66.36	12.04	-4.86
33	40.600	-80.93	-80.93	66.36	66.64	11.28	-4.55
34	40.400	-67.60	-67.60	66.64	66.90	10.47	-4.23
35	40.200	-54.22	-54.22	66.90	67.15	9.61	-3.88
36	40.000	-40.79	-40.79	67.15	61.35	8.72	------------
37	39.800	-28.52	-28.52	61.35	52.01	7.80	------------
38	39.600	-18.12	-18.12	52.01	41.74	6.86	------------
39	39.400	-9.77	-9.77	41.74	30.53	5.91	------------
40	39.200	-3.67	-3.67	30.53	18.37	4.96	------------
41	39.000	0.01	0.01	18.37	8.29	4.00	-13.45
42	38.800	1.67	1.67	8.29	1.18	3.04	-10.22

node No	Y co GL(m)	moment kN.m/m top	bottom	shear force kN/m top	bottom	disp Del.x mm	reaction Q kN/m
43	38.600	1.90	1.90	1.18	-2.97	2.08	-7.00
44	38.400	1.31	1.31	-2.97	-4.16	1.12	-3.78
45	38.200	0.48	0.48	-4.16	-2.39	0.17	-0.56
46	38.000	0.00	----------	-2.39	----------	-0.79	1.33

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -158.60kN.m/m (G.L. 42.400m)
max shear force Smax= -69.13kN/m (G.L. 46.000m)
max displacement Del.xmax= 15.31mm (G.L. 42.400m)



Moment graph / Shear force diagram / Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/m)

4.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	158.60	0.00	69.13

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \leq Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	88	180	OK

(4) shear stress

$$Tau = \frac{S}{A} \leq Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	3	83	OK

4.3.4 Tensile member stress

(1) check on tensile member

1) member in use

diameter in use : Phi 32(mm)
material in use : ,'£-í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
72.76	1.800	130.98

3) stress

$$\mathrm{Sig.} = \frac{P * 10^3}{n * A} \leq \mathrm{Sig.a}$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
163	176	OK

4.3.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 140(N/mm2)

installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
130.98	1.800	23.58

3)stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
103	140	OK

4.4 riverside sheet pile

4.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1

total length in use : 9.000(m)

position of tensile member G.L. : 46.000(m)

external force above tensile member: Ignore

non effective layer in passive side: 0.000(m)

R.WL : 44.000(m)

L.WL : 43.000(m)

Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)

Mp : moment at tensile member by passive earth pressure

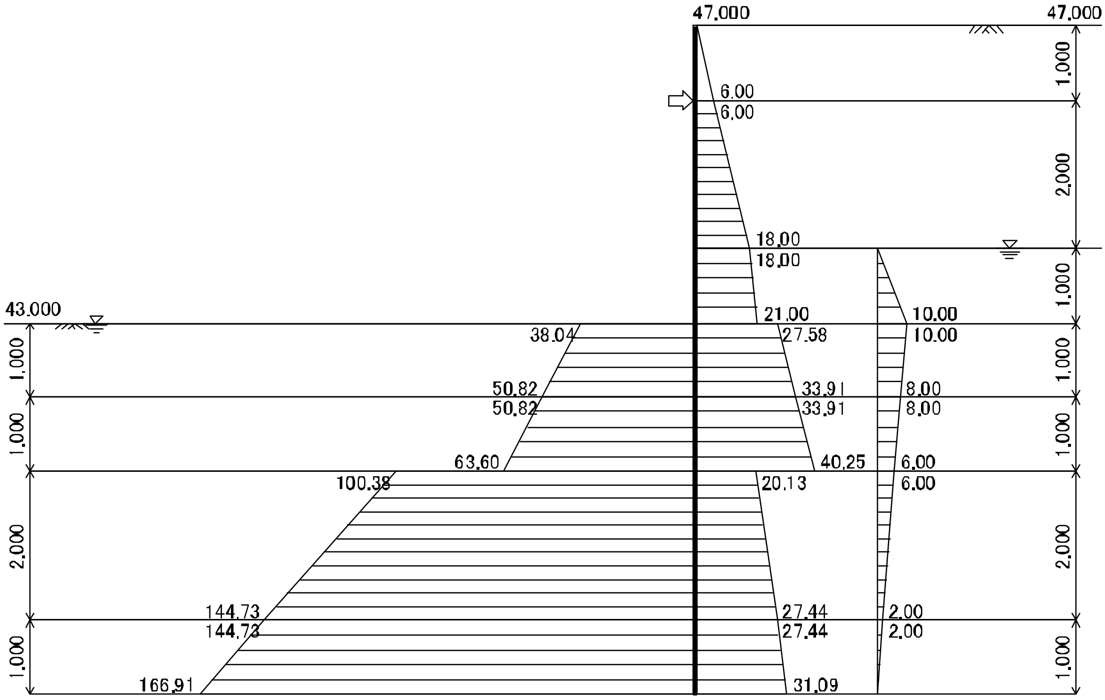
Ma : moment at tensile member by active earth pressure

Mw : moment at tensile member by water pressure

Mac: active moment at tensile member by other loads

Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	40.470	38.000
active sd	Ma+Mw+Mac(kN.m/m)	473.40	990.18
passive sd	Mp+Mpc(kN.m/m)	711.87	3071.08
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.504>=1.50	3.102>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.00 18.00	24.00	1.167	28.00
2	44.000 43.000	1.000	18.00 21.00	19.50	2.513	49.00
3	43.000 42.000	1.000	27.58 33.91	30.74	3.517	108.13
4	42.000 41.000	1.000	33.91 40.25	37.08	4.514	167.39
5	41.000 39.000	2.000	20.13 27.44	47.57	6.051	287.87
6	39.000 38.000	1.000	27.44 31.09	29.26	7.510	219.79
Sum				188.16		860.18

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 8.00	9.00	3.481	31.33
3	42.000 41.000	1.000	8.00 6.00	7.00	4.476	31.33
4	41.000 39.000	2.000	6.00 2.00	8.00	5.833	46.67
5	39.000 38.000	1.000	2.00 0.00	1.00	7.333	7.33
Sum				30.00		130.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	38.04 50.82	44.43	3.524	156.57
2	42.000 41.000	1.000	50.82 63.60	57.21	4.519	258.52
3	41.000 39.000	2.000	100.38 144.73	245.12	6.060	1485.49
4	39.000 38.000	1.000	144.73 166.91	155.82	7.512	1170.51
Sum				502.58		3071.08

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

4.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	72.05	G.L. 43.200
max shear force Smax(kN/m)	-44.16	G.L. 41.200
upper tension mbr rct R1(kN/m)	45.53	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss.
Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure'
effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	0.00 6.00	0.00 0.00	---- ----	---- ----	0.00 6.00	---- ----
2	46.000 44.000	6.00 18.00	0.00 0.00	---- ----	---- ----	6.00 18.00	---- ----
3	44.000 43.000	18.00 21.00	0.00 10.00	---- ----	---- ----	18.00 31.00	---- ----
4	43.000 42.000	27.58 33.91	10.00 8.00	38.04 50.82	8.26 15.70	29.31 26.21	29.77 35.12
5	42.000 41.000	33.91 40.25	8.00 6.00	50.82 63.60	15.70 23.14	26.21 23.11	35.12 40.46
6	41.000 39.000	20.13 27.44	6.00 2.00	100.38 144.73	16.17 26.56	9.97 2.88	84.22 118.17
7	39.000 38.000	27.44 31.09	2.00 0.00	144.73 166.91	26.56 31.76	2.88 0.00	118.17 135.15

Note: is non-effective for earth pressure in calculation.
other load

3)spring condition

passive spring is given by the following equation.

$$kH= Eta* \frac{1}{0.3} *Alpha\ Eo* \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0
BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	673
2	42.000	41.000	1.000	8400	2018
3	41.000	39.000	2.000	70000	16820
4	39.000	37.000	2.000	64400	15474
5	37.000	35.000	2.000	14000	3364
6	35.000	34.000	1.000	47600	11437
7	34.000	33.000	1.000	53200	12783
8	33.000	32.000	1.000	53200	12783
9	32.000	31.000	1.000	117600	28257
10	31.000	30.000	1.000	137200	32967
11	30.000	29.000	1.000	165200	39694
12	29.000	28.000	1.000	67200	16147
13	28.000	27.000	1.000	106400	25566
14	27.000	26.000	1.000	123200	29603
15	26.000	25.000	1.000	106400	25566

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks= \frac{Alp.*(2*number*A*E)}{(L*s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
wall section (filling soil). back and active side pressure are considered. no ground spring.

* passive elastic
in embedment section, displacement on excavation side is within limit displacement.
effective active side prss from back is considered. ground springs exist. no exv load.

* passive plastic
in embedment section, displacement on excavation side exceeds limit displacement.
effective active side prss from back is considered. no ground spring. exv load exists

* active elastic
in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.20	1.20	0.24	--------	--------	--------	--------
3	46.600	On excavation plane	2.40	2.40	0.48	--------	--------	--------	--------
4	46.400	On excavation plane	3.60	3.60	0.72	--------	--------	--------	--------
5	46.200	On excavation plane	4.80	4.80	0.96	--------	--------	--------	--------
6	46.000	Tensile member	6.00	6.00	1.20	--------	--------	--------	29787
7	45.800	On excavation plane	7.20	7.20	1.44	--------	--------	--------	--------
8	45.600	On excavation plane	8.40	8.40	1.68	--------	--------	--------	--------
9	45.400	On excavation plane	9.60	9.60	1.92	--------	--------	--------	--------
10	45.200	On excavation plane	10.80	10.80	2.16	--------	--------	--------	--------
11	45.000	On excavation plane	12.00	12.00	2.40	--------	--------	--------	--------
12	44.800	On excavation plane	13.20	13.20	2.64	--------	--------	--------	--------
13	44.600	On excavation plane	14.40	14.40	2.88	--------	--------	--------	--------
14	44.400	On excavation plane	15.60	15.60	3.12	--------	--------	--------	--------
15	44.200	On excavation plane	16.80	16.80	3.36	--------	--------	--------	--------
16	44.000	On excavation plane	18.00	18.00	3.64	--------	--------	--------	--------
17	43.800	On excavation plane	20.60	20.60	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	23.20	23.20	4.64	--------	--------	--------	--------
19	43.400	On excavation plane	25.80	25.80	5.16	--------	--------	--------	--------
20	43.200	On excavation plane	28.40	28.40	5.68	--------	--------	--------	--------
21	43.000	Pas ela.	31.00	29.31	5.95	0.00	29.77	--------	67
22	42.800	Pas ela.	28.69	28.69	5.74	30.84	30.84	--------	135

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
23	42.600	Pas ela.	28.07	28.07	5.61	31.91	31.91	--------	135
24	42.400	Pas ela.	27.45	27.45	5.49	32.98	32.98	--------	135
25	42.200	Pas ela.	26.83	26.83	5.37	34.05	34.05	--------	135
26	42.000	Pas ela.	26.21	26.21	5.24	35.12	35.12	--------	269
27	41.800	Pas ela.	25.59	25.59	5.12	36.19	36.19	--------	404
28	41.600	Pas ela.	24.97	24.97	4.99	37.26	37.26	--------	404
29	41.400	Pas ela.	24.35	24.35	4.87	38.33	38.33	--------	404
30	41.200	Pas ela.	23.73	23.73	4.75	39.40	39.40	--------	404
31	41.000	Pas ela.	23.11	9.97	3.31	40.46	84.22	--------	1884
32	40.800	Pas ela.	9.26	9.26	1.85	87.61	87.61	--------	3364
33	40.600	Pas ela.	8.55	8.55	1.71	91.01	91.01	--------	3364
34	40.400	Pas ela.	7.84	7.84	1.57	94.40	94.40	--------	3364
35	40.200	Pas ela.	7.13	7.13	1.43	97.80	97.80	--------	3364
36	40.000	Pas ela.	6.42	6.42	1.28	101.20	101.20	--------	3364
37	39.800	Pas ela.	5.71	5.71	1.14	104.59	104.59	--------	3364
38	39.600	Pas ela.	5.01	5.01	1.00	107.99	107.99	--------	3364
39	39.400	Pas ela.	4.30	4.30	0.86	111.38	111.38	--------	3364
40	39.200	Pas ela.	3.59	3.59	0.72	114.78	114.78	--------	3364
41	39.000	Pas ela.	2.88	2.88	0.58	118.17	118.17	--------	3229
42	38.800	Pas ela.	2.30	2.30	0.46	121.57	121.57	--------	3095
43	38.600	Act ela.	1.73	1.73	0.35	124.97	124.97	--------	3095
44	38.400	Act ela.	1.15	1.15	0.23	128.36	128.36	--------	3095
45	38.200	Act ela.	0.58	0.58	0.12	131.76	131.76	--------	3095
46	38.000	Act ela.	0.00	0.00	0.01	135.15	0.00	--------	1547
Sum					118.21			0.00	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= -5.71mm(G.L. 43.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	----	0.70	----	----
2	46.800	on exv	----	0.25	----	----
3	46.600	on exv	----	-0.19	----	----
4	46.400	on exv	----	-0.64	----	----
5	46.200	on exv	----	-1.08	----	----
6	46.000	on exv	29787	-1.53	----	Note: 45.53
7	45.800	on exv	----	-1.97	----	----
8	45.600	on exv	----	-2.41	----	----
9	45.400	on exv	----	-2.85	----	----
10	45.200	on exv	----	-3.26	----	----
11	45.000	on exv	----	-3.66	----	----
12	44.800	on exv	----	-4.03	----	----
13	44.600	on exv	----	-4.37	----	----
14	44.400	on exv	----	-4.68	----	----
15	44.200	on exv	----	-4.96	----	----
16	44.000	on exv	----	-5.19	----	----
17	43.800	on exv	----	-5.39	----	----
18	43.600	on exv	----	-5.54	----	----
19	43.400	on exv	----	-5.64	----	----
20	43.200	on exv	----	-5.70	----	----
21	43.000	pssv el	67	-5.71	44.65	0.38
22	42.800	pssv el	135	-5.68	45.84	0.76
23	42.600	pssv el	135	-5.60	47.43	0.75
24	42.400	pssv el	135	-5.48	49.02	0.74

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	135	-5.31	50.61	0.71
26	42.000	pssv el	269	-5.11	26.10	1.37
27	41.800	pssv el	404	-4.87	17.93	1.97
28	41.600	pssv el	404	-4.61	18.46	1.86
29	41.400	pssv el	404	-4.31	18.99	1.74
30	41.200	pssv el	404	-4.00	19.52	1.61
31	41.000	pssv el	1884	-3.67	6.65	6.91
32	40.800	pssv el	3364	-3.33	5.21	11.20
33	40.600	pssv el	3364	-2.98	5.41	10.04
34	40.400	pssv el	3364	-2.64	5.61	8.88
35	40.200	pssv el	3364	-2.30	5.81	7.72
36	40.000	pssv el	3364	-1.96	6.02	6.58
37	39.800	pssv el	3364	-1.62	6.22	5.46
38	39.600	pssv el	3364	-1.30	6.42	4.36
39	39.400	pssv el	3364	-0.97	6.62	3.28
40	39.200	pssv el	3364	-0.66	6.82	2.21
41	39.000	pssv el	3229	-0.35	7.32	1.12
42	38.800	pssv el	3095	-0.04	7.86	0.12
43	38.600	actv el	3095	0.27	8.08	-0.82
44	38.400	actv el	3095	0.57	8.30	-1.76
45	38.200	actv el	3095	0.87	8.51	-2.70
46	38.000	actv el	1547	1.17	8.68	-1.82
Sum						118.21

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

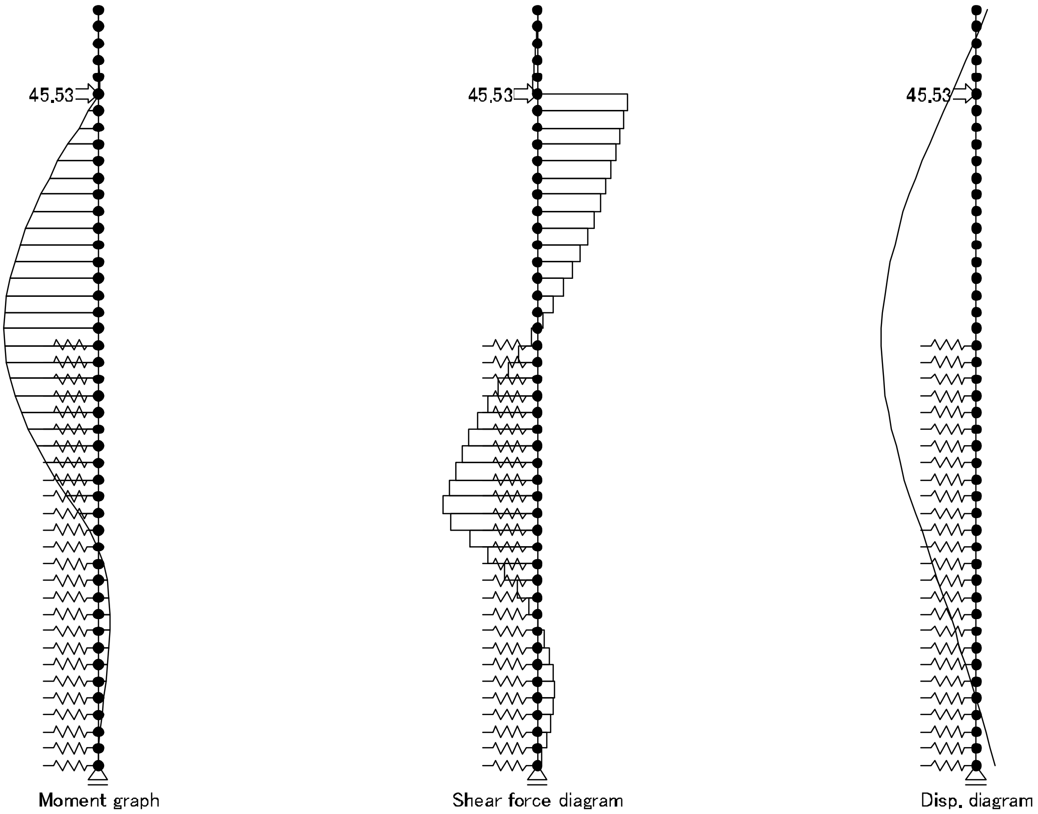
max bending moment Mmax= 72.05kN.m/m(G.L. 43.200m)
max shear force Smax= -44.16kN/m (G.L. 41.200m)
max displacement Del.xmax= -5.71mm (G.L. 43.000m)

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	-0.03	0.70	------------
2	46.800	-0.01	-0.01	-0.03	-0.27	0.25	------------
3	46.600	-0.06	-0.06	-0.27	-0.75	-0.19	------------
4	46.400	-0.21	-0.21	-0.75	-1.47	-0.64	------------
5	46.200	-0.50	-0.50	-1.47	-2.43	-1.08	------------
6	46.000	-0.99	-0.99	-2.43	41.90	-1.53	* 45.53
7	45.800	7.39	7.39	41.90	40.46	-1.97	------------
8	45.600	15.48	15.48	40.46	38.78	-2.41	------------
9	45.400	23.24	23.24	38.78	36.86	-2.85	------------
10	45.200	30.61	30.61	36.86	34.70	-3.26	------------
11	45.000	37.55	37.55	34.70	32.30	-3.66	------------
12	44.800	44.00	44.00	32.30	29.66	-4.03	------------
13	44.600	49.94	49.94	29.66	26.78	-4.37	------------
14	44.400	55.29	55.29	26.78	23.66	-4.68	------------
15	44.200	60.02	60.02	23.66	20.30	-4.96	------------
16	44.000	64.08	64.08	20.30	16.66	-5.19	------------
17	43.800	67.41	67.41	16.66	12.54	-5.39	------------
18	43.600	69.92	69.92	12.54	7.90	-5.54	------------
19	43.400	71.50	71.50	7.90	2.74	-5.64	------------
20	43.200	72.05	72.05	2.74	-2.94	-5.70	------------
21	43.000	71.46	71.46	-2.94	-8.51	-5.71	0.38
22	42.800	69.76	69.76	-8.51	-13.48	-5.68	0.76
23	42.600	67.06	67.06	-13.48	-18.34	-5.60	0.75
24	42.400	63.40	63.40	-18.34	-23.09	-5.48	0.74
25	42.200	58.78	58.78	-23.09	-27.75	-5.31	0.71
26	42.000	53.23	53.23	-27.75	-31.61	-5.11	1.37
27	41.800	46.90	46.90	-31.61	-34.77	-4.87	1.97
28	41.600	39.95	39.95	-34.77	-37.90	-4.61	1.86
29	41.400	32.37	32.37	-37.90	-41.03	-4.31	1.74
30	41.200	24.17	24.17	-41.03	-44.16	-4.00	1.61
31	41.000	15.33	15.33	-44.16	-40.56	-3.67	6.91
32	40.800	7.22	7.22	-40.56	-31.21	-3.33	11.20
33	40.600	0.98	0.98	-31.21	-22.88	-2.98	10.04
34	40.400	-3.60	-3.60	-22.88	-15.57	-2.64	8.88
35	40.200	-6.71	-6.71	-15.57	-9.28	-2.30	7.72
36	40.000	-8.57	-8.57	-9.28	-3.98	-1.96	6.58
37	39.800	-9.36	-9.36	-3.98	0.34	-1.62	5.46
38	39.600	-9.29	-9.29	0.34	3.69	-1.30	4.36
39	39.400	-8.56	-8.56	3.69	6.11	-0.97	3.28
40	39.200	-7.33	-7.33	6.11	7.61	-0.66	2.21
41	39.000	-5.81	-5.81	7.61	8.15	-0.35	1.12
42	38.800	-4.18	-4.18	8.15	7.80	-0.04	0.12
43	38.600	-2.62	-2.62	7.80	6.64	0.27	-0.82
44	38.400	-1.29	-1.29	6.64	4.64	0.57	-1.76
45	38.200	-0.37	-0.37	4.64	1.83	0.87	-2.70
46	38.000	0.00	----------	1.83	----------	1.17	-1.82

Note: * mark shows reaction of tensile member

(5)Member force diagram

max bending moment Mmax= 72.05kN m/m(G.L. 43.200m)
max shear force Smax= -44.16kN/m (G.L. 41.200m)
max displacement Del.xmax= -5.71mm (G.L. 43.000m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	72.05	0.00	44.16

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	40	180	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	2	83	OK

4.4.4 Tensile member stress

(1) check on tensile member

1)member in use

diameter in use : Phi 32(mm)

material in use : ,'£–í |690

allowable stress : 176(N/mm2)

tensile member layout pitch L : 1.800(m)

number of tensile member in use : 1

tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2)calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
45.53	1.800	81.95

3)stress

$$Sig. = \frac{P * 10^3}{n * A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
102	176	OK

4.4.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 140(N/mm2)

installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
81.95	1.800	14.75

3)stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
64	140	OK

5 Check case (earthquake time)

5.1 calculation of external forces

design seismicity during an earthquake : Kh= 0.04

design seismicity method: river standard equation

$$Kh' = \frac{Gam\ sat}{Gam\ sat - Gam\ w} * Kh$$

where,

Gam sat: soil saturated weight

Gam w : water unit weight

5.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1)water pressure table(riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 44.000	2.000	0.00 20.00
2	44.000 43.000	1.000	20.00 30.00
3	43.000 42.000	1.000	30.00 40.00
4	42.000 41.000	1.000	40.00 35.00
5	41.000 39.000	2.000	35.00 25.00
6	39.000 38.000	1.000	25.00 20.00

(2)active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h)+ q)- 2c*Sqrt(Ka)

$$Ka= \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1+ Sqrt\{\sin(Phi) * \sin(Phi - Theta)/ \cos(Theta)\}]^2}$$

in case of clay, Kh= 0 in 10m below GL and active earth pressure is linearly estimated

Kh = 0 for clay in 10m below GL.

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN m2)	srchg prss Sum(rh)+q (kN m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 0.00
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 0.00
3	41.000 39.739	1.261	9.0	25.00	10.0 10.0	18.00 29.35	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
4	39.739 39.000	0.739	9.0	25.00	10.0 10.0	29.35 36.00	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 3.09
5	39.000 37.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	0.464 0.464	3.09 11.44
6	37.000 35.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	0.0844 0.0844	4.83 4.83	0.789 0.789	24.83 39.03
7	35.000 34.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.555 0.555	25.08 30.08
8	34.000 33.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	0.555 0.555	30.08 35.08
9	33.000 32.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	0.555 0.555	35.08 40.07
10	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	0.386 0.386	25.78 29.26
11	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	0.386 0.386	29.26 32.73
12	30.000 29.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	0.318 0.318	25.95 28.82
13	29.000 28.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	0.464 0.464	44.87 49.05
14	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.386 0.386	39.68 43.15
15	27.000 26.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	0.318 0.318	34.55 37.41
16	26.000 25.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	0.318 0.318	37.41 40.28

(3) passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q) + 2c*Sqrt(Kp)

$$Kp = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 - Sqrt(\{\sin(Phi) * \sin(Phi - Theta) / \cos(Theta)\}]^2}$$

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	42.000 41.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	41.000 40.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	40.000 38.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	0.0844 0.0844	4.83 4.83	2.327 2.327	72.39 114.27
4	38.000 36.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	36.000 34.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	0.0844 0.0844	4.83 4.83	1.306 1.306	93.37 116.87
6	34.000 33.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	1.913 1.913	165.41 182.62
7	33.000 32.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	1.913 1.913	182.62 199.84
8	32.000 31.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	1.913 1.913	199.84 217.06
9	31.000 30.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
10	30.000 29.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
11	29.000 28.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	3.525 3.525	449.93 481.65
12	28.000 27.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.327 2.327	323.67 344.61
13	27.000 26.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
14	26.000 25.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	3.525 3.525	545.10 576.82
15	25.000 24.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	3.525 3.525	576.82 608.54

(4)active earth pressure intensity table(embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN m2)	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ka	active e-prss pa (kN m2)	e-prss in use pa (kN m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.406	20.13 27.44	20.13 27.44
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.406	27.44 34.74	27.44 34.74
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.704	65.60 78.27	65.60 78.27
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.490	52.19 56.60	52.19 56.60
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.490	56.60 61.01	56.60 61.01
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.490	61.01 65.42	61.01 65.42
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.271	38.37 40.81	38.37 40.81
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.406	63.97 67.62	63.97 67.62
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.271	45.68 48.12	45.68 48.12
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.271	48.12 50.56	48.12 50.56

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	3.000	0.00 54.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	3.000	54.00 162.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	3.000	162.00 189.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	1.420	113.31 126.09
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	1.420	126.09 138.88
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	2.464	230.97 275.32
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	2.464	275.32 319.67
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	1.420	190.01 215.57
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	2.040	303.91 322.27
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	2.040	322.27 340.62
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	2.040	340.62 358.98
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	3.000	520.64 547.64
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	3.000	547.64 574.64
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	3.690	702.65 735.86
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	2.464	497.07 519.25
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	3.000	628.64 655.64
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	3.690	802.29 835.50
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	3.690	835.50 868.71

(6)passive earth pressure intensity table (out of embankment: passive resistant moment below)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	41.000 39.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	0.0844 0.0844	4.83 4.83	2.327 2.327	72.39 114.27
4	39.000 37.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	37.000 35.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	0.0844 0.0844	4.83 4.83	1.306 1.306	93.37 116.87
6	35.000 34.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	1.913 1.913	165.41 182.62
7	34.000 33.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	1.913 1.913	182.62 199.84
8	33.000 32.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	1.913 1.913	199.84 217.06
9	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
10	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
11	30.000 29.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	3.525 3.525	449.93 481.65
12	29.000 28.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.327 2.327	323.67 344.61
13	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
14	27.000 26.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	3.525 3.525	545.10 576.82
15	26.000 25.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	3.525 3.525	576.82 608.54

(7)seismicity for inertia force, H-force distribution table(embankment section: for inertia moment)
seismicity for inertia force is linearly distributed from GL to 10m depth, calculate with reducing seismicity. Regardless WT, design seismicity is considered using next equation. Basic design seismicity is applied with input design seismicity for the case of earthquake.

pe= Gam * B* Kh

where,

pe : inertia force intensity, H-force, for each layer (top and bottom)
Gam : wet weight of each layer
B : embankment width in use (6.000)m
Kh : design seismicity for each layer (top and bottom)

No	depth GL(m)	layer thick. h (m)	soil unit weight wet Gam t	sub Gam '	sat Gam sat	seis-micity Kh	inertia H-compo pe=Gam . B. Kh
1	47.000 46.000	1.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
2	46.000 44.000	2.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
3	44.000 43.000	1.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
4	43.000 42.000	1.000	18.0	9.0	19.0	0.0400 0.0360	* 4.32 * 3.89
5	42.000 41.000	1.000	18.0	9.0	19.0	0.0360 0.0320	* 3.89 * 3.46
6	41.000 39.000	2.000	18.0	9.0	19.0	0.0320 0.0240	* 3.46 * 2.59
7	39.000 37.000	2.000	18.0	9.0	19.0	0.0240 0.0160	* 2.59 * 1.73
8	37.000 35.000	2.000	18.0	9.0	19.0	0.0160 0.0080	* 1.73 * 0.86
9	35.000 34.000	1.000	18.0	9.0	19.0	0.0080 0.0040	* 0.86 * 0.43
10	34.000 33.000	1.000	18.0	9.0	19.0	0.0040 0.0000	* 0.43 * 0.00
11	33.000 32.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
12	32.000 31.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
13	31.000 30.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
14	30.000 29.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
15	29.000 28.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
16	28.000 27.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
17	27.000 26.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
18	26.000 25.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00

Note:* character shows a section where linearly reduced seismicity.

5.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)
L.W.L. 42.000(m)
soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 20.00
3	42.000 41.000	1.000	20.00 15.00
4	41.000 39.000	2.000	15.00 5.00
5	39.000 38.000	1.000	5.00 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 6.43
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.0400 0.0400	2.29 2.29	0.357 0.357	6.43 19.29
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.0844 0.0844	4.83 4.83	0.386 0.386	20.84 24.31
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	0.789 0.789	31.93 39.03
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.789 0.789	39.03 46.13
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.0844 0.0844	4.83 4.83	0.464 0.464	23.98 32.34
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.0844 0.0844	4.83 4.83	0.464 0.464	32.34 40.70
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.0844 0.0844	4.83 4.83	0.789 0.789	74.53 88.72
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.555 0.555	60.07 65.06
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	0.555 0.555	65.06 70.06
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	0.555 0.555	70.06 75.06
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.0844 0.0844	4.83 4.83	0.386 0.386	50.10 53.57
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.0844 0.0844	4.83 4.83	0.386 0.386	53.57 57.04
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.0844 0.0844	4.83 4.83	0.318 0.318	46.00 48.87
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.0844 0.0844	4.83 4.83	0.464 0.464	74.13 78.30
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.0844 0.0844	4.83 4.83	0.386 0.386	63.99 67.46
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.0844 0.0844	4.83 4.83	0.318 0.318	54.60 57.46
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.0844 0.0844	4.83 4.83	0.318 0.318	57.46 60.33

(3)passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	42.000 41.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	41.000 40.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	40.000 38.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	0.0844 0.0844	4.83 4.83	2.327 2.327	72.39 114.27
4	38.000 36.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	36.000 34.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	0.0844 0.0844	4.83 4.83	1.306 1.306	93.37 116.87
6	34.000 33.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	1.913 1.913	165.41 182.62
7	33.000 32.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	1.913 1.913	182.62 199.84
8	32.000 31.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	1.913 1.913	199.84 217.06
9	31.000 30.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
10	30.000 29.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
11	29.000 28.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	3.525 3.525	449.93 481.65
12	28.000 27.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.327 2.327	323.67 344.61
13	27.000 26.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
14	26.000 25.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	3.525 3.525	545.10 576.82
15	25.000 24.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	3.525 3.525	576.82 608.54

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	42.000 41.000	1.000	9.0	0.00 9.00	0.826	0.00 7.44
2	41.000 40.000	1.000	9.0	9.00 18.00	0.826	7.44 14.87
3	40.000 38.000	2.000	9.0	18.00 36.00	0.577	10.39 20.79
4	38.000 36.000	2.000	9.0	36.00 54.00	0.577	20.79 31.18
5	36.000 34.000	2.000	9.0	54.00 72.00	0.826	44.62 59.50
6	34.000 33.000	1.000	9.0	72.00 81.00	0.658	47.37 53.30
7	33.000 32.000	1.000	9.0	81.00 90.00	0.658	53.30 59.22
8	32.000 31.000	1.000	9.0	90.00 99.00	0.658	59.22 65.14
9	31.000 30.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
10	30.000 29.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
11	29.000 28.000	1.000	9.0	117.00 126.00	0.426	49.89 53.73
12	28.000 27.000	1.000	9.0	126.00 135.00	0.577	72.75 77.95
13	27.000 26.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00
14	26.000 25.000	1.000	9.0	144.00 153.00	0.426	61.40 65.24
15	25.000 24.000	1.000	9.0	153.00 162.00	0.426	65.24 69.08

Note:is a layer without earth pressure in calculation.

5.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure table (embankment section)

H.W.L. 44.000(m)

L.W.L. 43.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 8.00
3	42.000 41.000	1.000	8.00 6.00
4	41.000 39.000	2.000	6.00 2.00
5	39.000 38.000	1.000	2.00 0.00

(2) active earth pressure magnitude table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 6.43
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.0400 0.0400	2.29 2.29	0.357 0.357	6.43 19.29
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.0844 0.0844	4.83 4.83	0.386 0.386	20.84 24.31
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	0.789 0.789	31.93 39.03
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.789 0.789	39.03 46.13
6	41.000 39.000	2.000	9.0	25.00	10.0 10.0	81.00 99.00	0.0844 0.0844	4.83 4.83	0.464 0.464	23.98 32.34
7	39.000 37.000	2.000	9.0	25.00	10.0 10.0	99.00 117.00	0.0844 0.0844	4.83 4.83	0.464 0.464	32.34 40.70
8	37.000 35.000	2.000	9.0	10.00	10.0 10.0	117.00 135.00	0.0844 0.0844	4.83 4.83	0.789 0.789	74.53 88.72
9	35.000 34.000	1.000	9.0	20.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.555 0.555	60.07 65.06
10	34.000 33.000	1.000	9.0	20.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	0.555 0.555	65.06 70.06
11	33.000 32.000	1.000	9.0	20.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	0.555 0.555	70.06 75.06
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.0844 0.0844	4.83 4.83	0.386 0.386	50.10 53.57
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.0844 0.0844	4.83 4.83	0.386 0.386	53.57 57.04
14	30.000 29.000	1.000	9.0	35.00	10.0 10.0	180.00 189.00	0.0844 0.0844	4.83 4.83	0.318 0.318	46.00 48.87
15	29.000 28.000	1.000	9.0	25.00	10.0 10.0	189.00 198.00	0.0844 0.0844	4.83 4.83	0.464 0.464	74.13 78.30
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.0844 0.0844	4.83 4.83	0.386 0.386	63.99 67.46
17	27.000 26.000	1.000	9.0	35.00	10.0 10.0	207.00 216.00	0.0844 0.0844	4.83 4.83	0.318 0.318	54.60 57.46
18	26.000 25.000	1.000	9.0	35.00	10.0 10.0	216.00 225.00	0.0844 0.0844	4.83 4.83	0.318 0.318	57.46 60.33

(3)passive earth pressure intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	41.000 39.000	2.000	9.0	25.00	10.0 10.0	18.00 36.00	0.0844 0.0844	4.83 4.83	2.327 2.327	72.39 114.27
4	39.000 37.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	37.000 35.000	2.000	9.0	10.00	10.0 10.0	54.00 72.00	0.0844 0.0844	4.83 4.83	1.306 1.306	93.37 116.87
6	35.000 34.000	1.000	9.0	20.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	1.913 1.913	165.41 182.62
7	34.000 33.000	1.000	9.0	20.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	1.913 1.913	182.62 199.84
8	33.000 32.000	1.000	9.0	20.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	1.913 1.913	199.84 217.06
9	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
10	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
11	30.000 29.000	1.000	9.0	35.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	3.525 3.525	449.93 481.65
12	29.000 28.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.327 2.327	323.67 344.61
13	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
14	27.000 26.000	1.000	9.0	35.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	3.525 3.525	545.10 576.82
15	26.000 25.000	1.000	9.0	35.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	3.525 3.525	576.82 608.54

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	43.000 42.000	1.000	9.0	0.00 9.00	0.826	0.00 7.44
2	42.000 41.000	1.000	9.0	9.00 18.00	0.826	7.44 14.87
3	41.000 39.000	2.000	9.0	18.00 36.00	0.577	10.39 20.79
4	39.000 37.000	2.000	9.0	36.00 54.00	0.577	20.79 31.18
5	37.000 35.000	2.000	9.0	54.00 72.00	0.826	44.62 59.50
6	35.000 34.000	1.000	9.0	72.00 81.00	0.658	47.37 53.30
7	34.000 33.000	1.000	9.0	81.00 90.00	0.658	53.30 59.22
8	33.000 32.000	1.000	9.0	90.00 99.00	0.658	59.22 65.14
9	32.000 31.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
10	31.000 30.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
11	30.000 29.000	1.000	9.0	117.00 126.00	0.426	49.89 53.73
12	29.000 28.000	1.000	9.0	126.00 135.00	0.577	72.75 77.95
13	28.000 27.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00
14	27.000 26.000	1.000	9.0	144.00 153.00	0.426	61.40 65.24
15	26.000 25.000	1.000	9.0	153.00 162.00	0.426	65.24 69.08

Note: is a layer without earth pressure in calculation.

5.2 Stability analysis

5.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.00)
Md: shear deformation moment on check plane(kN*m/m)
Mr: shear resistant moment on check plane(kN*m/m)

$$Mr = Mro*(1+\frac{d}{H})+Msp$$

$$Mro = \int_{0}^{yo} (pRP-pRA)\,y\,dy$$

where,

Mro: basic shear resistant moment of filling soil
d : depth from current ground surface to check level
H : wall height(from top of wall to ground level in embankment range)
pRP: passive earth pressure above check level with a distance y(kN/m2)
pRA: active earth pressure above check level with a distance y(kN/m2)
y : a distance from the location of pRP,pRA working(m)
yo : cross point coordinates of the failure plane in filling soil
Msp: resistant moment caused by two rows sheet piles
smaller resistance either landside or riverside and make double to evaluate
Msp= 2*(smaller value either Msp1 or Msp2)
Msp1: resistant moment derived from sheet pile
Msp1= Sig.a* Zsp
Sig.a: allowable stress of sheet pile in use(N/mm2)
Zsp : section modulus considering joint(splice) of sheet pile in use(mm3/m)
Msp2: resistant moment allowed by embedment deeper than check level.
Msp2= Ppu* hpu
Ppu: passive resultant force from check elevation to sheet pile tip
hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	38.000	5.000	503.47	1935.14	3.84>=1.00
Layer boundary surface	39.000	4.000	478.72	1379.34	2.88>=1.00
Layer boundary surface	41.000	2.000	276.35	1721.22	6.23>=1.00
Layer boundary surface	42.000	1.000	165.21	1583.47	9.58>=1.00
Min safety factor	39.000	4.000	478.72	1379.34	2.88>=1.00
Current ground level	43.000	0.000	82.08	1335.39	16.27>=1.00

(2)check level(Embedment tip: G.L. 38.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	503.47
resistant moment	Mr(kN.m/m)	1935.14
factor of safety	Mr/Md	3.84>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	693.33
active earth-prss moment	Ma	3.66
pssv earth-prss moment	-Mp	372.50
other load moment	Mc	0.00
inertia force moment	Me	165.96
dynamic hydraulic moment	Mwd	13.02
deformation moment	Md(kN.m/m)	503.47

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	6.667	133.33
2	44.000 43.000	1.000	20.00 30.00	25.00	5.467	136.67
3	43.000 42.000	1.000	30.00 40.00	35.00	4.476	156.67
4	42.000 41.000	1.000	40.00 35.00	37.50	3.511	131.67
5	41.000 39.000	2.000	35.00 25.00	60.00	2.056	123.33
6	39.000 38.000	1.000	25.00 20.00	22.50	0.519	11.67
Sum				200.00		693.33

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	4.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	3.500	0.00
3	41.000 39.739	1.261	0.00 0.00	0.00	2.369	0.00
4	39.739 39.000	0.739	0.00 3.09	1.14	1.246	1.42
5	39.000 38.000	1.000	3.09 7.27	5.18	0.433	2.24
Sum				6.32		3.66

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	22.85 34.61	28.73	3.466	99.58
2	41.000 40.000	1.000	34.61 46.36	40.48	2.476	100.23
3	40.000 38.000	2.000	72.39 114.27	186.66	0.925	172.70
Sum				255.87		372.50

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 33.48(kN/m)

Me = Sum(Me)+ Mew

= 165.96(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	8.500	36.72
2	46.000 44.000	2.000	4.32 4.32	8.64	7.000	60.48
3	44.000 43.000	1.000	4.32 4.32	4.32	5.500	23.76
4	43.000 42.000	1.000	4.32 3.89	4.10	4.509	18.50
5	42.000 41.000	1.000	3.89 3.46	3.67	3.510	12.89
6	41.000 39.000	2.000	3.46 2.59	6.05	2.048	12.38
7	39.000 38.000	1.000	2.59 2.16	2.38	0.515	1.22
Sum				33.48		165.96

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 13.02(kN m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN m/m
46.000	43.000	3.000	3.000	1.800	2.10	6.200	13.02

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1935.14 0.00 486.00 0.00
rsst moment Mr(kN.m/m)	1935.14

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 860.06* (1+ 1.250)= 1935.14(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	40.718 39.000	1.718	237.22 275.32	21.16 27.44	216.06 247.88	398.53	1.839	733.04
2	39.000 38.000	1.000	275.32 297.50	27.44 31.09	247.88 266.40	257.14	0.494	127.03
Sum						655.67		860.06

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	40.718 39.000	39.000 38.000	1.718 1.000	25.00 25.00	0.00 0.00	32.50 32.50	2.697 1.570	57.50 57.50	1.094 0.637	3.791 2.207
Interval Sum(Bp) + Ba										5.998

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 0.00)= 0.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m3/m - - - - - - - - $* 10^{-6}$ m3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 39.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	478.72
resistant moment	Mr(kN.m/m)	1379.34
factor of safety	Mr/ Md	2.88>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	504.17
active earth-prss moment	Ma	0.28
pssv earth-prss moment	- Mp	170.27
other load moment	Mc	0.00
inertia force moment	Me	133.63
dynamic hydraulic moment	Mwd	10.92
deformation moment	Md(kN.m/m)	478.72

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	5.667	113.33
2	44.000 43.000	1.000	20.00 30.00	25.00	4.467	111.67
3	43.000 42.000	1.000	30.00 40.00	35.00	3.476	121.67
4	42.000 41.000	1.000	40.00 35.00	37.50	2.511	94.17
5	41.000 39.000	2.000	35.00 25.00	60.00	1.056	63.33
Sum				177.50		504.17

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	3.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	2.500	0.00
3	41.000 39.739	1.261	0.00 0.00	0.00	1.369	0.00
4	39.739 39.000	0.739	0.00 3.09	1.14	0.246	0.28
Sum				1.14		0.28

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	22.85 34.61	28.73	2.466	70.85
2	41.000 40.000	1.000	34.61 46.36	40.48	1.476	59.74
3	40.000 39.000	1.000	72.39 93.33	82.86	0.479	39.68
Sum				152.07		170.27

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew
= 31.10(kN/m)

Me = Sum(Me)+ Mew
= 133.63(kN.m/m)

* surcharge load

Pew = q* B* Kh
= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)
= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	7.500	32.40
2	46.000 44.000	2.000	4.32 4.32	8.64	6.000	51.84
3	44.000 43.000	1.000	4.32 4.32	4.32	4.500	19.44
4	43.000 42.000	1.000	4.32 3.89	4.10	3.509	14.40
5	42.000 41.000	1.000	3.89 3.46	3.67	2.510	9.22
6	41.000 39.000	2.000	3.46 2.59	6.05	1.048	6.34
Sum				31.10		133.63

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure
Fwd= 2.10(kN/m)
Mwd= 10.92(kN.m/m)
* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	5.200	10.92

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.
* inside dynamic hydraulic pressure
Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro*(1+ d/ H)	1251.11
Msp= 2* min(Msp1, Msp2)	128.23
Msp1	486.00
Msp2	64.11
rsst moment Mr(kN.m/m)	1379.34

a.resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro*(1+ d/ H)= 625.55*(1+ 1.000)= 1251.11(kN.m/m)
Arm length = distance from check level to layer bottom + (h/ 3)*(2* p1+ p2)/(p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.781 41.000	0.781	128.89 138.88	35.30 40.25	93.59 98.63	75.06	2.387	179.18
2	41.000 39.000	2.000	230.97 275.32	20.13 27.44	210.84 247.88	458.72	0.973	446.37
Sum						533.78		625.55

b.yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+Ba (m)
1	41.781	41.000	0.781	10.00	0.00	40.00	0.931	50.00	0.655	1.586
2	41.000	39.000	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane
Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))
* active failure plane
Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))
* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level
Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 64.11)= 128.23(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m^3/m - - - - - - - - * 10^{-6} m^3/m * 10^3 kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	114.27 135.21	124.74	0.514	64.11
Sum				124.74		64.11

(4)check level(Layer boundary surface: G.L. 41.000m)

1)check result

item	value
deformation moment MH(kN.m/m)	276.35
resistant moment Mr(kN.m/m)	1721.22
factor of safety Mr/ MH	6.23>=1.00

2)deformation moment(MH)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc inertia force moment Me dynamic hydraulic moment Mwd	205.83 0.00 13.39 0.00 77.18 6.72
deformation moment MH(kN.m/m)	276.35

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	3.667	73.33
2	44.000 43.000	1.000	20.00 30.00	25.00	2.467	61.67
3	43.000 42.000	1.000	30.00 40.00	35.00	1.476	51.67
4	42.000 41.000	1.000	40.00 35.00	37.50	0.511	19.17
Sum				117.50		205.83

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	1.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	22.85 34.61	28.73	0.466	13.39
Sum				28.73		13.39

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)
* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew
 = 25.06(kN/m)

Me = Sum(Me) + Mew
 = 77.18(kN.m/m)

* surcharge load

Pew = q * B * Kh
 = 0.00(kN/m)

Mew = Pew * (height from check level to top of wall)
 = 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	5.500	23.76
2	46.000 44.000	2.000	4.32 4.32	8.64	4.000	34.56
3	44.000 43.000	1.000	4.32 4.32	4.32	2.500	10.80
4	43.000 42.000	1.000	4.32 3.89	4.10	1.509	6.19
5	42.000 41.000	1.000	3.89 3.46	3.67	0.510	1.87
Sum				25.06		77.18

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd * (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 6.72(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	3.200	6.72

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H)	749.22
Msp= 2* min(Msp1, Msp2)	972.00
Msp1	486.00
Msp2	514.21
rsst moment Mr(kN.m/m)	1721.22

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 499.48* (1+ 0.500)= 749.22(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	43.839 43.000	0.839	166.35 189.00	18.48 21.00	147.86 168.00	132.50	2.411	319.41
2	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	1.494	132.90
3	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	0.494	47.17
Sum						316.87		499.48

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	43.839	43.000	0.839	30.00	0.00	30.00	1.453	60.00	0.484	1.938
2	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
3	42.000	41.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- $\tan^{-1}$ (cot(xip))

* active failure plane

Ba= cot(xia)* h

cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(- $\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}$ -)

xia= 90.0- $\tan^{-1}$ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 514.21)= 972.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m^3/m - - - - - - - - * 10^{-6} m^3/m * 10^3 kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	41.000 39.000	2.000	72.39 114.27	186.66	1.075	200.62
2	39.000 38.000	1.000	114.27 135.21	124.74	2.514	313.59
Sum				311.40		514.21

(5)check level(Layer boundary surface: G.L. 42.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	165.21
resistant moment	Mr(kN.m/m)	1583.47
factor of safety	Mr/ Md	9.58>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	106.67
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	0.00
other load moment	Mc	0.00
inertia force moment	Me	53.93
dynamic hydraulic moment	Mwd	4.62
deformation moment	Md(kN.m/m)	165.21

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	2.667	53.33
2	44.000 43.000	1.000	20.00 30.00	25.00	1.467	36.67
3	43.000 42.000	1.000	30.00 40.00	35.00	0.476	16.67
Sum				80.00		106.67

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m   Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 21.38(kN/m)

Me = Sum(Me)+ Mew

= 53.93(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	4.500	19.44
2	46.000 44.000	2.000	4.32 4.32	8.64	3.000	25.92
3	44.000 43.000	1.000	4.32 4.32	4.32	1.500	6.48
4	43.000 42.000	1.000	4.32 3.89	4.10	0.509	2.09
Sum				21.38		53.93

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 4.62(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	2.200	4.62

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H)	611.47
Msp= 2* min(Msp1, Msp2)	972.00
Msp1	486.00
Msp2	846.83
rsst moment Mr(kN.m/m)	1583.47

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 489.18* (1+ 0.250)= 611.47(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	44.718 44.000	0.718	123.23 162.00	13.69 18.00	109.54 144.00	91.02	2.343	213.23
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	1.487	232.00
3	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	0.494	43.94
Sum						335.98		489.18

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	44.718	44.000	0.718	30.00	0.00	30.00	1.244	60.00	0.415	1.658
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
3	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.998

* passive failure plane

Bp= cot(xip)* h

cot(xip)= tan(Phi)+sec(Phi)*Sqrt(- $\frac{\cos(-\ Theta)\sin(Phi)}{\sin(Phi-\ Theta)}$)

xip= 90.0- tan⁻¹ (cot(xip))

* active failure plane

Ba= cot(xia)* h

cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(- $\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-\ Theta)}$)

xia= 90.0- tan⁻¹ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 846.83)= 972.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m^3/m - - - - - - - - * 10^{-6} m^3/m * 10^3 kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	34.61 46.36	40.48	0.524	21.22
2	41.000 39.000	2.000	72.39 114.27	186.66	2.075	387.27
3	39.000 38.000	1.000	114.27 135.21	124.74	3.514	438.33
Sum				351.88		846.83

(6)check level(Min safety factor: G.L. 39.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	478.72
resistant moment	Mr(kN.m/m)	1379.34
factor of safety	Mr/ Md	2.88>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment inertia force moment dynamic hydraulic moment	Mw Ma - Mp Mc Me Mwd	504.17 0.28 170.27 0.00 133.63 10.92
deformation moment	Md(kN.m/m)	478.72

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	5.667	113.33
2	44.000 43.000	1.000	20.00 30.00	25.00	4.467	111.67
3	43.000 42.000	1.000	30.00 40.00	35.00	3.476	121.67
4	42.000 41.000	1.000	40.00 35.00	37.50	2.511	94.17
5	41.000 39.000	2.000	35.00 25.00	60.00	1.056	63.33
Sum				177.50		504.17

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	3.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	2.500	0.00
3	41.000 39.739	1.261	0.00 0.00	0.00	1.369	0.00
4	39.739 39.000	0.739	0.00 3.09	1.14	0.246	0.28
Sum				1.14		0.28

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	42.000 41.000	1.000	22.85 34.61	28.73	2.466	70.85
2	41.000 40.000	1.000	34.61 46.36	40.48	1.476	59.74
3	40.000 39.000	1.000	72.39 93.33	82.86	0.479	39.68
Sum				152.07		170.27

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)
* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

  Fe = Sum(Pe) + Pew
  = 31.10(kN/m)

  Me = Sum(Me) + Mew
  = 133.63(kN.m/m)

* surcharge load

  Pew = q* B* Kh
  = 0.00(kN/m)

  Mew = Pew* (height from check level to top of wall)
  = 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	7.500	32.40
2	46.000 44.000	2.000	4.32 4.32	8.64	6.000	51.84
3	44.000 43.000	1.000	4.32 4.32	4.32	4.500	19.44
4	43.000 42.000	1.000	4.32 3.89	4.10	3.509	14.40
5	42.000 41.000	1.000	3.89 3.46	3.67	2.510	9.22
6	41.000 39.000	2.000	3.46 2.59	6.05	1.048	6.34
Sum				31.10		133.63

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure
Lwd: distance from water level to resultant force working position.
Mwd: dynamic hydraulic moment on check level
Kh : design seismicity(0.04)
Gamw: water unit weight
he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)
Mwd= 10.92(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	5.200	10.92

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1251.11 128.23 486.00 64.11
rsst moment Mr(kN.m/m)	1379.34

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mfo* (1+ d/ H)= 625.55* (1+ 1.000)= 1251.11(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mfo kN m/m
1	41.781 41.000	0.781	128.89 138.88	35.30 40.25	93.59 98.63	75.06	2.387	179.18
2	41.000 39.000	2.000	230.97 275.32	20.13 27.44	210.84 247.88	458.72	0.973	446.37
Sum						533.78		625.55

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	41.781 41.000	41.000 39.000	0.781 2.000	10.00 25.00	0.00 0.00	40.00 32.50	0.931 3.139	50.00 57.50	0.655 1.274	1.586 4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(486.00, 64.11)= 128.23(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	39.000 38.000	1.000	114.27 135.21	124.74	0.514	64.11

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
Sum				124.74		64.11

(7)check level(Current ground level: G.L. 43.000m)

1)check result

item	value
deformation moment Md(kN.m/m)	82.08
resistant moment Mr(kN.m/m)	1335.39
factor of safety Mr/ Md	16.27>=1.00

2)deformation moment(Md)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc inertia force moment Me dynamic hydraulic moment Mwd	45.00 0.00 0.00 0.00 34.56 2.52
deformation moment Md(kN.m/m)	82.08

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	1.667	33.33
2	44.000 43.000	1.000	20.00 30.00	25.00	0.467	11.67
Sum				45.00		45.00

b.active earth pressure moment

Sum(Pa) = 0.00kN/m Sum(Ma) = 0.00kN.m/m

c.passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d.other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e.inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew
= 17.28(kN/m)

Me = Sum(Me)+ Mew
= 34.56(kN.m/m)

* surcharge load

Pew = q* B* Kh
= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)
= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	3.500	15.12
2	46.000 44.000	2.000	4.32 4.32	8.64	2.000	17.28
3	44.000 43.000	1.000	4.32 4.32	4.32	0.500	2.16
Sum				17.28		34.56

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 2.52(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	1.200	2.52

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	363.39 972.00 486.00 1214.05
rsst moment Mr(kN.m/m)	1335.39

FORUM8

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mfo* (1+ d/ H) = 363.39* (1+ 0.000) = 363.39(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mfo kN m/m
1	45.598 44.000	1.598	75.71 162.00	8.41 18.00	67.30 144.00	168.83	1.702	287.39
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	0.487	76.00
Sum						324.83		363.39

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	45.598	44.000	1.598	30.00	0.00	30.00	2.768	60.00	0.923	3.690
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*Sqrt(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi- Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(486.00, 1214.05) = 972.00(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item		unit	landside	riverside
Steel material name		- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z		$*\ 10^{-6}\ m^3/m$	3000	3000
eff ratio for section modulus Alp.		- - - - - - - -	0.60	0.60
section modulus in use	Alp.Z	$*\ 10^{-6}\ m^3/m$	1800	1800
allowable stress	Sig.a	$*\ 10^{3}\ kN/m2$	270.0	270.0
resistant mt Msp1 = Sig.a* Alp.Z		kN* m/m	486.00	486.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	43.000 42.000	1.000	22.85 34.61	28.73	0.534	15.34

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
2	42.000 41.000	1.000	34.61 46.36	40.48	1.524	61.70
3	41.000 39.000	2.000	72.39 114.27	186.66	3.075	573.93
4	39.000 38.000	1.000	114.27 135.21	124.74	4.514	563.07
Sum				380.61		1214.05

5.2.2 Check on wall slide

(1) result summery

1) check equation

wall width B= 6.000, height H= 4.000(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.00)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2) check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	38.000	5.000	241.90	618.04	2.55>=1.00

(2) check level(embedment tip: G.L. 38.000m)

1) check result

item	value
sum of H force Fd(kN/m)	241.90
sum of rsst Fr(kN/m)	618.04
factor of safety Fr/ Fd	2.55>=1.00

2) sum of horizontal force(Fd)

horizontal force in detail		H force
water pressure	Fw	200.00
active earth pressure	Fa	6.32
other load	Fc	0.00
inertia force	Fe	33.48
dynamic hydraulic prrs	Fwd	2.10
sum of H force	Fd(kN/m)	241.90

a. water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b. active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c. other load

table of other load when shear deformation failures is check at tip of embedment.

d. inertia force

table of inertia force when shear deformation failures is check at tip of embedment.

e. dynamic hydraulic pressure

table of dynamic hydraulic press. when shear deform failures is checked at tip of embedment.

3) calculation on sum of sliding resistance(Fr)

resistance in detail		H force
ground H resistance	Fs	362.17
passive earth pressure	Fp	255.87
sum of resistance	Fr(kN/m)	618.04

a. calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 6.000+ 648.00* tan(25.00) Deg.

= 362.17(kN/m)

b. soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (108.00+ 0.00)* 6.000= 648.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	44.000	2.000	18.0	36.00
3	44.000	43.000	1.000	9.0	9.00
4	43.000	42.000	1.000	9.0	9.00
5	42.000	41.000	1.000	9.0	9.00
6	41.000	39.000	2.000	9.0	18.00
7	39.000	38.000	1.000	9.0	9.00
Sum			9.000		108.00

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

5.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 6.000, height H= 4.000(m) using the next equation.

$$\frac{Qu}{V - Gam2 * Df * Be} >= FS$$

$$Qu = Be\{ k * c * Nc + k * Gam2 * Df * (Nq - 1) + \frac{1}{2} * Gam1 * Be * NGam \}$$

where,

FS : required factor of safety(1.00)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B- 2e

B: wall width

e: eccentricity(e= Mb/ V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/ V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	38.000	5.000	3470.07	447.93	7.75>=1.00

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	648.00
	distance from ground to check level	Df	5.000
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	4.446
	v-compo sum V- Gam2.Df.Be (kN/m)		447.93
Qu	moment on check level	Mb	503.47
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	0.777
	resultant frc inclination(Hb/ V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		3470.07
factor of safety			7.75>=1.00

2)summery of external force

external force detail		moment Mb(kN.m/m)	H force Hb(kN/m)
water pressure	Mw(Fw)	693.33	200.00
active earth pressure	Ma(Fa)	3.66	6.32
passive earth pressure-	Mp(Fp)	372.50	255.87
other load	Mc(Fc)	0.00	0.00
inertia force	Me(Fe)	165.96	33.48
dynamic water prss	Mwd(Fwd)	13.02	2.10
external force sum		503.47	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b. active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

e. inertia load

refer to inertia force in checking shear failure at embedment tip

f. dynamic water pressure

refer to dynamic water pressure in checking shear failure at embedment tip

3) weight of filling soil(V)

refer to 'b.weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 648.00(kN/m)

4) eccentricity distance(e) calculation

e = Mb/ V

= 503.47/ 648.00

= 0.777(m)

Be = B- 2e

= 6.000- 2.0* 0.777

= 4.446(m)

5) calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 648.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\ 2 = \frac{Sum(Gam\ i\ hi)}{Sum(hi)}$$

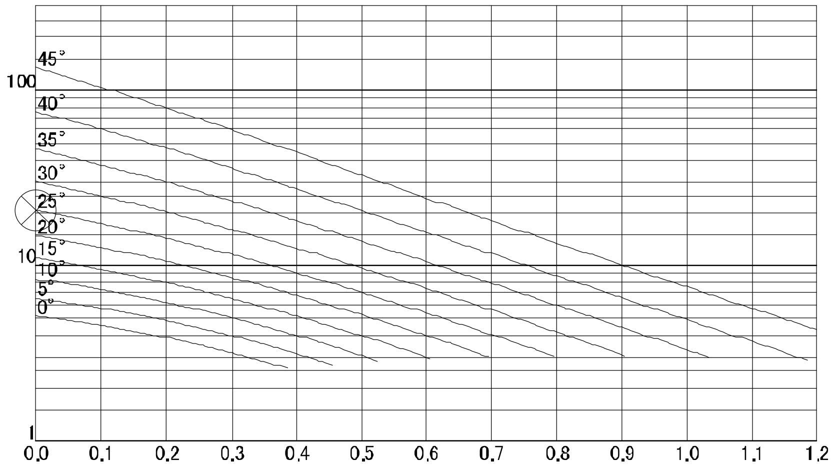
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	43.000	42.000	1.000	9.0	9.00
2	42.000	41.000	1.000	9.0	9.00
3	41.000	39.000	2.000	9.0	18.00
4	39.000	38.000	1.000	9.0	9.00
Sum			5.000		45.00

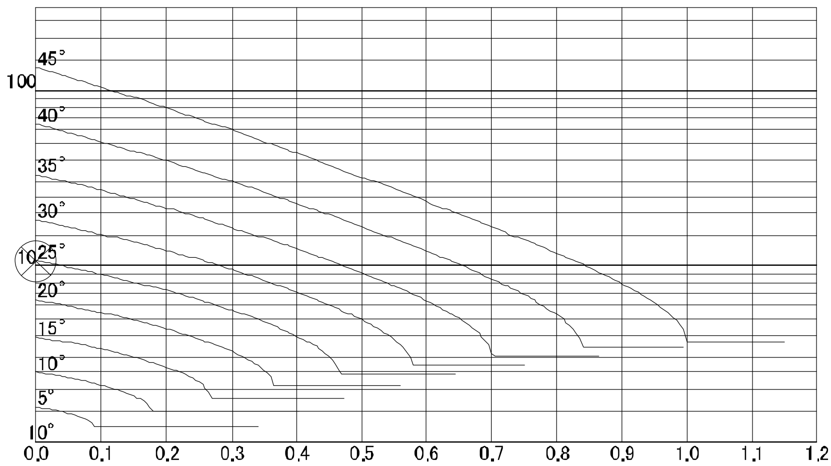
(3)bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

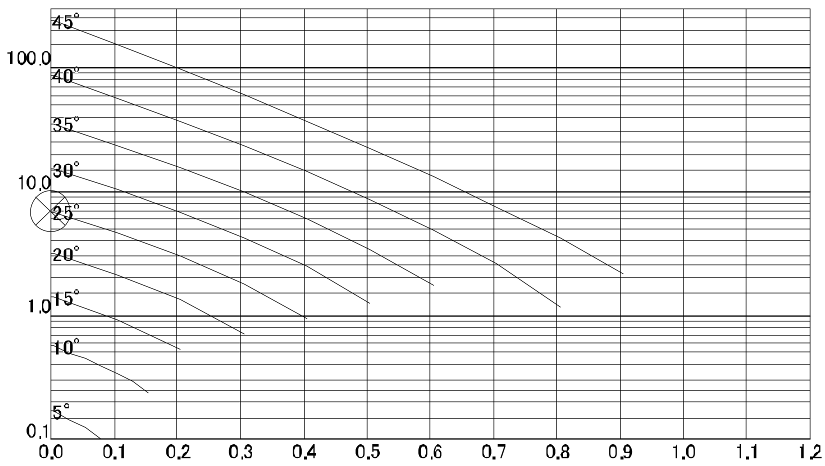
1)Nc calculation diagram



2)Nq calculation diagram



3)NGam calculation diagram



5.3 landside sheet pile

5.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 42.000(m)

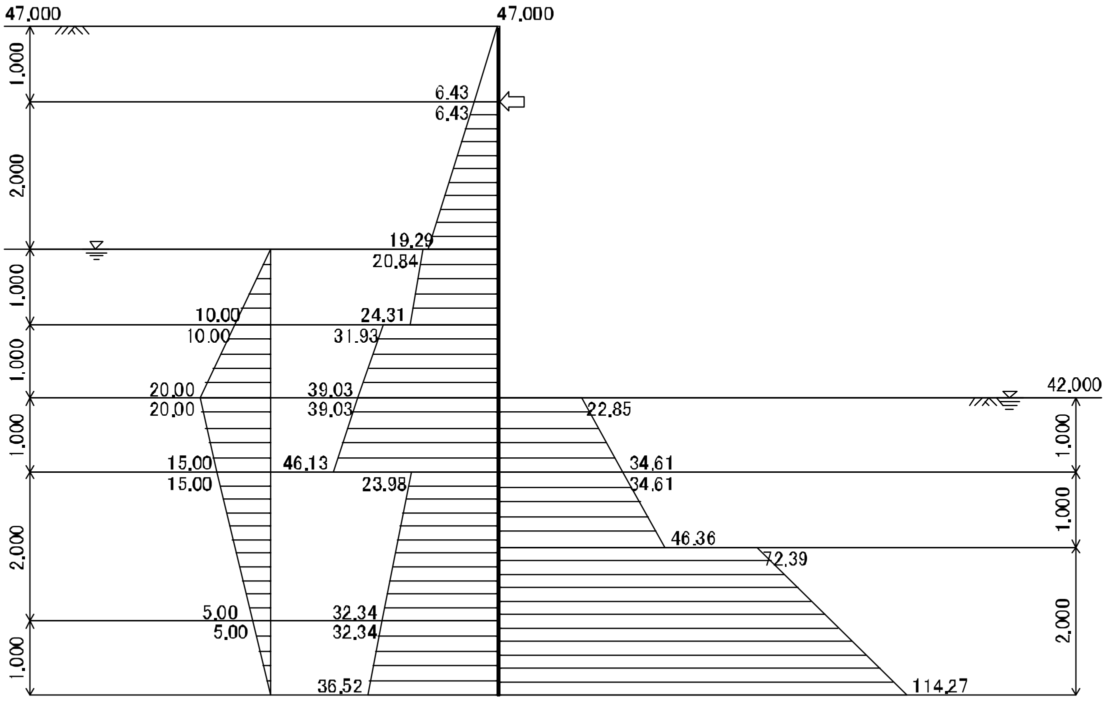
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	38.290	38.000
active sd	Ma+Mw+Mac(kN.m/m)	1182.11	1282.97
passive sd	Mp+Mpc(kN.m/m)	1421.03	1674.46
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.202>=1.20	1.305>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.43 19.29	25.72	1.167	30.01
2	44.000 43.000	1.000	20.84 24.31	22.58	2.513	56.73
3	43.000 42.000	1.000	31.93 39.03	35.48	3.517	124.77
4	42.000 41.000	1.000	39.03 46.13	42.58	4.514	192.20
5	41.000 39.000	2.000	23.98 32.34	56.32	6.049	340.70
6	39.000 38.000	1.000	32.34 36.52	34.43	7.510	258.56
Sum				217.11		1002.97

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 20.00	15.00	3.556	53.33
3	42.000 41.000	1.000	20.00 15.00	17.50	4.476	78.33
4	41.000 39.000	2.000	15.00 5.00	20.00	5.833	116.67
5	39.000 38.000	1.000	5.00 0.00	2.50	7.333	18.33
Sum				60.00		280.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	22.85 34.61	28.73	4.534	130.27
2	41.000 40.000	1.000	34.61 46.36	40.48	5.524	223.63
3	40.000 38.000	2.000	72.39 114.27	186.66	7.075	1320.56
Sum				255.87		1674.46

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

5.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-164.99	G.L. 42.600
max shear force Smax(kN/m)	-73.05	G.L. 46.000
upper tension mbr rct R1(kN/m)	-76.94	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	0.00 6.43	0.00 0.00	- - - - - - - -	- - - - - - - -	0.00 6.43	- - - - - - - -
2	46.000 44.000	6.43 19.29	0.00 0.00	- - - - - - - -	- - - - - - - -	6.43 19.29	- - - - - - - -
3	44.000 43.000	20.84 24.31	0.00 10.00	- - - - - - - -	- - - - - - - -	20.84 34.31	- - - - - - - -
4	43.000 42.000	31.93 39.03	10.00 20.00	- - - - - - - -	- - - - - - - -	41.93 59.03	- - - - - - - -
5	42.000 41.000	39.03 46.13	20.00 15.00	22.85 34.61	0.00 7.44	59.03 53.69	22.85 27.17
6	41.000 40.000	23.98 28.16	15.00 10.00	34.61 46.36	7.44 14.87	31.54 23.29	27.17 31.48
7	40.000 39.000	28.16 32.34	10.00 5.00	72.39 93.33	10.39 15.59	27.77 21.75	62.00 77.74
8	39.000 38.000	32.34 36.52	5.00 0.00	93.33 114.27	15.59 20.79	21.75 15.73	77.74 93.48

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta^{*}\frac{1}{0.3}{}^{*}Alpha\ Eo^{*}\left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	42.000	41.000	1.000	2800	1346
2	41.000	40.000	1.000	8400	4037
3	40.000	38.000	2.000	70000	33639
4	38.000	36.000	2.000	64400	30948
5	36.000	34.000	2.000	14000	6728
6	34.000	33.000	1.000	47600	22875
7	33.000	32.000	1.000	53200	25566
8	32.000	31.000	1.000	53200	25566
9	31.000	30.000	1.000	117600	56514
10	30.000	29.000	1.000	137200	65933
11	29.000	28.000	1.000	165200	79389
12	28.000	27.000	1.000	67200	32294
13	27.000	26.000	1.000	106400	51132
14	26.000	25.000	1.000	123200	59205
15	25.000	24.000	1.000	106400	51132

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.^{*}(2^{*}number^{*}A^{*}E)}{(L^{*}s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [6.000]m
s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
wall section (filling soil). back and active side pressure are considered. no ground spring.

* passive elastic
in embedment section, displacement on excavation side is within limit displacement.
effective active side prss from back is considered. ground springs exist. no exv load.

* passive plastic
in embedment section, displacement on excavation side exceeds limit displacement.
effective active side prss from back is considered. no ground spring. exv load exists

* active elastic
in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	29787
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	20.84	4.05	--------	--------	--------	--------
17	43.800	On excavation plane	23.54	23.54	4.71	--------	--------	--------	--------
18	43.600	On excavation plane	26.23	26.23	5.25	--------	--------	--------	--------
19	43.400	On excavation plane	28.92	28.92	5.78	--------	--------	--------	--------
20	43.200	On excavation plane	31.62	31.62	6.32	--------	--------	--------	--------

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
21	43.000	On excavation plane	34.31	41.93	7.64	--------	--------	--------	--------
22	42.800	On excavation plane	45.35	45.35	9.07	--------	--------	--------	--------
23	42.600	On excavation plane	48.77	48.77	9.75	--------	--------	--------	--------
24	42.400	On excavation plane	52.19	52.19	10.44	--------	--------	--------	--------
25	42.200	On excavation plane	55.61	55.61	11.12	--------	--------	--------	--------
26	42.000	Pas ela.	59.03	59.03	11.69	0.00	22.85	--------	135
27	41.800	Pas ela.	57.96	57.96	11.59	23.72	23.72	--------	269
28	41.600	Pas ela.	56.90	56.90	11.38	24.58	24.58	--------	269
29	41.400	Pas ela.	55.83	55.83	11.17	25.44	25.44	--------	269
30	41.200	Pas ela.	54.76	54.76	10.95	26.31	26.31	--------	269
31	41.000	Pa plas.	53.69	31.54	8.51	27.17	27.17	5.43	--------
32	40.800	Pa plas.	29.89	29.89	5.98	28.03	28.03	5.61	--------
33	40.600	Pa plas.	28.24	28.24	5.65	28.90	28.90	5.78	--------
34	40.400	Pa plas.	26.59	26.59	5.32	29.76	29.76	5.95	--------
35	40.200	Pa plas.	24.94	24.94	4.99	30.62	30.62	6.12	--------
36	40.000	Pa plas.	23.29	27.77	5.12	31.48	62.00	9.41	--------
37	39.800	Pa plas.	26.56	26.56	5.31	65.14	65.14	13.03	--------
38	39.600	Pa plas.	25.36	25.36	5.07	68.29	68.29	13.66	--------
39	39.400	Pa plas.	24.16	24.16	4.83	71.44	71.44	14.29	--------
40	39.200	Pa plas.	22.95	22.95	4.59	74.59	74.59	14.92	--------
41	39.000	Pa plas.	21.75	21.75	4.35	77.74	77.74	15.55	--------
42	38.800	Pa plas.	20.55	20.55	4.11	80.89	80.89	16.18	--------
43	38.600	Pas ela.	19.34	19.34	3.87	84.04	84.04	--------	6728
44	38.400	Pas ela.	18.14	18.14	3.63	87.19	87.19	--------	6728
45	38.200	Act ela.	16.93	16.93	3.39	90.33	90.33	--------	6728
46	38.000	Act ela.	15.73	0.00	1.60	93.48	0.00	--------	3364
Sum					234.27			125.92	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= 15.73mm(G.L. 42.400m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	----	-3.27	----	----
2	46.800	on exv	----	-2.10	----	----
3	46.600	on exv	----	-0.93	----	----
4	46.400	on exv	----	0.24	----	----
5	46.200	on exv	----	1.41	----	----
6	46.000	on exv	29787	2.58	----	Note: -76.94
7	45.800	on exv	----	3.75	----	----
8	45.600	on exv	----	4.91	----	----
9	45.400	on exv	----	6.06	----	----
10	45.200	on exv	----	7.17	----	----
11	45.000	on exv	----	8.25	----	----
12	44.800	on exv	----	9.29	----	----
13	44.600	on exv	----	10.27	----	----
14	44.400	on exv	----	11.19	----	----
15	44.200	on exv	----	12.05	----	----
16	44.000	on exv	----	12.83	----	----
17	43.800	on exv	----	13.53	----	----
18	43.600	on exv	----	14.14	----	----
19	43.400	on exv	----	14.66	----	----
20	43.200	on exv	----	15.08	----	----

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
21	43.000	on exv	- - - -	15.40	- - - -	- - - -
22	42.800	on exv	- - - -	15.62	- - - -	- - - -
23	42.600	on exv	- - - -	15.73	- - - -	- - - -
24	42.400	on exv	- - - -	15.73	- - - -	- - - -
25	42.200	on exv	- - - -	15.63	- - - -	- - - -
26	42.000	pssv el	135	15.42	17.15	-2.08
27	41.800	pssv el	269	15.11	17.63	-4.07
28	41.600	pssv el	269	14.71	18.27	-3.96
29	41.400	pssv el	269	14.21	18.91	-3.82
30	41.200	pssv el	269	13.62	19.55	-3.67
31	41.000	pssv pl	- - - -	12.96	10.10	- - - -
32	40.800	pssv pl	- - - -	12.23	6.94	- - - -
33	40.600	pssv pl	- - - -	11.43	7.16	- - - -
34	40.400	pssv pl	- - - -	10.58	7.37	- - - -
35	40.200	pssv pl	- - - -	9.69	7.59	- - - -
36	40.000	pssv pl	- - - -	8.76	2.50	- - - -
37	39.800	pssv pl	- - - -	7.81	1.94	- - - -
38	39.600	pssv pl	- - - -	6.83	2.03	- - - -
39	39.400	pssv pl	- - - -	5.84	2.12	- - - -
40	39.200	pssv pl	- - - -	4.85	2.22	- - - -
41	39.000	pssv pl	- - - -	3.85	2.31	- - - -
42	38.800	pssv pl	- - - -	2.85	2.40	- - - -
43	38.600	pssv el	6728	1.86	2.50	-12.52
44	38.400	pssv el	6728	0.87	2.59	-5.85
45	38.200	actv el	6728	-0.12	2.69	0.81
46	38.000	actv el	3364	-1.11	2.76	3.73
Sum						-108.35

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

max bending moment Mmax= -164.99kN m/m(G.L. 42.600m)
max shear force Smax= -73.05kN/m (G.L. 46.000m)
max displacement Del.xmax= 15.73mm (G.L. 42.400m)

node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	0.03	-3.27	------------
2	46.800	0.01	0.01	0.03	0.29	-2.10	------------
3	46.600	0.06	0.06	0.29	0.80	-0.93	------------
4	46.400	0.23	0.23	0.80	1.58	0.24	------------
5	46.200	0.54	0.54	1.58	2.60	1.41	------------
6	46.000	1.06	1.06	2.60	-73.05	2.58	* -76.94
7	45.800	-13.55	-13.55	-73.05	-71.51	3.75	------------
8	45.600	-27.85	-27.85	-71.51	-69.71	4.91	------------
9	45.400	-41.79	-41.79	-69.71	-67.65	6.06	------------
10	45.200	-55.32	-55.32	-67.65	-65.34	7.17	------------
11	45.000	-68.39	-68.39	-65.34	-62.76	8.25	------------
12	44.800	-80.94	-80.94	-62.76	-59.93	9.29	------------
13	44.600	-92.93	-92.93	-59.93	-56.85	10.27	------------
14	44.400	-104.30	-104.30	-56.85	-53.50	11.19	------------
15	44.200	-115.00	-115.00	-53.50	-49.90	12.05	------------
16	44.000	-124.98	-124.98	-49.90	-45.85	12.83	------------
17	43.800	-134.15	-134.15	-45.85	-41.15	13.53	------------
18	43.600	-142.38	-142.38	-41.15	-35.90	14.14	------------
19	43.400	-149.56	-149.56	-35.90	-30.12	14.66	------------
20	43.200	-155.58	-155.58	-30.12	-23.79	15.08	------------
21	43.000	-160.34	-160.34	-23.79	-16.15	15.40	------------
22	42.800	-163.57	-163.57	-16.15	-7.08	15.62	------------
23	42.600	-164.99	-164.99	-7.08	2.68	15.73	------------
24	42.400	-164.45	-164.45	2.68	13.11	15.73	------------
25	42.200	-161.83	-161.83	13.11	24.24	15.63	------------
26	42.000	-156.98	-156.98	24.24	33.85	15.42	-2.08
27	41.800	-150.21	-150.21	33.85	41.38	15.11	-4.07
28	41.600	-141.94	-141.94	41.38	48.80	14.71	-3.96
29	41.400	-132.18	-132.18	48.80	56.14	14.21	-3.82
30	41.200	-120.95	-120.95	56.14	63.43	13.62	-3.67
31	41.000	-108.26	-108.26	63.43	66.50	12.96	------------
32	40.800	-94.96	-94.96	66.50	66.88	12.23	------------
33	40.600	-81.59	-81.59	66.88	66.74	11.43	------------
34	40.400	-68.24	-68.24	66.74	66.11	10.58	------------
35	40.200	-55.02	-55.02	66.11	64.97	9.69	------------
36	40.000	-42.02	-42.02	64.97	60.69	8.76	------------
37	39.800	-29.88	-29.88	60.69	52.97	7.81	------------
38	39.600	-19.29	-19.29	52.97	44.38	6.83	------------
39	39.400	-10.41	-10.41	44.38	34.93	5.84	------------
40	39.200	-3.43	-3.43	34.93	24.60	4.85	------------
41	39.000	1.49	1.49	24.60	13.40	3.85	------------
42	38.800	4.17	4.17	13.40	1.33	2.85	------------

node No	Y co GL(m)	moment kN.m/m top	moment kN.m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
43	38.600	4.44	4.44	1.33	-7.32	1.86	-12.52
44	38.400	2.97	2.97	-7.32	-9.54	0.87	-5.85
45	38.200	1.07	1.07	-9.54	-5.34	-0.12	0.81
46	38.000	0.00	----------	-5.34	----------	-1.11	3.73

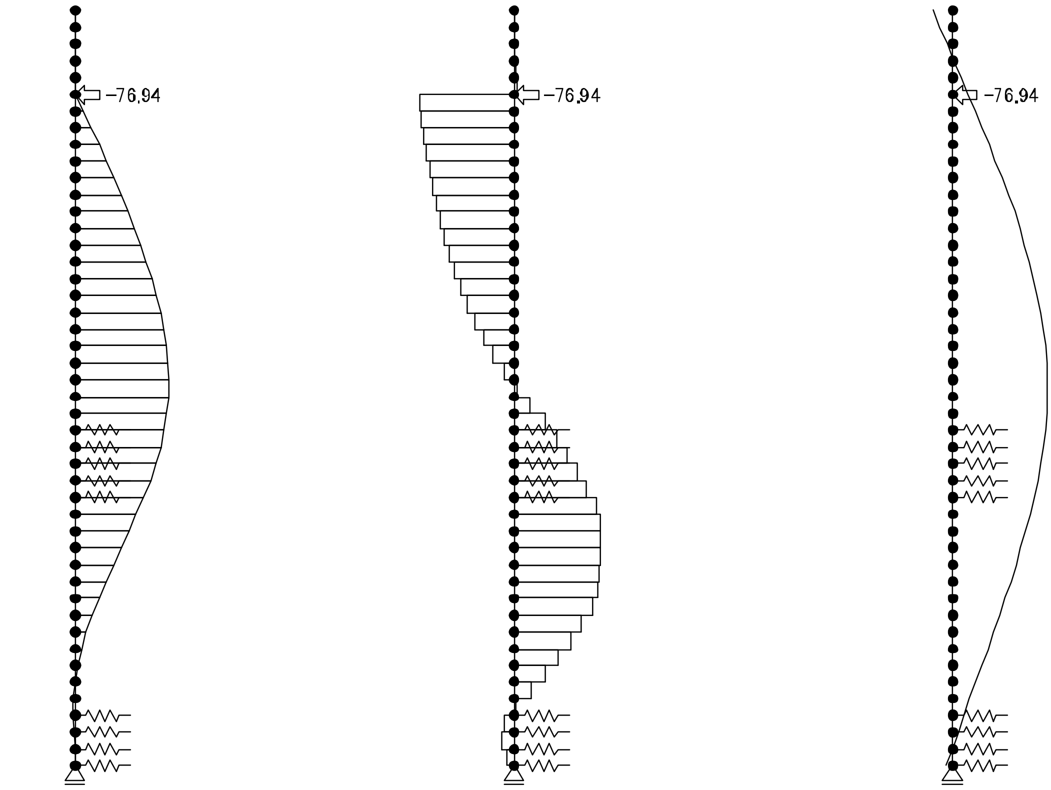
Note: * mark shows reaction of tensile member

(5)Member force diagram

max bending moment Mmax= -164.99kN.m/m(G.L. 42.600m)

max shear force Smax= -73.05kN/m (G.L. 46.000m)

max displacement Del.xmax= 15.73mm (G.L. 42.400m)



Moment graph　　Shear force diagram　　Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/m)

FORUM8

5.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	164.99	0.00	73.05

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	92	270	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	3	125	OK

5.3.4 Tensile member stress

(1) check on tensile member

1)member in use

diameter in use : Phi 32(mm)

material in use : ,'£-í |690

allowable stress : 264(N/mm2)

tensile member layout pitch L : 1.800(m)

number of tensile member in use : 1

tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2)calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
76.94	1.800	138.50

3)stress

$$Sig. = \frac{P * 10^3}{n * A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
172	264	OK

5.3.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 210(N/mm2)

installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P^*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
138.50	1.800	24.93

3)stress

$$Sig. = \frac{M^*10^6}{Z^*10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
108	210	OK

5.4 riverside sheet pile

5.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 43.000(m)

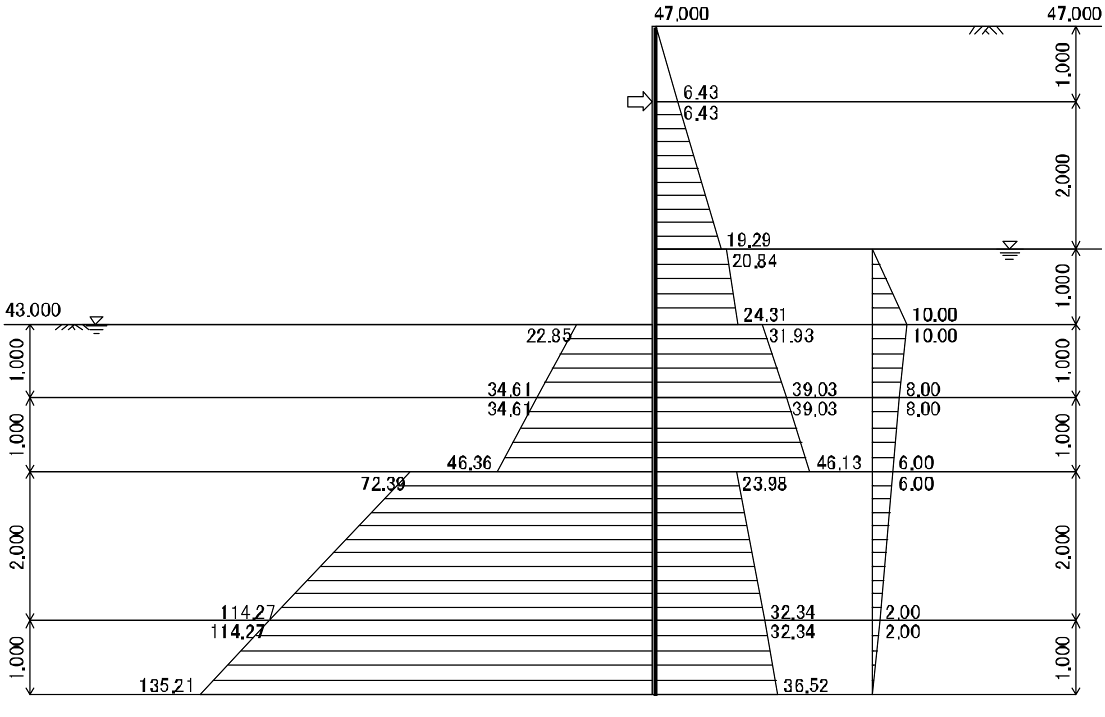
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	39.990	38.000
active sd	Ma+Mw+Mac(kN.m/m)	622.73	1132.97
passive sd	Mp+Mpc(kN.m/m)	747.76	2355.87
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.201>=1.20	2.079>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.43 19.29	25.72	1.167	30.01
2	44.000 43.000	1.000	20.84 24.31	22.58	2.513	56.73
3	43.000 42.000	1.000	31.93 39.03	35.48	3.517	124.77
4	42.000 41.000	1.000	39.03 46.13	42.58	4.514	192.20
5	41.000 39.000	2.000	23.98 32.34	56.32	6.049	340.70
6	39.000 38.000	1.000	32.34 36.52	34.43	7.510	258.56
Sum				217.11		1002.97

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 8.00	9.00	3.481	31.33
3	42.000 41.000	1.000	8.00 6.00	7.00	4.476	31.33
4	41.000 39.000	2.000	6.00 2.00	8.00	5.833	46.67
5	39.000 38.000	1.000	2.00 0.00	1.00	7.333	7.33
Sum				30.00		130.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	22.85 34.61	28.73	3.534	101.54
2	42.000 41.000	1.000	34.61 46.36	40.48	4.524	183.15
3	41.000 39.000	2.000	72.39 114.27	186.66	6.075	1133.90
4	39.000 38.000	1.000	114.27 135.21	124.74	7.514	937.29
Sum				380.61		2355.87

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

5.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m) max shear force Smax(kN/m) upper tension mbr rct R1(kN/m)	81.14 -56.36 50.36	G.L. 43.200 G.L. 41.200 G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss.
Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure'
effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure		exv side pressure		effectiv active (kN/m2)	effective passive (kN/m2)
		active (kN/m2)	water (kN/m2)	passive (kN/m2)	at rest (kN/m2)		
1	47.000 46.000	0.00 6.43	0.00 0.00	---- ----	---- ----	0.00 6.43	---- ----
2	46.000 44.000	6.43 19.29	0.00 0.00	---- ----	---- ----	6.43 19.29	---- ----
3	44.000 43.000	20.84 24.31	0.00 10.00	---- ----	---- ----	20.84 34.31	---- ----
4	43.000 42.000	31.93 39.03	10.00 8.00	22.85 34.61	0.00 7.44	41.93 39.59	22.85 27.17
5	42.000 41.000	39.03 46.13	8.00 6.00	34.61 46.36	7.44 14.87	39.59 37.26	27.17 31.48
6	41.000 39.000	23.98 32.34	6.00 2.00	72.39 114.27	10.39 20.79	19.59 13.55	62.00 93.48
7	39.000 38.000	32.34 36.52	2.00 0.00	114.27 135.21	20.79 25.98	13.55 10.53	93.48 109.23

Note: is non-effective for earth pressure in calculation.
other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta^* \frac{1}{0.3} {}^*Alpha\ Eo^* \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0
BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	1346
2	42.000	41.000	1.000	8400	4037
3	41.000	39.000	2.000	70000	33639
4	39.000	37.000	2.000	64400	30948
5	37.000	35.000	2.000	14000	6728
6	35.000	34.000	1.000	47600	22875
7	34.000	33.000	1.000	53200	25566
8	33.000	32.000	1.000	53200	25566
9	32.000	31.000	1.000	117600	56514
10	31.000	30.000	1.000	137200	65933
11	30.000	29.000	1.000	165200	79389
12	29.000	28.000	1.000	67200	32294
13	28.000	27.000	1.000	106400	51132
14	27.000	26.000	1.000	123200	59205
15	26.000	25.000	1.000	106400	51132

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.^*(2^*number^*A^*E)}{(L^*s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]
L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)

A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	29787
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	20.84	4.05	--------	--------	--------	--------
17	43.800	On excavation plane	23.54	23.54	4.71	--------	--------	--------	--------
18	43.600	On excavation plane	26.23	26.23	5.25	--------	--------	--------	--------
19	43.400	On excavation plane	28.92	28.92	5.78	--------	--------	--------	--------
20	43.200	On excavation plane	31.62	31.62	6.32	--------	--------	--------	--------
21	43.000	Pas ela.	34.31	41.93	7.55	0.00	22.85	--------	135
22	42.800	Pas ela.	41.46	41.46	8.29	23.72	23.72	--------	269

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
23	42.600	Pas ela.	41.00	41.00	8.20	24.58	24.58	--------	269
24	42.400	Pas ela.	40.53	40.53	8.11	25.44	25.44	--------	269
25	42.200	Pas ela.	40.06	40.06	8.01	26.31	26.31	--------	269
26	42.000	Pas ela.	39.59	39.59	7.92	27.17	27.17	--------	538
27	41.800	Pas ela.	39.13	39.13	7.83	28.03	28.03	--------	807
28	41.600	Pas ela.	38.66	38.66	7.73	28.90	28.90	--------	807
29	41.400	Pas ela.	38.19	38.19	7.64	29.76	29.76	--------	807
30	41.200	Pas ela.	37.72	37.72	7.54	30.62	30.62	--------	807
31	41.000	Pa plas.	37.26	19.59	5.68	31.48	62.00	9.41	--------
32	40.800	Pa plas.	18.98	18.98	3.80	65.14	65.14	13.03	--------
33	40.600	Pa plas.	18.38	18.38	3.68	68.29	68.29	13.66	--------
34	40.400	Pa plas.	17.78	17.78	3.56	71.44	71.44	14.29	--------
35	40.200	Pa plas.	17.17	17.17	3.43	74.59	74.59	14.92	--------
36	40.000	Pas ela.	16.57	16.57	3.31	77.74	77.74	--------	6728
37	39.800	Pas ela.	15.97	15.97	3.19	80.89	80.89	--------	6728
38	39.600	Pas ela.	15.36	15.36	3.07	84.04	84.04	--------	6728
39	39.400	Pas ela.	14.76	14.76	2.95	87.19	87.19	--------	6728
40	39.200	Pas ela.	14.16	14.16	2.83	90.33	90.33	--------	6728
41	39.000	Pas ela.	13.55	13.55	2.71	93.48	93.48	--------	6459
42	38.800	Pas ela.	12.95	12.95	2.59	96.63	96.63	--------	6190
43	38.600	Act ela.	12.35	12.35	2.47	99.78	99.78	--------	6190
44	38.400	Act ela.	11.74	11.74	2.35	102.93	102.93	--------	6190
45	38.200	Act ela.	11.14	11.14	2.23	106.08	106.08	--------	6190
46	38.000	Act ela.	10.53	0.00	1.07	109.23	0.00	--------	3095
Sum					180.89			65.30	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= -6.19mm(G.L. 43.000m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	0.74	- - - -	- - - -
2	46.800	on exv	- - - -	0.25	- - - -	- - - -
3	46.600	on exv	- - - -	-0.23	- - - -	- - - -
4	46.400	on exv	- - - -	-0.72	- - - -	- - - -
5	46.200	on exv	- - - -	-1.20	- - - -	- - - -
6	46.000	on exv	29787	-1.69	- - - -	Note: 50.36
7	45.800	on exv	- - - -	-2.18	- - - -	- - - -
8	45.600	on exv	- - - -	-2.66	- - - -	- - - -
9	45.400	on exv	- - - -	-3.13	- - - -	- - - -
10	45.200	on exv	- - - -	-3.58	- - - -	- - - -
11	45.000	on exv	- - - -	-4.01	- - - -	- - - -
12	44.800	on exv	- - - -	-4.41	- - - -	- - - -
13	44.600	on exv	- - - -	-4.78	- - - -	- - - -
14	44.400	on exv	- - - -	-5.12	- - - -	- - - -
15	44.200	on exv	- - - -	-5.42	- - - -	- - - -
16	44.000	on exv	- - - -	-5.67	- - - -	- - - -
17	43.800	on exv	- - - -	-5.87	- - - -	- - - -
18	43.600	on exv	- - - -	-6.03	- - - -	- - - -
19	43.400	on exv	- - - -	-6.13	- - - -	- - - -
20	43.200	on exv	- - - -	-6.19	- - - -	- - - -
21	43.000	pssv el	135	-6.19	17.15	0.83
22	42.800	pssv el	269	-6.14	17.63	1.65
23	42.600	pssv el	269	-6.03	18.27	1.62
24	42.400	pssv el	269	-5.88	18.91	1.58

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	269	-5.68	19.55	1.53
26	42.000	pssv el	538	-5.44	10.10	2.93
27	41.800	pssv el	807	-5.17	6.94	4.17
28	41.600	pssv el	807	-4.86	7.16	3.92
29	41.400	pssv el	807	-4.52	7.37	3.65
30	41.200	pssv el	807	-4.16	7.59	3.36
31	41.000	pssv pl	- - - -	-3.79	2.50	- - - -
32	40.800	pssv pl	- - - -	-3.42	1.94	- - - -
33	40.600	pssv pl	- - - -	-3.04	2.03	- - - -
34	40.400	pssv pl	- - - -	-2.67	2.12	- - - -
35	40.200	pssv pl	- - - -	-2.31	2.22	- - - -
36	40.000	pssv el	6728	-1.97	2.31	13.25
37	39.800	pssv el	6728	-1.64	2.40	11.02
38	39.600	pssv el	6728	-1.32	2.50	8.89
39	39.400	pssv el	6728	-1.02	2.59	6.86
40	39.200	pssv el	6728	-0.73	2.69	4.92
41	39.000	pssv el	6459	-0.45	2.89	2.92
42	38.800	pssv el	6190	-0.18	3.12	1.13
43	38.600	actv el	6190	0.08	3.22	-0.51
44	38.400	actv el	6190	0.34	3.33	-2.12
45	38.200	actv el	6190	0.60	3.43	-3.72
46	38.000	actv el	3095	0.86	3.50	-2.66
Sum						115.59

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

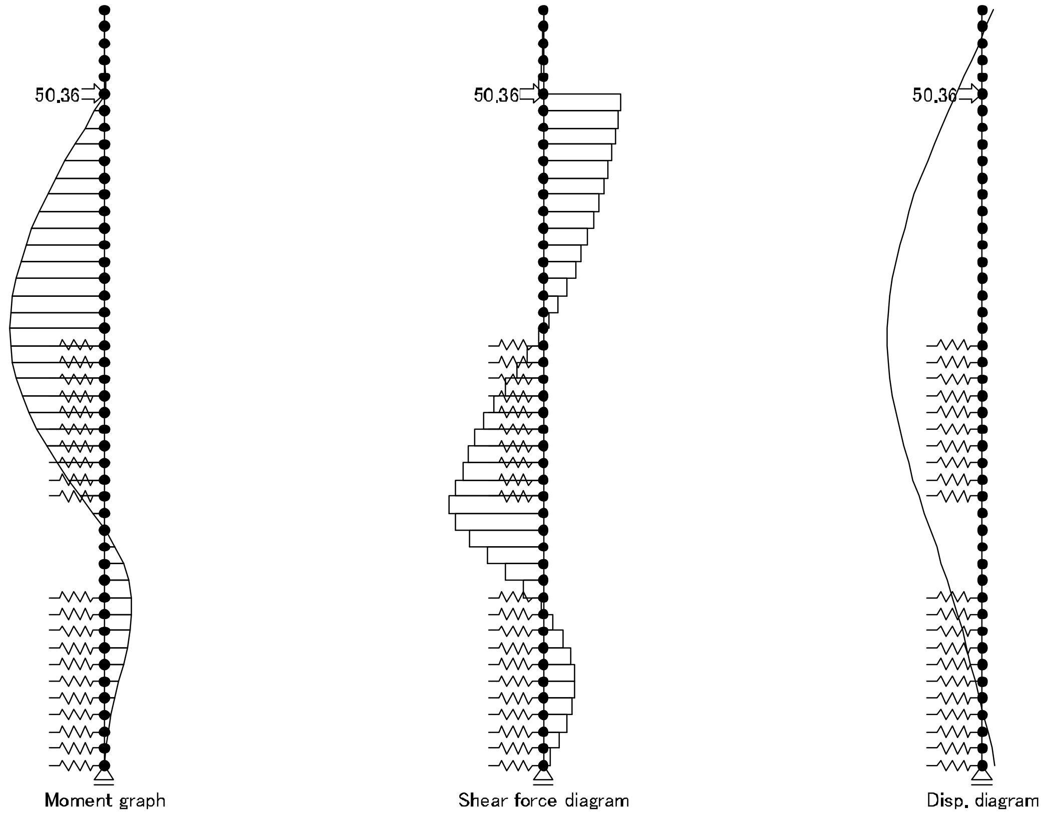
max bending moment Mmax= 81.14kN m/m(G.L. 43.200m)
max shear force Smax= -56.36kN/m (G.L. 41.200m)
max displacement Del.xmax= -6.19mm (G.L. 43.000m)

node No	Y co GL(m)	moment kN m/m top	moment kN m/m bottom	shear force kN/m top	shear force kN/m bottom	disp Del.x mm	reaction Q kN/m
1	47.000	----------	0.00	----------	-0.03	0.74	------------
2	46.800	-0.01	-0.01	-0.03	-0.29	0.25	------------
3	46.600	-0.06	-0.06	-0.29	-0.80	-0.23	------------
4	46.400	-0.23	-0.23	-0.80	-1.58	-0.72	------------
5	46.200	-0.54	-0.54	-1.58	-2.60	-1.20	------------
6	46.000	-1.06	-1.06	-2.60	46.47	-1.69	* 50.36
7	45.800	8.23	8.23	46.47	44.92	-2.18	------------
8	45.600	17.22	17.22	44.92	43.12	-2.66	------------
9	45.400	25.84	25.84	43.12	41.06	-3.13	------------
10	45.200	34.05	34.05	41.06	38.75	-3.58	------------
11	45.000	41.80	41.80	38.75	36.18	-4.01	------------
12	44.800	49.04	49.04	36.18	33.35	-4.41	------------
13	44.600	55.71	55.71	33.35	30.26	-4.78	------------
14	44.400	61.76	61.76	30.26	26.92	-5.12	------------
15	44.200	67.14	67.14	26.92	23.31	-5.42	------------
16	44.000	71.81	71.81	23.31	19.27	-5.67	------------
17	43.800	75.66	75.66	19.27	14.56	-5.87	------------
18	43.600	78.57	78.57	14.56	9.31	-6.03	------------
19	43.400	80.43	80.43	9.31	3.53	-6.13	------------
20	43.200	81.14	81.14	3.53	-2.80	-6.19	------------
21	43.000	80.58	80.58	-2.80	-9.51	-6.19	0.83
22	42.800	78.68	78.68	-9.51	-16.15	-6.14	1.65
23	42.600	75.45	75.45	-16.15	-22.73	-6.03	1.62
24	42.400	70.90	70.90	-22.73	-29.25	-5.88	1.58
25	42.200	65.05	65.05	-29.25	-35.73	-5.68	1.53
26	42.000	57.91	57.91	-35.73	-40.72	-5.44	2.93
27	41.800	49.76	49.76	-40.72	-44.37	-5.17	4.17
28	41.600	40.89	40.89	-44.37	-48.19	-4.86	3.92
29	41.400	31.25	31.25	-48.19	-52.17	-4.52	3.65
30	41.200	20.82	20.82	-52.17	-56.36	-4.16	3.36
31	41.000	9.54	9.54	-56.36	-52.63	-3.79	------------
32	40.800	-0.98	-0.98	-52.63	-43.40	-3.42	------------
33	40.600	-9.66	-9.66	-43.40	-33.42	-3.04	------------
34	40.400	-16.35	-16.35	-33.42	-22.69	-2.67	------------
35	40.200	-20.88	-20.88	-22.69	-11.20	-2.31	------------
36	40.000	-23.12	-23.12	-11.20	-1.27	-1.97	13.25
37	39.800	-23.38	-23.38	-1.27	6.56	-1.64	11.02
38	39.600	-22.07	-22.07	6.56	12.38	-1.32	8.89
39	39.400	-19.59	-19.59	12.38	16.29	-1.02	6.86
40	39.200	-16.33	-16.33	16.29	18.38	-0.73	4.92
41	39.000	-12.66	-12.66	18.38	18.59	-0.45	2.92
42	38.800	-8.94	-8.94	18.59	17.13	-0.18	1.13
43	38.600	-5.51	-5.51	17.13	14.15	0.08	-0.51
44	38.400	-2.68	-2.68	14.15	9.68	0.34	-2.12
45	38.200	-0.75	-0.75	9.68	3.73	0.60	-3.72
46	38.000	0.00	----------	3.73	----------	0.86	-2.66

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= 81.14kN m/m (G.L. 43.200m)
max shear force Smax= -56.36kN/m (G.L. 41.200m)
max displacement Del.xmax= -6.19mm (G.L. 43.000m)



* in figure, number in arrow shows tensile reaction (kN/m)

5.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	81.14	0.00	56.36

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \le Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	45	270	OK

(4) shear stress

$$Tau = \frac{S}{A} \le Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	2	125	OK

5.4.4 Tensile member stress

(1) check on tensile member

1)member in use

diameter in use : Phi 32(mm)
material in use : ,’£–í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2)calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
50.36	1.800	90.64

3)stress

$$Sig. = \frac{P^* 10^3}{n^* A} <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
113	264	OK

5.4.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 210(N/mm2)

installation spacing : 1.800(m)

2)moment calculation

$$M= \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
90.64	1.800	16.32

3)stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <=Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
71	210	OK

6 Calculation on impermeability

(1)check method

impermeability effect (seepage pass) is checked through two passes.

water level condition is ordinary case for stability (and landside sheet pile as well).

1)seepage pass part 1 (along sheet pile)

$$F1= \frac{L1}{h1} >= FS$$

2)seepage pass part 2(pass through excavation bottom in land side: omit if no shape)

$$F2= \frac{L2}{h2} >= FS$$

where,

FS: required factor of safety(Sandy foundation: 3.25)

Fi: factor of safety

L1: seepage pass part 1(along sheet pile)

h1: water level difference part 1(from ordinal H.W.L. to landside ground surface)

L2: seepage pass part 2(pass through landside excavation bottom)

h2: water level difference part 2(from ordinal H.W.L. to landside ground surface)

(2)calculation result summery

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
nomal time	15.000	4.000	3.75>=3.25

(3)seepage pass part 1(along sheet pile)

L1= D1+ Lb+ D2

where,

D1: sheet pile embedment length on riverside(m)

D2: sheet pile embedment length on landside(m)

Lb: distance between sheet piles(m)

$Lb= Sqrt(B^2+ Del.L^2)$

B : embankment width (6.000m)

Del.L: difference of sheet pile between riverside and landside(0.000m)

L1= 5.000+ 6.000+ 4.000

= 15.000(m)

(4)seepage pass part 2(pass through landside excavation bottom)

Because of no excavation shape, omit calculation.

Cover

(3)Saheylia Canal

Contents

D-478

1 Design condition

File name:Sahelyia 1

1.1 Properties

(1)wall scale

final wall width : 6.000(m)
length of landside final sheet pile : 9.000(m)
length of riverside final sheet pile : 9.000(m)

(2)basic data

title : Ibrahimia 1
comment :
wall type : Steel sheet pile
influence of water level : Yes consider
water unit weight Gamw : 10.00(kN/m3)
check earthquake case : Yes
check liquefaction case : No
check riverside sheet pile : Yes
tensile member installation position

No	position G.L.(m)
1	46.000

1.2 shape

(1)plane

wall extension

wall No	inter wl len.(m)	angle (deg)	object wall
1	8.400	----.---	
2	28.900	140.000	
3	8.400	140.000	OK

wall direction: Vertical

(2)side

top of filling soil : G.L. 47.000(m)
top of landside sheet pile : G.L. 47.000(m)
top of riverside sheet pile : G.L. 47.000(m)

(3)tensile member planar layout

tensile member adjusting installation method : Equally layout

wall 1

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

wall 2

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

wall 3

row	standard pitch (m)	start side adjust		end side adjust	
		LS (m)	number	LE (m)	number
1	1.800	3.000	3	3.00	3

1.3 Method

(1)check points

Check 4* C > Sum(Gam h) : No check
Check shielding effect : check sand ground
Check discharge : No
Check circle slope : No
Check, change of bearing capacity : No

(2)design method

shear deformation failure check points

search the position of min FS : Yes
ditto searching pitch : 1.00(m)
calculation of self-weight : Conforming design manual
consider external force above tensile member with the limit equivalent method : No consider
elasto-plastic analysis and calculation condition member force in liquefaction
coefficient of allowance when tensile member spring is calculated Alp. : 1.0
equivalent loading width for calculation BH : 10.0m
deformation coefficient in earthquake : 2.00 of ordinary time (input)
wall tip bearing condition : Free
calculation pitch : 0.20(m)
check elastic zone in elasto-plastic calculation : No
required elastic zone rate as above : 50.0%

design of residual water level

residual water level setting(riverside water level - landside water level)* ratio: 0.500

1.4 Strata data

(1)soil character of filling soil

filled soil	soil unit weight			inter fric angle (deg)	cohesion	
	wet kN/m3	submrg kN/m3	satur. kN/m3		Co kN/m2	increment k kN/m3
Sandy soil	18.0	9.0	19.0	30.0	0.0	0.0

(2)River side section(current ground level G.L. 43.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m2
				Wet kN/m3	Submerged kN/m3	Saturation kN/m3		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	2.0	18.0	9.0	19.0	10.0	10.0	0.0	5600
3	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
4	2.000	Sandy	16.0	18.0	9.0	19.0	25.0	10.0	0.0	44800
5	1.000	Sandy	18.0	18.0	9.0	19.0	25.0	10.0	0.0	50400
6	1.000	Sandy	27.0	18.0	9.0	19.0	30.0	10.0	0.0	75600
7	1.000	Sandy	17.0	18.0	9.0	19.0	25.0	10.0	0.0	47600
8	1.000	Sandy	21.0	18.0	9.0	19.0	25.0	10.0	0.0	58800
9	1.000	Sandy	47.0	18.0	9.0	19.0	30.0	10.0	0.0	131600
10	1.000	Sandy	31.0	18.0	9.0	19.0	30.0	10.0	0.0	86800
11	1.000	Sandy	29.0	18.0	9.0	19.0	30.0	10.0	0.0	81200
12	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
13	1.000	Sandy	41.0	18.0	9.0	19.0	30.0	10.0	0.0	114800
14	1.000	Sandy	30.0	18.0	9.0	19.0	30.0	10.0	0.0	84000
15	1.000	Sandy	40.0	18.0	9.0	19.0	30.0	10.0	0.0	112000

(3)Embankment body section(current ground level G.L. 43.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight			Inner Friction angle(Deg)	Cohesion		Defor.coeff. coeff. Alp.Eo kN/m2
				Wet kN/m3	Submerged kN/m3	Saturation kN/m3		Co kN/m2	Increment k kN/m3	
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	2.0	18.0	9.0	19.0	10.0	10.0	0.0	5600
3	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
4	2.000	Sandy	16.0	18.0	9.0	19.0	25.0	10.0	0.0	44800
5	1.000	Sandy	18.0	18.0	9.0	19.0	25.0	10.0	0.0	50400
6	1.000	Sandy	27.0	18.0	9.0	19.0	30.0	10.0	0.0	75600
7	1.000	Sandy	17.0	18.0	9.0	19.0	25.0	10.0	0.0	47600

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
8	1.000	Sandy	21.0	18.0	9.0	19.0	25.0	10.0	0.0	58800
9	1.000	Sandy	47.0	18.0	9.0	19.0	30.0	10.0	0.0	131600
10	1.000	Sandy	31.0	18.0	9.0	19.0	30.0	10.0	0.0	86800
11	1.000	Sandy	29.0	18.0	9.0	19.0	30.0	10.0	0.0	81200
12	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
13	1.000	Sandy	41.0	18.0	9.0	19.0	30.0	10.0	0.0	114800
14	1.000	Sandy	30.0	18.0	9.0	19.0	30.0	10.0	0.0	84000
15	1.000	Sandy	40.0	18.0	9.0	19.0	30.0	10.0	0.0	112000

(4)Land side section(current ground level G.L. 43.000m)

No	Thick. m	Soil Type	Average N value	Soil unit weight Wet kN/m3	Submerged kN/m3	Saturation kN/m³	Inner Friction angle(Deg)	Cohesion Co kN/m2	Increment k kN/m3	Defor.coeff. coeff. Alp.Eo kN/m²
1	1.000	Sandy	1.0	18.0	9.0	19.0	10.0	10.0	0.0	2800
2	1.000	Sandy	2.0	18.0	9.0	19.0	10.0	10.0	0.0	5600
3	1.000	Sandy	3.0	18.0	9.0	19.0	10.0	10.0	0.0	8400
4	2.000	Sandy	16.0	18.0	9.0	19.0	25.0	10.0	0.0	44800
5	1.000	Sandy	18.0	18.0	9.0	19.0	25.0	10.0	0.0	50400
6	1.000	Sandy	27.0	18.0	9.0	19.0	30.0	10.0	0.0	75600
7	1.000	Sandy	17.0	18.0	9.0	19.0	25.0	10.0	0.0	47600
8	1.000	Sandy	21.0	18.0	9.0	19.0	25.0	10.0	0.0	58800
9	1.000	Sandy	47.0	18.0	9.0	19.0	30.0	10.0	0.0	131600
10	1.000	Sandy	31.0	18.0	9.0	19.0	30.0	10.0	0.0	86800
11	1.000	Sandy	29.0	18.0	9.0	19.0	30.0	10.0	0.0	81200
12	1.000	Sandy	42.0	18.0	9.0	19.0	30.0	10.0	0.0	117600
13	1.000	Sandy	41.0	18.0	9.0	19.0	30.0	10.0	0.0	114800
14	1.000	Sandy	30.0	18.0	9.0	19.0	30.0	10.0	0.0	84000
15	1.000	Sandy	40.0	18.0	9.0	19.0	30.0	10.0	0.0	112000

1.5 members

(1)wall data

effective rate of sheet pile

moment of inertia (stress deformation calculation) : 0.45

modulus of section : 0.60

landside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

riverside

steel sheet pile in use : PU28+1

material in use : SY295

non-effective thickness of sheet pile front : 0.000(m)

ground evaluation when embedment is checked : Sandy ground

(2)tensile member, wailing data

tensile member

No	position G.L.(m)	tns mbr spring tns	tns mbr H-pitch m	tns mbr dia mm	tns mbr mat	tns mbr number	tns mbr direct iput	tns spring sprg cost. kN/m/m	wailing material
1	46.000	Use	1.800	32.0	7	1	No	----------	SS400

waling member

wailing member : Channel steel

wailing check equation : TL/10

1.5 Study case data

(1)check case [deal Normal time]

check case name : ｲ7ｽ

internal setting

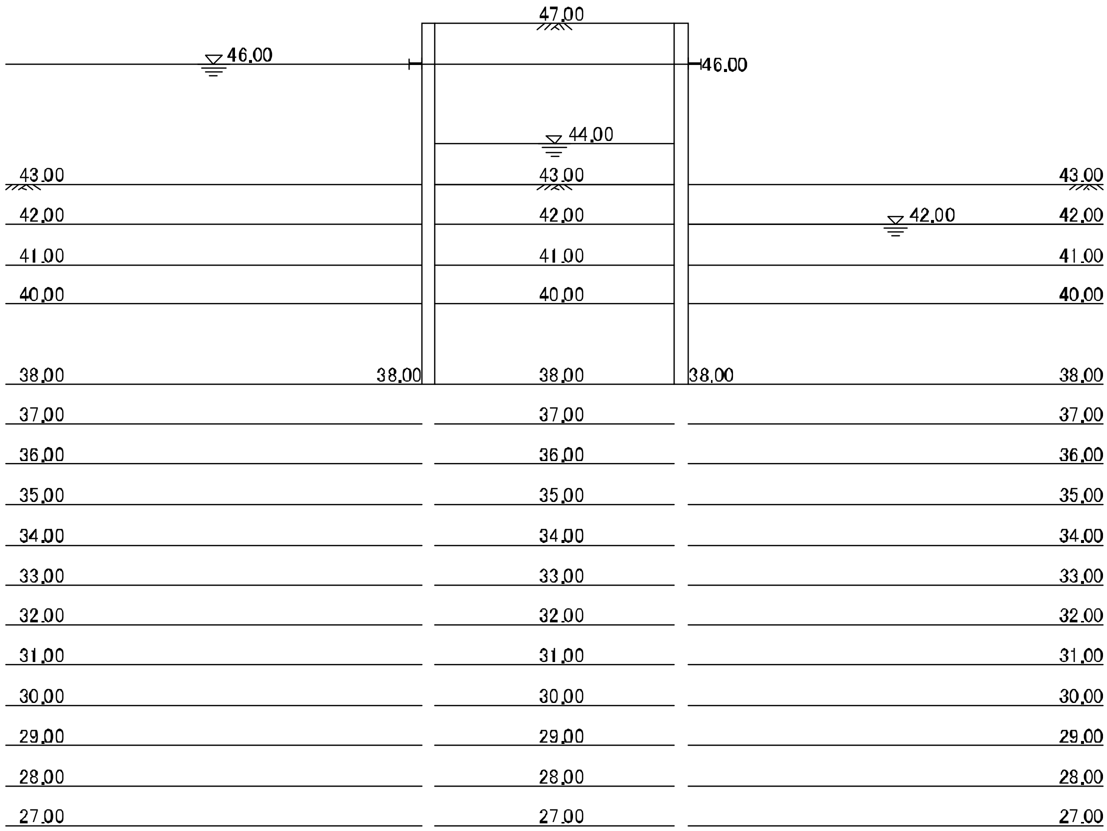
e-prss	soil spring	allowable
Normal time	Normal time	Normal time

water level condition
* stability calculation and check of landside sheet pile
  riverside water level : G.L. 46.000(m)
  landside water level : G.L. 42.000(m)
* check of riverside sheet pile
  wall residual water level : G.L. 44.000(m)
  riverside water level : G.L. 43.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	10.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



(2)check case [deal Earthquake time]
check case name : ′n kŽž
internal setting

e-prss	soil spring	allowable
Earthquake time	Earthquake time	Earthquake time

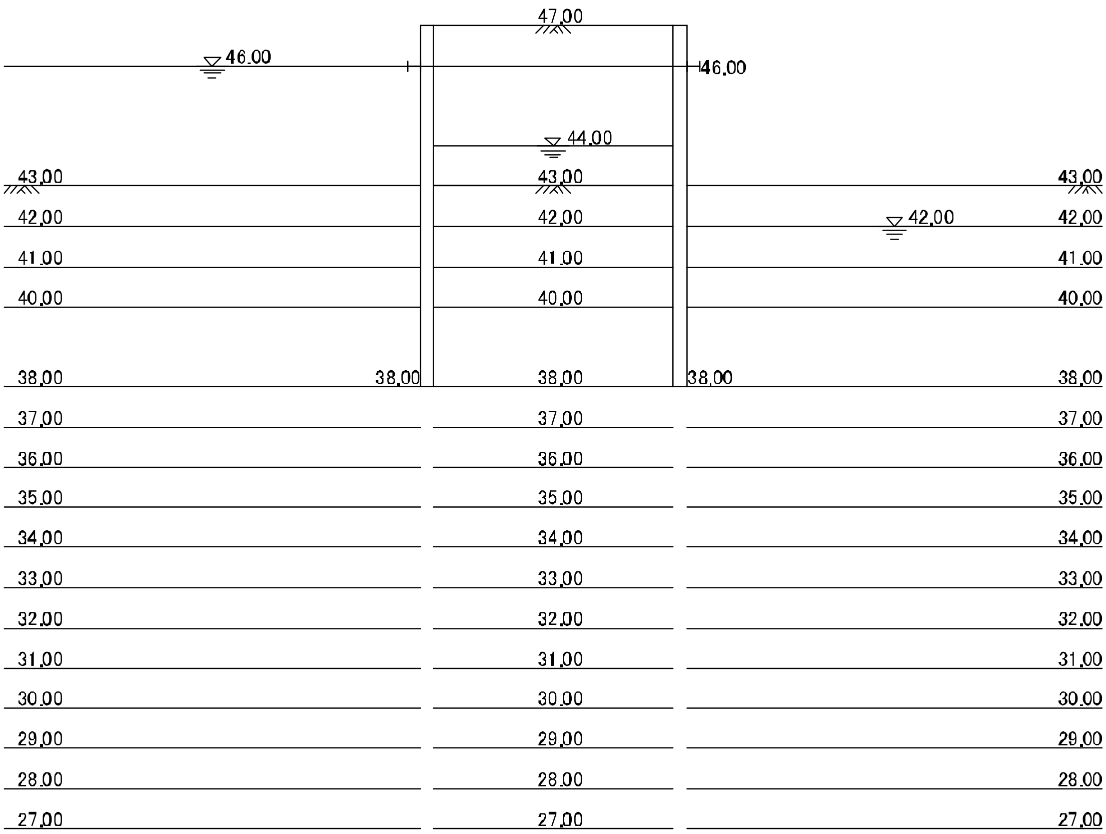
design seismicity
* design seismicity : 0.04
* seismic assumption : River standard method
resistant moment above shear deformation check level : Normal time
water level condition

* stability calculation and check of landside sheet pile
  riverside water level : G.L. 46.000(m)
  landside water level : G.L. 42.000(m)
* check of riverside sheet pile
  wall residual water level : G.L. 44.000(m)
  riverside water level : G.L. 43.000(m)

surcharge load

section	riverside	wall	landside
load (kN/m2)	0.00	0.00	0.00

other load
stability calculation
no other load
landside sheet pile
* vertical force(stress calculation) : 0.00(kN/m)
riverside sheet pile
* vertical force (stress calculation) : 0.00(kN/m)



1.7 circular failure

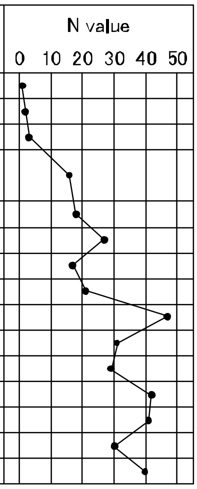
Not calculate circular failure

1.8 discharge data

not check discharge

1. 9 Drillhole log

Depth(m)	土質記号	N value
1.00	● ● ● ●	
2.00	● ● ● ●	
3.00	● ● ● ●	
5.00	● ● ● ●	
6.00	● ● ● ●	
7.00	● ● ● ●	
8.00	● ● ● ●	
9.00	● ● ● ●	
10.00	● ● ● ●	
11.00	● ● ● ●	
12.00	● ● ● ●	
13.00	● ● ● ●	
14.00	● ● ● ●	
15.00	● ● ● ●	
16.00	● ● ● ●	



FORUM8

1.10 Steel data

steel sheet pile

No	steel name	w (mm)	h (mm)	W (kg/m2)	A (cm2/m)	I (cm4/m)	Z (cm3/m)
1	IIŒ^	400	100	48.0	153.00	8740	874
2	IIICF^	400	125	60.0	191.00	16800	1340
3	IIIŒ^	400	130	60.0	191.00	17400	1340
4	IVŒ^	400	170	76.1	242.50	38600	2270
5	VLCF^	500	200	105.0	267.60	63000	3150
6	PU28+1	600	228	106.2	226.00	68380	3000

wailing(steel trench)

No	steel name	h (mm)	B (mm)	t_1 (mm)	t_2 (mm)	A (cm2)	w (kg/m)	Zx (cm3)
1	m150 ~75 ~6.5 ~10	150	75	6.5	10.0	23.71	18.6	115
2	m150 ~75 ~9 ~12.5	150	75	9.0	12.5	30.59	24.0	140
3	m180 ~75 ~7 ~10.5	180	75	7.0	10.5	27.20	21.4	153
4	m200 ~80 ~7.5 ~11	200	80	7.5	11.0	31.33	24.6	195
5	m200 ~90 ~8 ~13.5	200	90	8.0	13.5	38.65	30.3	249
6	m250 ~90 ~9 ~13	250	90	9.0	13.0	44.07	34.6	334
7	m250 ~90 ~11 ~14.5	250	90	11.0	14.5	51.17	40.2	374
8	m300 ~90 ~9 ~13	300	90	9.0	13.0	48.57	38.1	429
9	m300 ~90 ~10 ~15.5	300	90	10.0	15.5	55.74	43.8	494
10	m300 ~90 ~12 ~16	300	90	12.0	16.0	61.90	48.6	525
11	m380 ~100 ~10.5 ~16	380	100	10.5	16.0	69.39	54.5	763
12	m380 ~100 ~13 ~16.5	380	100	13.0	16.5	78.96	62.0	823
13	m380 ~100 ~13 ~20	380	100	13.0	20.0	85.71	67.3	926
14	[125 ~65 ~6 ~8	125	65	6.0	8.0	17.11	13.4	67

Note: Two sheets makes one set for stress check, doubly count in calculation process.

1. 11 material data

steel sheet pile material

Young's modulus : 2.00* 10^5 N/mm2

unit weight : 77.0 kN/m³

allowable stress (unit: N/mm2)	SY295		SY390	
	normal	earthq.	normal	earthq.
allw bending str	180	270	235	353
allw shear str	83	125	110	165

Material of steel pipe pile

Young's modulus : 2.00* 10^5 N/mm2

Unit weight : 77.0 kN/m³

allowable stress (unit: N/mm2)	SKY400		SY490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	278
allw shear str	80	120	106	160

material of wailing member

Young's modulus : 2.00* 10^5 N/mm2

allowable stress (unit: N/mm2)	SS400		SM490	
	normal	earthq.	normal	earthq.
allw bending str	140	210	185	280

material of tensile member

Young's modulus : 2.00* 10^5 N/mm2

<table>
<tr><th rowspan="2">No</th><th rowspan="2">type</th><th colspan="2">allw M stress (unit: N/mm2)</th></tr>
<tr><th>normal</th><th>earthq.</th></tr>
<tr><td>1</td><td>SS400 i ƒ40mm j</td><td>94</td><td>141</td></tr>
<tr><td>2</td><td>SS400 i „40mm j</td><td>86</td><td>129</td></tr>
<tr><td>3</td><td>SS490 i ƒ40mm j</td><td>110</td><td>165</td></tr>
<tr><td>4</td><td>SS490 i „40mm j</td><td>102</td><td>153</td></tr>
<tr><td>5</td><td>‚'£–Í |490</td><td>125</td><td>195</td></tr>
<tr><td>6</td><td>‚'£–Í |590</td><td>155</td><td>235</td></tr>
<tr><td>7</td><td>‚'£–Í |690</td><td>176</td><td>264</td></tr>
</table>

1.12 standard value

(1)factor of safety

check items	requrie FS	
	normal	earthq.
check shear deform failure check slide check bear cap of found grnd check circular slope	1.20 1.20 1.20 1.20	1.00 1.00 1.00 1.00
chk embedment (sand grnd) chk embedment (clay grnd)	1.50 1.20	1.20 1.20
chk shielding (sand grnd) chk shielding (clay grnd)	3.25 3.00	------ ------

(2)design method for liquefaction

1)seismicity for evaluating liquefaction

region	strong	middle	weak
earthq.	0.18	0.15	0.12

2)soil layer classification according to FL

FL range	class
<= 1.00 1.00<= and <=1.30 >= 1.30	liquefied semi-liquefied non-liquefied

3)classification

internally fixed

classifi-cation	increment vibration	active passive
liquefied semi-liq non-liq	consider not not	not not ordinary

4)minimum embedment length to non-liquefied layer at tip: 1.000(m)

5)evaluation method of embedment length : suppose both front and back side of wall satisfied

2 Abbreviation Table

No	Abbreviation	Standard nomenclature
1	actv	active
2	agl	angle
3	bear cap. fac	bearing capacity factor
4	bf	before
5	bt	between
6	cntrt	concentrated
7	co. coord.	coordinate
8	coeff	coefficient
9	coh	cohesion, cohesive
10	comb	combination
11	coord	coordinate
12	crs area	cross section area
13	cs	case
14	dfr	deformation
15	dia	diameter
16	earthq.	earthquake
17	ecc	eccentricity
18	effsrchg	effective surcharge
19	el	elastic
20	embd L	embedment length
21	e-prss	earth pressure
22	exv	excavation
23	frc	force
24	freq compo	frequency component
25	fric	friction
26	Fs	safety factor
27	H-	horizontal
28	inc	increment
29	inrt	inertia force
30	inter	internal, inner
31	ld	load
32	LEM	limit equilibrium method
33	liq	liquefaction
34	lv	level
35	ly	layer
36	lyr thck	layer thickness
37	mat	material
38	max	maximum
39	mbr	member
40	min	minimum
41	mt	moment
42	mthd	method
43	nd	node

No	Abbreviation	Standard nomenclature
44	non-liq	non-liquefaction
45	num	number
46	pl	plastic
47	prss	pressure
48	pssv	passive
49	rct	reaction (force)
50	rdc fcr	reduction factor
51	relstiff	relative stiffness
52	rfrm	reinforcement force, deterrent force
53	rsd	residual
54	rslt frc	resultant force
55	rsst	resistance
56	satur	saturation
57	sd	side
58	semi-liq	semi-liquefaction
59	stbl	stability
60	stffns	stiffness, deformation modulus(coeff.)
61	stnd	standard
62	str	stress
63	submrg	submerge, under water
64	Sum	summation
65	tns	tension, tensile
66	w/	with consideration
67	wl	wall
68	wt	weight
69	WT	water, water line, water level
70	wtr prss	water pressure

3 Result table

3.1 table of stability calculation result

Results of wall width B= 6.000(m), L of sheet pile landside LR= 9.000(m), riverside LL= 9.000(m)

(1) check result on shear deformation failure

*) check case: íŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m m/m)	rsst moment Mr(kN.m m/m)	Factor of safety F
Embedment tip	38.000	5.000	0.00	1517.92	999.99 >= 1.20
Layer boundary surface	40.000	3.000	138.05	1313.86	9.52 >= 1.20
Layer boundary surface	41.000	2.000	126.31	1397.22	11.06 >= 1.20
Layer boundary surface	42.000	1.000	90.49	1259.47	13.92 >= 1.20
Min safety factor	40.000	3.000	138.05	1313.86	9.52 >= 1.20
Current ground level	43.000	0.000	45.00	1011.39	22.48 >= 1.20

*) check case: 'n kŽž

check pt	check lv G.L.(m)	check depth d	dfr moment Md(kN.m m/m)	rsst moment Mr(kN.m m/m)	Factor of safety F
Embedment tip	38.000	5.000	121.82	1517.92	12.46 >= 1.00
Layer boundary surface	40.000	3.000	257.18	1190.35	4.63 >= 1.00
Layer boundary surface	41.000	2.000	213.05	1721.22	8.08 >= 1.00
Layer boundary surface	42.000	1.000	149.40	1583.47	10.60 >= 1.00
Min safety factor	39.000	4.000	241.76	1071.93	4.43 >= 1.00
Current ground level	43.000	0.000	82.08	1335.39	16.27 >= 1.00

(2) check result for slide

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	H-frc sum Fd(kN/m)	rsst sum Fr(kN/m)	Factor of safety F
íŽž	38.000	5.000	218.64	807.69	3.69 >= 1.20
'n kŽž	38.000	5.000	242.78	784.55	3.23 >= 1.00

(3) check result on bearing capacity of foundational ground

Check only at tip of embedment.

check case	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam 2.Df.Be (kN/m)	Factor of safety F
´ǮŽ	38.000	5.000	4973.29	378.00	13.16>=1.20
'n kŽž	38.000	5.000	4595.77	394.92	11.64>=1.00

* check result on embedment

(1) check result based on the limit equilibrium method

*) landside sheet pile

total length= 9.000m(G.L. 38.000m)

check case	required length (m)	final length (m)	active moment (kN.m m/m)	passive moment (kN.m m/m)	Factor of safety F
íŽž	7.750	9.000	1258.42	2767.20	2.20 >= 1.50
'n kŽž	7.620	9.000	1413.07	2622.97	1.86 >= 1.20

*) riverside sheet pile

total length= 9.000 m(G.L. 38.000m)

check case	required length (m)	final length (m)	active moment (kN.m m/m)	passive moment (kN.m m/m)	Factor of safety F
íŽž	7.380	9.000	1108.42	2842.17	2.56 >= 1.50
'n kŽž	7.840	9.000	1263.07	2186.68	1.73 >= 1.20

(2) check result on water shielding effect

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
íŽž	16.000	3.000	5.33>=3.25

(3) check about 4c > Sum(Gam h)

Not check about 4c > Sum(Gam h)

FORUM8

3.2 table of member force check result

(1)bending, shear, displacement results

*)landside sheet pile

Total length = 9.000m(G.L. 38.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
ŽžŽ	-119.64	42.600	-57.47	46.000	11.87	42.400
’n kŽž	-108.97	42.800	-55.90	46.000	10.03	42.600

*)riverside sheet pile

Total length = 9.000m(G.L. 38.000m)

check case	moment		shear force		displacement	
	moment (kN.m)	position (GL.m)	shear frc (kN)	position (GL.m)	disp (mm)	position (GL.m)
ŽžŽ	95.20	43.000	49.81	46.000	-9.33	42.600
’n kŽž	104.84	43.000	54.55	46.000	-9.74	42.600

(2)result of tensile member reaction

*)landside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
´ï%	-61.10	--------
’n kŽž	-59.79	--------

*)riverside sheet pile

check case for reaction	upper (kN/m)	lower (kN/m)
ŽžŽ	53.44	--------
’n kï%	58.44	--------

(3)table of check result on length of elastic state

Not check for elastic state

3.3 table of member force calculation result (wall, tensile member, wailing)

(1) wall

section type: Steel sheet pile

unit(N/mm²)

	Landside sheet pile		River side sheet pile	
Steel name Steel name	PU28+1 SY295		PU28+1 SY295	
Examined case	Bending stress	Shear stress	Bending stress	Shear stress
ĺŽž 'n kŽž	66.5<= 180.0 60.5<= 270.0	2.5<= 83.0 2.5<= 125.0	52.9<= 180.0 58.2<= 270.0	2.2<= 83.0 2.4<= 125.0

(2) tensile member

1) upper tensile member

diameter : Phi 32(mm)

material : ,'ƒ. ĭ |690

installing pitch : 1.800(m)

number in use : 1

unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ĺŽž 'n kŽž	136.8<= 176.0 133.8<= 264.0	119.6<= 176.0 130.8<= 264.0

(3) wailing member

1) upper wiling member

steel material : m150 ~75 ~6.5 ~10

material in use : SS400

unit(N/mm²)

Examined case	Landside sheet pile tension force :Bending stress	River side sheet pile extension force :Bending stress
ĺŽž 'n kŽž	86.1<= 140.0 84.2<= 210.0	75.3<= 140.0 82.3<= 210.0

4 Check case (nomal time)

4.1 calculation of external forces

4.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1) water pressure table (riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 44.000	2.000	0.00 20.00
2	44.000 43.000	1.000	20.00 30.00
3	43.000 42.000	1.000	30.00 40.00
4	42.000 41.000	1.000	40.00 35.00
5	41.000 40.000	1.000	35.00 30.00
6	40.000 38.000	2.000	30.00 20.00

(2)active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h) + q)- 2c*Sqrt(Ka)

$$Ka = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta)* [1+ Sqrt\{\sin(Phi)* \sin(Phi- Theta)/ \cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN m2)	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ka	active e-prss pa (kN m2)	e-prss in use pa (kN m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	0.704	-9.74 -3.40	0.00 0.00
2	42.000 41.463	0.537	9.0	10.00	10.0 10.0	19.00 23.84	0.704	-3.40 0.00	0.00 0.00
3	41.463 41.000	0.463	9.0	10.00	10.0 10.0	23.84 28.00	0.704	0.00 2.93	0.00 2.93
4	41.000 40.000	1.000	9.0	10.00	10.0 10.0	28.00 37.00	0.704	2.93 9.27	2.93 9.27
5	40.000 38.000	2.000	9.0	25.00	10.0 10.0	37.00 55.00	0.406	2.28 9.58	2.28 9.58
6	38.000 37.000	1.000	9.0	25.00	10.0 10.0	55.00 64.00	0.406	9.58 13.23	9.58 13.23
7	37.000 36.000	1.000	9.0	30.00	10.0 10.0	64.00 73.00	0.333	9.79 12.79	9.79 12.79
8	36.000 35.000	1.000	9.0	25.00	10.0 10.0	73.00 82.00	0.406	16.89 20.54	16.89 20.54
9	35.000 34.000	1.000	9.0	25.00	10.0 10.0	82.00 91.00	0.406	20.54 24.19	20.54 24.19
10	34.000 33.000	1.000	9.0	30.00	10.0 10.0	91.00 100.00	0.333	18.79 21.79	18.79 21.79
11	33.000 32.000	1.000	9.0	30.00	10.0 10.0	100.00 109.00	0.333	21.79 24.79	21.79 24.79
12	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	0.333	24.79 27.79	24.79 27.79
13	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	0.333	27.79 30.79	27.79 30.79
14	30.000 29.000	1.000	9.0	30.00	10.0 10.0	127.00 136.00	0.333	30.79 33.79	30.79 33.79
15	29.000 28.000	1.000	9.0	30.00	10.0 10.0	136.00 145.00	0.333	33.79 36.79	33.79 36.79
16	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	0.333	36.79 39.79	36.79 39.79

(3) passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q) + 2c*Sqrt(Kp)

$$Kp = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 - Sqrt\{\sin(Phi) * \sin(Phi - Theta) / \cos(Theta)\}]^2}$$

where, assume Theta= 0

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	18.0	10.00	10.0 10.0	0.00 18.00	1.420	23.84 49.40
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	1.420	49.40 62.18
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	27.00 36.00	1.420	62.18 74.97
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	2.464	120.09 164.45
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	54.00 63.00	2.464	164.45 186.62
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	63.00 72.00	3.000	223.64 250.64
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	2.464	208.80 230.97
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	81.00 90.00	2.464	230.97 253.15
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	3.000	304.64 331.64
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	3.000	331.64 358.64
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	3.000	358.64 385.64
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	3.000	385.64 412.64
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	3.000	412.64 439.64
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	3.000	439.64 466.64
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	3.000	466.64 493.64

(4)active earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.704	40.25 46.59	40.25 46.59
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.406	23.79 31.09	23.79 31.09
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.406	31.09 34.74	31.09 34.74
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.333	27.45 30.45	27.45 30.45
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.406	38.40 42.05	38.40 42.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.406	42.05 45.70	42.05 45.70
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.333	36.45 39.45	36.45 39.45
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.333	39.45 42.45	39.45 42.45
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.333	48.45 51.45	48.45 51.45
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.333	51.45 54.45	51.45 54.45
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	3.000	0.00 54.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	3.000	54.00 162.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	3.000	162.00 189.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	1.420	113.31 126.09
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	1.420	126.09 138.88
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	1.420	138.88 151.66
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	2.464	253.15 297.50
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	2.464	297.50 319.67
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	3.000	385.64 412.64
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	2.464	341.85 364.02
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	2.464	364.02 386.20
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	3.000	466.64 493.64
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	3.000	493.64 520.64
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	3.000	520.64 547.64
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	3.000	547.64 574.64
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	3.000	574.64 601.64
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	3.000	601.64 628.64
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	3.000	628.64 655.64

(6)passive earth pressure intensity table (out of embankment: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	1.420	38.04 50.82
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	19.00 28.00	1.420	50.82 63.60
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	28.00 37.00	1.420	63.60 76.39
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	37.00 55.00	2.464	122.56 166.91
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	55.00 64.00	2.464	166.91 189.08
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	64.00 73.00	3.000	226.64 253.64
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	73.00 82.00	2.464	211.26 233.43
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	82.00 91.00	2.464	233.43 255.61
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	91.00 100.00	3.000	307.64 334.64
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	100.00 109.00	3.000	334.64 361.64
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	3.000	361.64 388.64
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	3.000	388.64 415.64
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	127.00 136.00	3.000	415.64 442.64
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	136.00 145.00	3.000	442.64 469.64
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	3.000	469.64 496.64

4.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 20.00
3	42.000 41.000	1.000	20.00 15.00
4	41.000 40.000	1.000	15.00 10.00
5	40.000 38.000	2.000	10.00 0.00

(2) active earth pressure intensity table (embankment section: working external force)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.704	40.25 46.59	40.25 46.59
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.406	23.79 31.09	23.79 31.09
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.406	31.09 34.74	31.09 34.74
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.333	27.45 30.45	27.45 30.45
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.406	38.40 42.05	38.40 42.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.406	42.05 45.70	42.05 45.70
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.333	36.45 39.45	36.45 39.45
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.333	39.45 42.45	39.45 42.45
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.333	48.45 51.45	48.45 51.45
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.333	51.45 54.45	51.45 54.45
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45

(3)passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	18.0	10.00	10.0 10.0	0.00 18.00	1.420	23.84 49.40
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	1.420	49.40 62.18
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	27.00 36.00	1.420	62.18 74.97
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	2.464	120.09 164.45
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	54.00 63.00	2.464	164.45 186.62
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	63.00 72.00	3.000	223.64 250.64
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	2.464	208.80 230.97
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	81.00 90.00	2.464	230.97 253.15
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	3.000	304.64 331.64
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	3.000	331.64 358.64
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	3.000	358.64 385.64
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	3.000	385.64 412.64
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	3.000	412.64 439.64
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	3.000	439.64 466.64
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	3.000	466.64 493.64

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

po= Ko(Sum(Gam h)+ q)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ko	active e-prss po (kN m2)
1	43.000 42.000	1.000	18.0	0.00 18.00	0.826	0.00 14.87
2	42.000 41.000	1.000	9.0	18.00 27.00	0.826	14.87 22.31
3	41.000 40.000	1.000	9.0	27.00 36.00	0.826	22.31 29.75
4	40.000 38.000	2.000	9.0	36.00 54.00	0.577	20.79 31.18
5	38.000 37.000	1.000	9.0	54.00 63.00	0.577	31.18 36.38
6	37.000 36.000	1.000	9.0	63.00 72.00	0.500	31.50 36.00
7	36.000 35.000	1.000	9.0	72.00 81.00	0.577	41.57 46.77
8	35.000 34.000	1.000	9.0	81.00 90.00	0.577	46.77 51.96
9	34.000 33.000	1.000	9.0	90.00 99.00	0.500	45.00 49.50
10	33.000 32.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
11	32.000 31.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
12	31.000 30.000	1.000	9.0	117.00 126.00	0.500	58.50 63.00
13	30.000 29.000	1.000	9.0	126.00 135.00	0.500	63.00 67.50
14	29.000 28.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00
15	28.000 27.000	1.000	9.0	144.00 153.00	0.500	72.00 76.50

Note: is a layer without earth pressure in calculation.

4.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)
L.W.L. 43.000(m)
soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 8.00
3	42.000 41.000	1.000	8.00 6.00
4	41.000 40.000	1.000	6.00 4.00
5	40.000 38.000	2.000	4.00 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.704	40.25 46.59	40.25 46.59
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.406	23.79 31.09	23.79 31.09
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.406	31.09 34.74	31.09 34.74
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.333	27.45 30.45	27.45 30.45
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.406	38.40 42.05	38.40 42.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.406	42.05 45.70	42.05 45.70
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.333	36.45 39.45	36.45 39.45
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.333	39.45 42.45	39.45 42.45
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.333	48.45 51.45	48.45 51.45
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.333	51.45 54.45	51.45 54.45
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45

(3)passive earth pressure intensity table(out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	10.00 19.00	1.420	38.04 50.82
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	19.00 28.00	1.420	50.82 63.60
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	28.00 37.00	1.420	63.60 76.39
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	37.00 55.00	2.464	122.56 166.91
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	55.00 64.00	2.464	166.91 189.08
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	64.00 73.00	3.000	226.64 253.64
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	73.00 82.00	2.464	211.26 233.43
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	82.00 91.00	2.464	233.43 255.61
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	91.00 100.00	3.000	307.64 334.64
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	100.00 109.00	3.000	334.64 361.64
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	109.00 118.00	3.000	361.64 388.64
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	118.00 127.00	3.000	388.64 415.64
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	127.00 136.00	3.000	415.64 442.64
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	136.00 145.00	3.000	442.64 469.64
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	145.00 154.00	3.000	469.64 496.64

Note:is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (out of embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	43.000 42.000	1.000	9.0	10.00 19.00	0.826	8.26 15.70
2	42.000 41.000	1.000	9.0	19.00 28.00	0.826	15.70 23.14
3	41.000 40.000	1.000	9.0	28.00 37.00	0.826	23.14 30.58
4	40.000 38.000	2.000	9.0	37.00 55.00	0.577	21.36 31.76
5	38.000 37.000	1.000	9.0	55.00 64.00	0.577	31.76 36.95
6	37.000 36.000	1.000	9.0	64.00 73.00	0.500	32.00 36.50
7	36.000 35.000	1.000	9.0	73.00 82.00	0.577	42.15 47.35
8	35.000 34.000	1.000	9.0	82.00 91.00	0.577	47.35 52.54
9	34.000 33.000	1.000	9.0	91.00 100.00	0.500	45.50 50.00
10	33.000 32.000	1.000	9.0	100.00 109.00	0.500	50.00 54.50
11	32.000 31.000	1.000	9.0	109.00 118.00	0.500	54.50 59.00
12	31.000 30.000	1.000	9.0	118.00 127.00	0.500	59.00 63.50
13	30.000 29.000	1.000	9.0	127.00 136.00	0.500	63.50 68.00
14	29.000 28.000	1.000	9.0	136.00 145.00	0.500	68.00 72.50
15	28.000 27.000	1.000	9.0	145.00 154.00	0.500	72.50 77.00

Note: is a layer without earth pressure in calculation.

4.2 Stability analysis

4.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.20)

Md: shear deformation moment on check plane(kN*m/m)

Mr: shear resistant moment on check plane(kN*m/m)

$$Mr = Mro * \left(1 + \frac{d}{H} \right) + Msp$$

$$Mro = \int_0^{yo} (pRP - pRA)\, y\, dy$$

where,

Mro: basic shear resistant moment of filling soil

d : depth from current ground surface to check level

H : wall height(from top of wall to ground level in embankment range)

pRP: passive earth pressure above check level with a distance y(kN/m2)

pRA: active earth pressure above check level with a distance y(kN/m2)

y : a distance from the location of pRP, pRA working(m)

yo : cross point coordinates of the failure plane in filling soil

Msp: resistant moment caused by two rows sheet piles
smaller resistance either landside or riverside and make double to evaluate
Msp= 2* (smaller value either Msp1 or Msp2)

Msp1: resistant moment derived from sheet pile
Msp1= Sig.a* Zsp
Sig.a: allowable stress of sheet pile in use(N/mm2)
Zsp : section modulus considering joint(splice) of sheet pile in use(mm³/m)

Msp2: resistant moment allowed by embedment deeper than check level.
Msp2= Ppu* hpu
Ppu: passive resultant force from check elevation to sheet pile tip
hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	38.000	5.000	0.00	1517.92	999.99>=1.20
Layer boundary surface	40.000	3.000	138.05	1313.86	9.52>=1.20
Layer boundary surface	41.000	2.000	126.31	1397.22	11.06>=1.20
Layer boundary surface	42.000	1.000	90.49	1259.47	13.92>=1.20
Min safety factor	40.000	3.000	138.05	1313.86	9.52>=1.20
Current ground level	43.000	0.000	45.00	1011.39	22.48>=1.20

(2)check level(Embedment tip: G.L. 38.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	0.00
resistant moment	Mr(kN.m/m)	1517.92
factor of safety	Mr/Md	999.99>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	693.33
active earth-prss moment	Ma	26.29
pssv earth-prss moment	-Mp	796.98
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	0.00

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	6.667	133.33
2	44.000 43.000	1.000	20.00 30.00	25.00	5.467	136.67
3	43.000 42.000	1.000	30.00 40.00	35.00	4.476	156.67
4	42.000 41.000	1.000	40.00 35.00	37.50	3.511	131.67
5	41.000 40.000	1.000	35.00 30.00	32.50	2.513	81.67
6	40.000 38.000	2.000	30.00 20.00	50.00	1.067	53.33
Sum				200.00		693.33

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	4.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	3.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	3.154	2.14
4	41.000 40.000	1.000	2.93 9.27	6.10	2.413	14.72
5	40.000 38.000	2.000	2.28 9.58	11.86	0.795	9.42
Sum				18.64		26.29

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	4.442	162.65
2	42.000 41.000	1.000	49.40 62.18	55.79	3.481	194.20
3	41.000 40.000	1.000	62.18 74.97	68.57	2.484	170.37
4	40.000 38.000	2.000	120.09 164.45	284.54	0.948	269.76
Sum				445.52		796.98

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1517.92 0.00 324.00 0.00
rsst moment Mr(kN.m/m)	1517.92

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H) = 674.63* (1+ 1.250) = 1517.92(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN m/m
1	40.781 40.000	0.781	141.68 151.66	41.64 46.59	100.04 105.07	80.10	2.387	191.22
2	40.000 38.000	2.000	253.15 297.50	23.79 31.09	229.36 266.40	495.76	0.975	483.42
Sum						575.86		674.63

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	40.781	40.000	0.781	10.00	0.00	40.00	0.931	50.00	0.655	1.586
2	40.000	38.000	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip) = tan(Phi) + sec(Phi) * Sqrt(\frac{cos(-Theta) sin(Phi)}{sin(Phi - Theta)})$$

$$xip = 90.0 - tan^{-1}(cot(xip))$$

* active failure plane

Ba= cot(xia)* h

$$cot(xia) = -tan(Phi) + sec(Phi) * Sqrt(\frac{cos(Theta) sin(Phi)}{sin(Phi - Theta)})$$

$$xia = 90.0 - tan^{-1}(cot(xia))$$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 0.00) = 0.00(kN m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m3/m - - - - - - - - $* 10^{-6}$ m3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3) check level(Layer boundary surface: G.L. 40.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	138.05
resistant moment	Mr(kN.m/m)	1313.86
factor of safety	Mr/ Md	9.52>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	340.00 3.31 205.26 0.00
deformation moment	Md(kN.m/m)	138.05

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	4.667	93.33
2	44.000 43.000	1.000	20.00 30.00	25.00	3.467	86.67
3	43.000 42.000	1.000	30.00 40.00	35.00	2.476	86.67
4	42.000 41.000	1.000	40.00 35.00	37.50	1.511	56.67
5	41.000 40.000	1.000	35.00 30.00	32.50	0.513	16.67
Sum				150.00		340.00

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	2.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	1.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	1.154	0.78
4	41.000 40.000	1.000	2.93 9.27	6.10	0.413	2.52
Sum				6.78		3.31

c.passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	2.442	89.41
2	42.000 41.000	1.000	49.40 62.18	55.79	1.481	82.62
3	41.000 40.000	1.000	62.18 74.97	68.57	0.484	33.22
Sum				160.98		205.26

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)
* Sum(Mc) = 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	705.36 608.50 324.00 304.25
rsst moment Mr(kN.m/m)	1313.86

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 403.06* (1+ 0.750)= 705.36(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	42.954 42.000	0.954	113.90 126.09	27.87 33.91	86.03 92.18	85.01	2.472	210.10
2	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	1.494	142.57
3	41.000 40.000	1.000	138.88 151.66	40.25 46.59	98.63 105.07	101.85	0.495	50.39
Sum						282.27		403.06

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	42.954	42.000	0.954	10.00	0.00	40.00	1.137	50.00	0.801	1.937
2	42.000	41.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
3	41.000	40.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

xip= 90.0- $\tan^{-1}$ (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*Sqrt(-\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}-)$$

xia= 90.0- $\tan^{-1}$ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)
= 2* min(324.00, 304.25)= 608.50(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m³/m - - - - - - - - * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	40.000 38.000	2.000	122.56 166.91	289.47	1.051	304.25
Sum				289.47		304.25

(4)check level(Layer boundary surface: G.L. 41.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	126.31
resistant moment	Mr(kN.m/m)	1397.22
factor of safety	Mr/ Md	11.06>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	205.83 0.10 79.63 0.00
deformation moment	Md(kN.m/m)	126.31

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	3.667	73.33
2	44.000 43.000	1.000	20.00 30.00	25.00	2.467	61.67
3	43.000 42.000	1.000	30.00 40.00	35.00	1.476	51.67
4	42.000 41.000	1.000	40.00 35.00	37.50	0.511	19.17
Sum				117.50		205.83

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	1.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	0.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	0.154	0.10
Sum				0.68		0.10

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	1.442	52.80
2	42.000 41.000	1.000	49.40 62.18	55.79	0.481	26.83
Sum				92.41		79.63

d. other load moment

* Sum(Pc) = 0.00(kN m/m)

* Sum(Mc) = 0.00(kN m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	749.22 648.00 324.00 629.78
rsst moment Mr(kN m/m)	1397.22

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H) = 499.48* (1+ 0.500) = 749.22(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN m/m
1	43.839 43.000	0.839	166.35 189.00	18.48 21.00	147.86 168.00	132.50	2.411	319.41
2	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	1.494	132.90
3	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	0.494	47.17
Sum						316.87		499.48

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active

Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth top GL(m)	depth bottom GL(m)	thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure angle xip	passive failure width Bp (m)	active failure angle xia	active failure width Ba (m)	failure W Bp+Ba (m)
1	43.839	43.000	0.839	30.00	0.00	30.00	1.453	60.00	0.484	1.938
2	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
3	42.000	41.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- $\tan^{-1}$ (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- $\tan^{-1}$ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(324.00, 629.78)= 648.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	180.0	180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	41.000 40.000	1.000	63.60 76.39	69.99	0.515	36.06
2	40.000 38.000	2.000	122.56 166.91	289.47	2.051	593.72
Sum				359.46		629.78

(5)check level(Layer boundary surface: G.L. 42.000m)

1)check result

item	value
deformation moment MH(kN.m/m)	90.49
resistant moment Mr(kN.m/m)	1259.47
factor of safety Mr/ MH	13.92>=1.20

2)deformation moment(MH)calculation

deformation moment in detail	moment
water pressure moment Mw	106.67
active earth-prss moment Ma	0.00
pssv earth-prss moment - Mp	16.18
other load moment Mc	0.00
deformation moment MH(kN.m/m)	90.49

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H frc Pw (kN/m)	arm L y (m)	moment Mw (kN m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	2.667	53.33
2	44.000 43.000	1.000	20.00 30.00	25.00	1.467	36.67
3	43.000 42.000	1.000	30.00 40.00	35.00	0.476	16.67
Sum				80.00		106.67

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H frc Pa (kN/m)	arm L y (m)	moment Ma (kN m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	0.442	16.18
Sum				36.62		16.18

d. other load moment

* Sum(Pc)= 0.00(kN m/m)

* Sum(Mc)= 0.00(kN m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	611.47 648.00 324.00 1018.91
rsst moment Mr(kN m/m)	1259.47

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 489.18* (1+ 0.250)= 611.47(kN m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H frc Pr (kN/m)	arm L y (m)	moment Mro kN m/m
1	44.718 44.000	0.718	123.23 162.00	13.69 18.00	109.54 144.00	91.02	2.343	213.23
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	1.487	232.00
3	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	0.494	43.94
Sum						335.98		489.18

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top

height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis- angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	44.718	44.000	0.718	30.00	0.00	30.00	1.244	60.00	0.415	1.658
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
3	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.998

* passive failure plane
Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*Sqrt\left(-\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xip= 90.0- tan⁻¹ (cot(xip))

* active failure plane
Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*Sqrt\left(-\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xia= 90.0- tan⁻¹ (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level
Msp= 2* min(Msp1,Msp2)
= 2* min(324.00, 1018.91)= 648.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile
It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	180.0	180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e.passive earth pressure moment below check level (Msp2)
Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	50.82 63.60	57.21	0.519	29.67
2	41.000 40.000	1.000	63.60 76.39	69.99	1.515	106.06
3	40.000 38.000	2.000	122.56 166.91	289.47	3.051	883.19
Sum				416.67		1018.91

(6)check level(Min safety factor: G.L. 40.000m)
1)check result

item		value
deformation moment	Md(kN.m/m)	138.05
resistant moment	Mr(kN.m/m)	1313.86
factor of safety	Mr/ Md	9.52>=1.20

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	340.00
active earth-prss moment	Ma	3.31
pssv earth-prss moment	- Mp	205.26
other load moment	Mc	0.00
deformation moment	Md(kN.m/m)	138.05

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	4.667	93.33
2	44.000 43.000	1.000	20.00 30.00	25.00	3.467	86.67
3	43.000 42.000	1.000	30.00 40.00	35.00	2.476	86.67
4	42.000 41.000	1.000	40.00 35.00	37.50	1.511	56.67
5	41.000 40.000	1.000	35.00 30.00	32.50	0.513	16.67
Sum				150.00		340.00

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	2.500	0.00
2	42.000 41.463	0.537	0.00 0.00	0.00	1.731	0.00
3	41.463 41.000	0.463	0.00 2.93	0.68	1.154	0.78
4	41.000 40.000	1.000	2.93 9.27	6.10	0.413	2.52
Sum				6.78		3.31

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	2.442	89.41
2	42.000 41.000	1.000	49.40 62.18	55.79	1.481	82.62
3	41.000 40.000	1.000	62.18 74.97	68.57	0.484	33.22
Sum				160.98		205.26

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	705.36 608.50 324.00 304.25
rsst moment Mr(kN.m/m)	1313.86

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 403.06* (1+ 0.750)= 705.36(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	42.954 42.000	0.954	113.90 126.09	27.87 33.91	86.03 92.18	85.01	2.472	210.10
2	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	1.494	142.57
3	41.000 40.000	1.000	138.88 151.66	40.25 46.59	98.63 105.07	101.85	0.495	50.39
Sum						282.27		403.06

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active

Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2 3	42.954 42.000 41.000	42.000 41.000 40.000	0.954 1.000 1.000	10.00 10.00 10.00	0.00 0.00 0.00	40.00 40.00 40.00	1.137 1.192 1.192	50.00 50.00 50.00	0.801 0.839 0.839	1.937 2.031 2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

Bp= cot(xip)* h

$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$

$xip= 90.0- tan^{-1} (cot(xip))$

* active failure plane

Ba= cot(xia)* h

$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$

$xia= 90.0- tan^{-1} (cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(324.00, 304.25)= 608.50(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	40.000 38.000	2.000	122.56 166.91	289.47	1.051	304.25
Sum				289.47		304.25

(7) check level(Current ground level: G.L. 43.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	45.00
resistant moment	Mr(kN.m/m)	1011.39
factor of safety	Mr/ Md	22.48>=1.20

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment active earth-prss moment pssv earth-prss moment other load moment	Mw Ma - Mp Mc	45.00 0.00 0.00 0.00
deformation moment	Md(kN.m/m)	45.00

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	1.667	33.33
2	44.000 43.000	1.000	20.00 30.00	25.00	0.467	11.67
Sum				45.00		45.00

b. active earth pressure moment

Sum(Pa) = 0.00kN/m Sum(Ma) = 0.00kN.m/m

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

3) resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	363.39 648.00 324.00 1458.87
rsst moment Mr(kN.m/m)	1011.39

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mfo* (1+ d/ H)= 363.39* (1+ 0.000)= 363.39(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mfo kN.m/m
1	45.598 44.000	1.598	75.71 162.00	8.41 18.00	67.30 144.00	168.83	1.702	287.39
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	0.487	76.00
Sum						324.83		363.39

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active

Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	45.598	44.000	1.598	30.00	0.00	30.00	2.768	60.00	0.923	3.690
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(324.00, 1458.87)= 648.00(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 180.0	PU28+1 3000 0.60 1800 180.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	324.00	324.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	38.04 50.82	44.43	0.524	23.28

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN m/m)
2	42.000 41.000	1.000	50.82 63.60	57.21	1.519	86.88
3	41.000 40.000	1.000	63.60 76.39	69.99	2.515	176.05
4	40.000 38.000	2.000	122.56 166.91	289.47	4.051	1172.65
Sum				461.10		1458.87

4.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.20)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H-frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	38.000	5.000	218.64	807.69	3.69>=1.20

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item	value
sum of H-force Fd(kN/m)	218.64
sum of rsst Fr(kN/m)	807.69
factor of safety Fr/ Fd	3.69>=1.20

2)sum of horizontal force(Fd)

horizontal force in detail		H-force
water pressure	Fw	200.00
active earth pressure	Fa	18.64
other load	Fc	0.00
sum of H-force	Fd(kN/m)	218.64

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail		H-force
ground H resistance	Fs	362.17
passive earth pressure	Fp	445.52
sum of resistance	Fr(kN/m)	807.69

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 6.000+ 648.00* tan(25.00) Deg.

= 362.17(kN/m)

b.soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (108.00+ 0.00)* 6.000= 648.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	44.000	2.000	18.0	36.00
3	44.000	43.000	1.000	9.0	9.00
4	43.000	42.000	1.000	9.0	9.00
5	42.000	41.000	1.000	9.0	9.00
6	41.000	40.000	1.000	9.0	9.00
7	40.000	38.000	2.000	9.0	18.00
Sum			9.000		108.00

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

4.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 6.000, height H= 4.000(m) using the next equation.

$$\frac{Qu}{V-Gam2*Df*Be} >= FS$$

$$Qu = Be\{ k*c*Nc+k*Gam2*Df*(Nq-1)+\frac{1}{2}*Gam1*Be*NGam \}$$

where,

FS : required factor of safety(1.20)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B-2e

B: wall width

e: eccentricity(e= Mb/V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	38.000	5.000	4973.29	378.00	13.16>=1.20

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	648.00
	distance from ground to check level	Df	5.000
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	6.000
	v-compo sum V-Gam2.Df.Be (kN/m)		378.00
Qu	moment on check level	Mb	0.00
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	0.000
	resultant frc inclination(Hb/V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		4973.29
factor of safety			13.16>=1.20

2)summery of external force

external force detail		moment Mb(kN.m/m)	H force Hb(kN/m)
water pressure	Mw(Fw)	693.33	200.00
active earth pressure	Ma(Fa)	26.29	18.64
passive earth pressure-	Mp(Fp)	796.98	445.52
other load	Mc(Fc)	0.00	0.00
external force sum		0.00	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b.active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

3) weight of filling soil(V)

refer to 'b. weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 648.00(kN/m)

4) eccentricity distance(e) calculation

e = Mb/ V

= 0.00/ 648.00

= 0.000(m)

Be= B- 2e

= 6.000- 2.0* 0.000

= 6.000(m)

5) calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 648.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$\text{Gam 2} = \frac{\text{Sum(Gam i hi)}}{\text{Sum(hi)}}$$

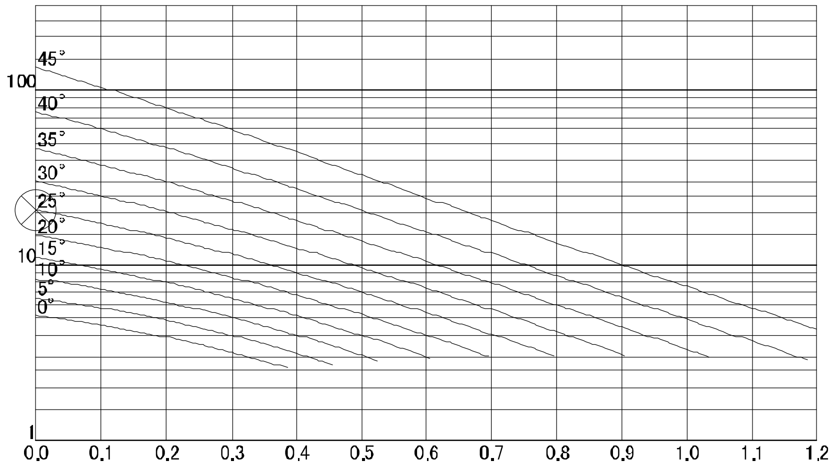
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	43.000	42.000	1.000	9.0	9.00
2	42.000	41.000	1.000	9.0	9.00
3	41.000	40.000	1.000	9.0	9.00
4	40.000	38.000	2.000	9.0	18.00
Sum			5.000		45.00

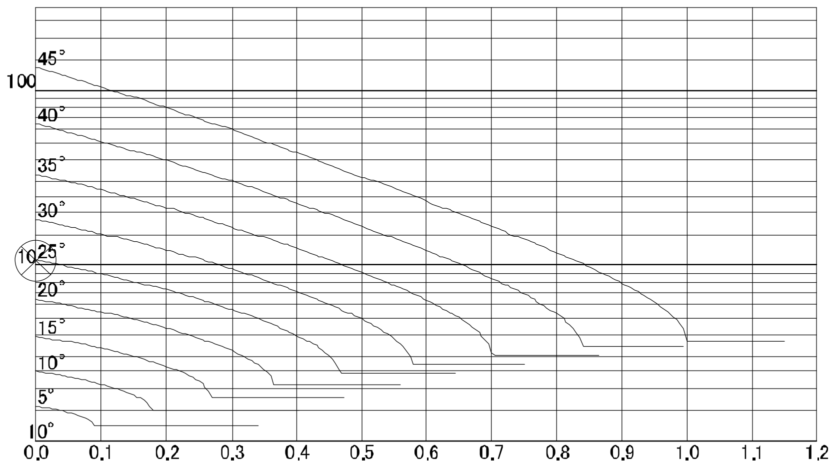
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

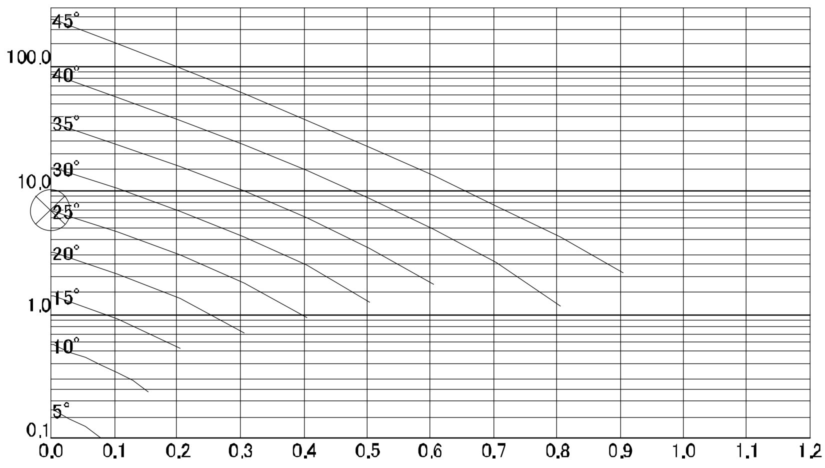
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



FORUM8

4.3 landside sheet pile

4.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 42.000(m)

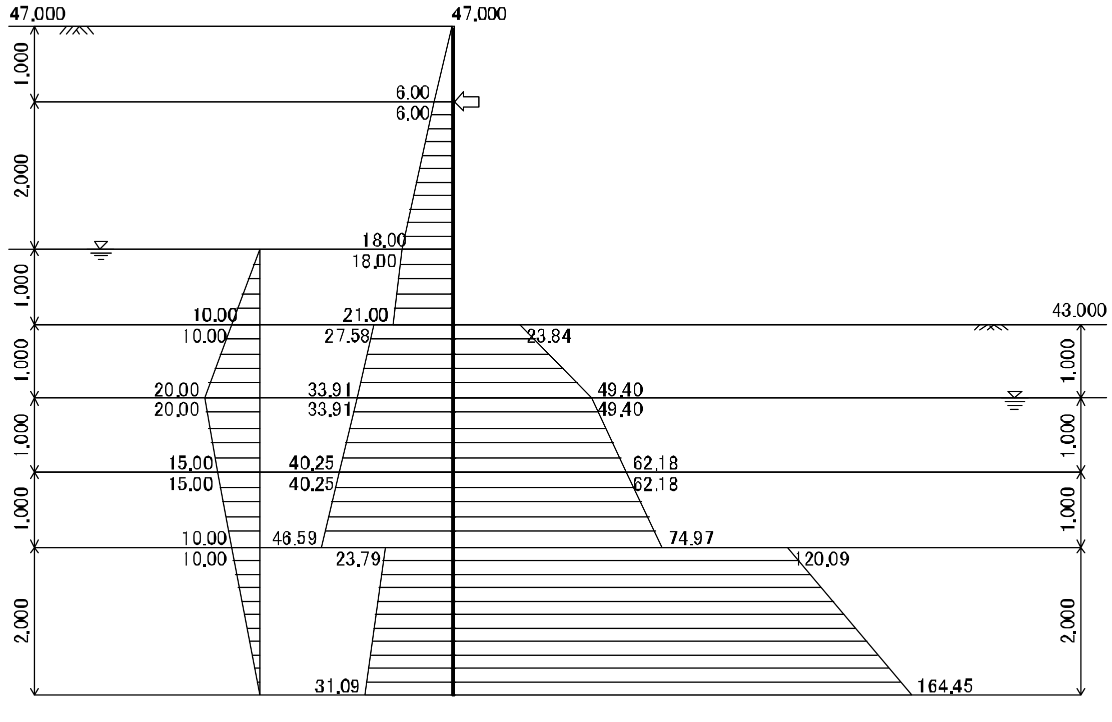
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	39.250	38.000
active sd	Ma+Mw+Mac(kN.m/m)	914.13	1258.42
passive sd	Mp+Mpc(kN.m/m)	1375.38	2767.20
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.505>=1.50	2.199>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.00 18.00	24.00	1.167	28.00
2	44.000 43.000	1.000	18.00 21.00	19.50	2.513	49.00
3	43.000 42.000	1.000	27.58 33.91	30.74	3.517	108.13
4	42.000 41.000	1.000	33.91 40.25	37.08	4.514	167.39
5	41.000 40.000	1.000	40.25 46.59	43.42	5.512	239.32
6	40.000 38.000	2.000	23.79 31.09	54.88	7.044	386.58
Sum				209.62		978.42

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 20.00	15.00	3.556	53.33
3	42.000 41.000	1.000	20.00 15.00	17.50	4.476	78.33
4	41.000 40.000	1.000	15.00 10.00	12.50	5.467	68.33
5	40.000 38.000	2.000	10.00 0.00	10.00	6.667	66.67
Sum				60.00		280.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.84 49.40	36.62	3.558	130.29
2	42.000 41.000	1.000	49.40 62.18	55.79	4.519	252.13
3	41.000 40.000	1.000	62.18 74.97	68.57	5.516	378.22
4	40.000 38.000	2.000	120.09 164.45	284.54	7.052	2006.56
Sum				445.52		2767.20

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac) = 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc) = 0.00kN/m

Sum(Mpc) = 0.00kN.m/m

4.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-119.64	G.L. 42.600
max shear force Smax(kN/m)	-57.47	G.L. 46.000
upper tension mbr rct R1(kN/m)	-61.10	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000	0.00	0.00	- - - -	- - - -	0.00	- - - -
	46.000	6.00	0.00	- - - -	- - - -	6.00	- - - -
2	46.000	6.00	0.00	- - - -	- - - -	6.00	- - - -
	44.000	18.00	0.00	- - - -	- - - -	18.00	- - - -
3	44.000	18.00	0.00	- - - -	- - - -	18.00	- - - -
	43.000	21.00	10.00	- - - -	- - - -	31.00	- - - -
4	43.000	27.58	10.00	23.84	0.00	37.58	23.84
	42.000	33.91	20.00	49.40	14.87	39.04	34.53
5	42.000	33.91	20.00	49.40	14.87	39.04	34.53
	41.000	40.25	15.00	62.18	22.31	32.94	39.87
6	41.000	40.25	15.00	62.18	22.31	32.94	39.87
	40.000	46.59	10.00	74.97	29.75	26.84	45.22
7	40.000	23.79	10.00	120.09	20.79	13.00	99.31
	38.000	31.09	0.00	164.45	31.18	0.00	133.27

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta^{*}\frac{1}{0.3}{}^{*}Alpha\ Eo^{*}\left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	673
2	42.000	41.000	1.000	5600	1346
3	41.000	40.000	1.000	8400	2018
4	40.000	38.000	2.000	44800	10765
5	38.000	37.000	1.000	50400	12110
6	37.000	36.000	1.000	75600	18165
7	36.000	35.000	1.000	47600	11437
8	35.000	34.000	1.000	58800	14129
9	34.000	33.000	1.000	131600	31621
10	33.000	32.000	1.000	86800	20856
11	32.000	31.000	1.000	81200	19511
12	31.000	30.000	1.000	117600	28257
13	30.000	29.000	1.000	114800	27584
14	29.000	28.000	1.000	84000	20184
15	28.000	27.000	1.000	112000	26911

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp.^{*}(2^{*}number^{*}A^{*}E)}{(L^{*}s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]

L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area
* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.20	1.20	0.24	--------	--------	--------	--------
3	46.600	On excavation plane	2.40	2.40	0.48	--------	--------	--------	--------
4	46.400	On excavation plane	3.60	3.60	0.72	--------	--------	--------	--------
5	46.200	On excavation plane	4.80	4.80	0.96	--------	--------	--------	--------
6	46.000	Tensile member	6.00	6.00	1.20	--------	--------	--------	29787
7	45.800	On excavation plane	7.20	7.20	1.44	--------	--------	--------	--------
8	45.600	On excavation plane	8.40	8.40	1.68	--------	--------	--------	--------
9	45.400	On excavation plane	9.60	9.60	1.92	--------	--------	--------	--------
10	45.200	On excavation plane	10.80	10.80	2.16	--------	--------	--------	--------
11	45.000	On excavation plane	12.00	12.00	2.40	--------	--------	--------	--------
12	44.800	On excavation plane	13.20	13.20	2.64	--------	--------	--------	--------
13	44.600	On excavation plane	14.40	14.40	2.88	--------	--------	--------	--------
14	44.400	On excavation plane	15.60	15.60	3.12	--------	--------	--------	--------
15	44.200	On excavation plane	16.80	16.80	3.36	--------	--------	--------	--------
16	44.000	On excavation plane	18.00	18.00	3.64	--------	--------	--------	--------
17	43.800	On excavation plane	20.60	20.60	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	23.20	23.20	4.64	--------	--------	--------	--------
19	43.400	On excavation plane	25.80	25.80	5.16	--------	--------	--------	--------
20	43.200	On excavation plane	28.40	28.40	5.68	--------	--------	--------	--------
21	43.000	Pas ela.	31.00	37.58	6.80	0.00	23.84	--------	67
22	42.800	Pas ela.	37.87	37.87	7.57	25.97	25.97	--------	135

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
23	42.600	Pas el a.	38.16	38.16	7.63	28.11	28.11	--------	135
24	42.400	Pas el a.	38.45	38.45	7.69	30.25	30.25	--------	135
25	42.200	Pas el a.	38.75	38.75	7.75	32.39	32.39	--------	135
26	42.000	Pas el a.	39.04	39.04	7.77	34.53	34.53	--------	202
27	41.800	Pas el a.	37.82	37.82	7.56	35.59	35.59	--------	269
28	41.600	Pas el a.	36.60	36.60	7.32	36.66	36.66	--------	269
29	41.400	Pas el a.	35.38	35.38	7.08	37.73	37.73	--------	269
30	41.200	Pas el a.	34.16	34.16	6.83	38.80	38.80	--------	269
31	41.000	Pas el a.	32.94	32.94	6.59	39.87	39.87	--------	336
32	40.800	Pas el a.	31.72	31.72	6.34	40.94	40.94	--------	404
33	40.600	Pas el a.	30.50	30.50	6.10	42.01	42.01	--------	404
34	40.400	Pas el a.	29.28	29.28	5.86	43.08	43.08	--------	404
35	40.200	Pas el a.	28.06	28.06	5.61	44.15	44.15	--------	404
36	40.000	Pas el a.	26.84	13.00	3.98	45.22	99.31	--------	1278
37	39.800	Pas el a.	11.70	11.70	2.34	102.70	102.70	--------	2153
38	39.600	Pas el a.	10.40	10.40	2.08	106.10	106.10	--------	2153
39	39.400	Pas el a.	9.10	9.10	1.82	109.50	109.50	--------	2153
40	39.200	Pas el a.	7.80	7.80	1.56	112.89	112.89	--------	2153
41	39.000	Pas el a.	6.50	6.50	1.30	116.29	116.29	--------	2153
42	38.800	Pas el a.	5.20	5.20	1.04	119.68	119.68	--------	2153
43	38.600	Pas el a.	3.90	3.90	0.78	123.08	123.08	--------	2153
44	38.400	Pas el a.	2.60	2.60	0.52	126.47	126.47	--------	2153
45	38.200	Pas el a.	1.30	1.30	0.26	129.87	129.87	--------	2153
46	38.000	Act el a.	0.00	0.00	0.03	133.27	0.00	--------	1076
Sum					168.68			0.00	

In case tensile member is shown, soil spring is that of tensile member.

(3) calculation result (spring, displacement, reaction)
max displacement Del.xmax= 11.87mm(G.L. 42.400m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-2.35	- - - -	- - - -
2	46.800	on exv	- - - -	-1.47	- - - -	- - - -
3	46.600	on exv	- - - -	-0.59	- - - -	- - - -
4	46.400	on exv	- - - -	0.29	- - - -	- - - -
5	46.200	on exv	- - - -	1.17	- - - -	- - - -
6	46.000	on exv	29787	2.05	- - - -	Note: -61.10
7	45.800	on exv	- - - -	2.93	- - - -	- - - -
8	45.600	on exv	- - - -	3.81	- - - -	- - - -
9	45.400	on exv	- - - -	4.67	- - - -	- - - -
10	45.200	on exv	- - - -	5.50	- - - -	- - - -
11	45.000	on exv	- - - -	6.31	- - - -	- - - -
12	44.800	on exv	- - - -	7.09	- - - -	- - - -
13	44.600	on exv	- - - -	7.83	- - - -	- - - -
14	44.400	on exv	- - - -	8.52	- - - -	- - - -
15	44.200	on exv	- - - -	9.15	- - - -	- - - -
16	44.000	on exv	- - - -	9.73	- - - -	- - - -
17	43.800	on exv	- - - -	10.25	- - - -	- - - -
18	43.600	on exv	- - - -	10.70	- - - -	- - - -
19	43.400	on exv	- - - -	11.08	- - - -	- - - -
20	43.200	on exv	- - - -	11.39	- - - -	- - - -
21	43.000	pssv el	67	11.63	36.22	-0.78
22	42.800	pssv el	135	11.79	38.61	-1.59
23	42.600	pssv el	135	11.87	41.78	-1.60
24	42.400	pssv el	135	11.87	44.96	-1.60

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	135	11.79	48.14	-1.59
26	42.000	pssv el	202	11.65	34.08	-2.35
27	41.800	pssv el	269	11.42	26.45	-3.07
28	41.600	pssv el	269	11.13	27.25	-3.00
29	41.400	pssv el	269	10.77	28.04	-2.90
30	41.200	pssv el	269	10.35	28.84	-2.78
31	41.000	pssv el	336	9.87	23.70	-3.32
32	40.800	pssv el	404	9.34	20.28	-3.77
33	40.600	pssv el	404	8.76	20.81	-3.53
34	40.400	pssv el	404	8.14	21.34	-3.28
35	40.200	pssv el	404	7.48	21.87	-3.02
36	40.000	pssv el	1278	6.80	11.35	-8.69
37	39.800	pssv el	2153	6.09	9.54	-13.12
38	39.600	pssv el	2153	5.37	9.86	-11.57
39	39.400	pssv el	2153	4.65	10.17	-10.00
40	39.200	pssv el	2153	3.91	10.49	-8.42
41	39.000	pssv el	2153	3.17	10.80	-6.83
42	38.800	pssv el	2153	2.43	11.12	-5.23
43	38.600	pssv el	2153	1.69	11.43	-3.64
44	38.400	pssv el	2153	0.95	11.75	-2.04
45	38.200	pssv el	2153	0.21	12.06	-0.45
46	38.000	actv el	1076	-0.53	12.30	0.58
Sum						-168.68

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

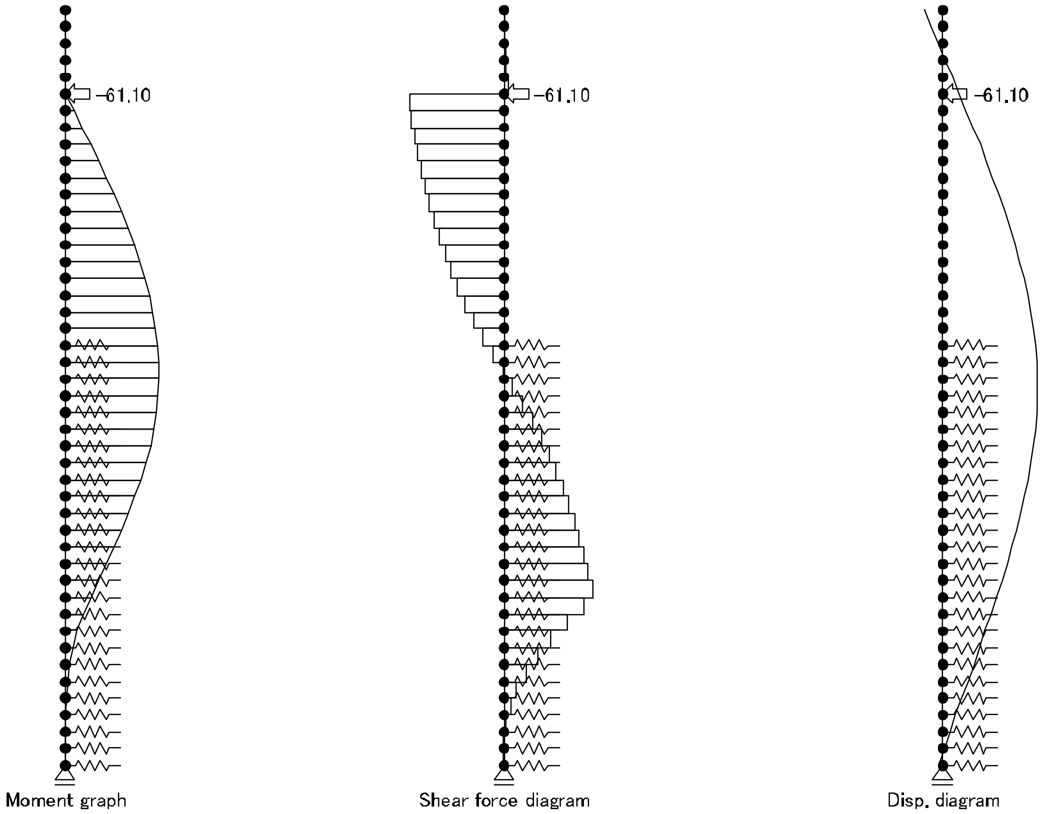
(4)calculation result(member force)
max bending moment Mmax= -119.64kN m/m(G.L. 42.600m)
max shear force Smax= -57.47kN/m (G.L. 46.000m)
max displacement Del.xmax= 11.87mm (G.L. 42.400m)

node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	0.03	-2.35	------------
2	46.800	0.01	0.01	0.03	0.27	-1.47	------------
3	46.600	0.06	0.06	0.27	0.75	-0.59	------------
4	46.400	0.21	0.21	0.75	1.47	0.29	------------
5	46.200	0.50	0.50	1.47	2.43	1.17	------------
6	46.000	0.99	0.99	2.43	-57.47	2.05	* -61.10
7	45.800	-10.50	-10.50	-57.47	-56.03	2.93	------------
8	45.600	-21.71	-21.71	-56.03	-54.35	3.81	------------
9	45.400	-32.58	-32.58	-54.35	-52.43	4.67	------------
10	45.200	-43.07	-43.07	-52.43	-50.27	5.50	------------
11	45.000	-53.12	-53.12	-50.27	-47.87	6.31	------------
12	44.800	-62.70	-62.70	-47.87	-45.23	7.09	------------
13	44.600	-71.74	-71.74	-45.23	-42.35	7.83	------------
14	44.400	-80.21	-80.21	-42.35	-39.23	8.52	------------
15	44.200	-88.06	-88.06	-39.23	-35.87	9.15	------------
16	44.000	-95.23	-95.23	-35.87	-32.24	9.73	------------
17	43.800	-101.68	-101.68	-32.24	-28.12	10.25	------------
18	43.600	-107.31	-107.31	-28.12	-23.48	10.70	------------
19	43.400	-112.00	-112.00	-23.48	-18.32	11.08	------------
20	43.200	-115.66	-115.66	-18.32	-12.64	11.39	------------
21	43.000	-118.19	-118.19	-12.64	-6.62	11.63	-0.78
22	42.800	-119.52	-119.52	-6.62	-0.63	11.79	-1.59
23	42.600	-119.64	-119.64	-0.63	5.40	11.87	-1.60
24	42.400	-118.56	-118.56	5.40	11.50	11.87	-1.60
25	42.200	-116.26	-116.26	11.50	17.66	11.79	-1.59
26	42.000	-112.73	-112.73	17.66	23.08	11.65	-2.35
27	41.800	-108.11	-108.11	23.08	27.57	11.42	-3.07
28	41.600	-102.60	-102.60	27.57	31.89	11.13	-3.00
29	41.400	-96.22	-96.22	31.89	36.07	10.77	-2.90
30	41.200	-89.01	-89.01	36.07	40.12	10.35	-2.78
31	41.000	-80.99	-80.99	40.12	43.38	9.87	-3.32
32	40.800	-72.31	-72.31	43.38	45.96	9.34	-3.77
33	40.600	-63.12	-63.12	45.96	48.52	8.76	-3.53
34	40.400	-53.41	-53.41	48.52	51.10	8.14	-3.28
35	40.200	-43.19	-43.19	51.10	53.69	7.48	-3.02
36	40.000	-32.45	-32.45	53.69	48.98	6.80	-8.69
37	39.800	-22.66	-22.66	48.98	38.20	6.09	-13.12
38	39.600	-15.02	-15.02	38.20	28.71	5.37	-11.57
39	39.400	-9.28	-9.28	28.71	20.53	4.65	-10.00
40	39.200	-5.17	-5.17	20.53	13.67	3.91	-8.42
41	39.000	-2.43	-2.43	13.67	8.15	3.17	-6.83
42	38.800	-0.80	-0.80	8.15	3.96	2.43	-5.23
43	38.600	-0.01	-0.01	3.96	1.10	1.69	-3.64
44	38.400	0.21	0.21	1.10	-0.42	0.95	-2.04
45	38.200	0.12	0.12	-0.42	-0.61	0.21	-0.45
46	38.000	0.00	----------	-0.61	----------	-0.53	0.58

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -119.64kN m/m (G.L. 42.600m)
max shear force Smax= -57.47kN/m (G.L. 46.000m)
max displacement Del.xmax= 11.87mm (G.L. 42.400m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	119.64	0.00	57.47

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	66	180	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	3	83	OK

4.3.4 Tensile member stress

(1) check on tensile member

1) member in use

diameter in use : Phi 32(mm)

material in use : ,'£–í |690

allowable stress : 176(N/mm2)

tensile member layout pitch L : 1.800(m)

number of tensile member in use : 1

tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
61.10	1.800	109.98

3) stress

$$Sig. = \frac{P * 10^3}{n * A} <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
137	176	OK

FORUM8

4.3.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M = \frac{P*L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
109.98	1.800	19.80

3)stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
86	140	OK

4.4 riverside sheet pile

4.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 43.000(m)

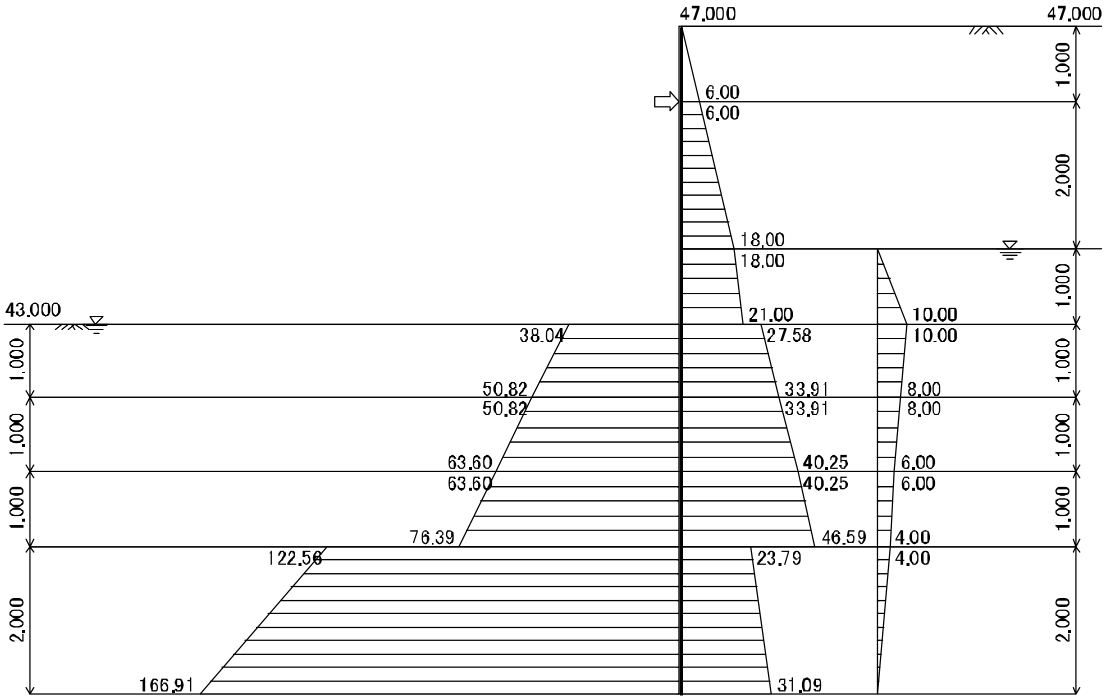
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.50)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	39.620	38.000
active sd	Ma+Mw+Mac(kN.m/m)	732.52	1108.42
passive sd	Mp+Mpc(kN.m/m)	1099.41	2842.17
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.501>=1.50	2.564>=1.50



(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.00 18.00	24.00	1.167	28.00
2	44.000 43.000	1.000	18.00 21.00	19.50	2.513	49.00
3	43.000 42.000	1.000	27.58 33.91	30.74	3.517	108.13
4	42.000 41.000	1.000	33.91 40.25	37.08	4.514	167.39
5	41.000 40.000	1.000	40.25 46.59	43.42	5.512	239.32
6	40.000 38.000	2.000	23.79 31.09	54.88	7.044	386.58
Sum				209.62		978.42

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 8.00	9.00	3.481	31.33
3	42.000 41.000	1.000	8.00 6.00	7.00	4.476	31.33
4	41.000 40.000	1.000	6.00 4.00	5.00	5.467	27.33
5	40.000 38.000	2.000	4.00 0.00	4.00	6.667	26.67
Sum				30.00		130.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	38.04 50.82	44.43	3.524	156.57
2	42.000 41.000	1.000	50.82 63.60	57.21	4.519	258.52
3	41.000 40.000	1.000	63.60 76.39	69.99	5.515	386.03
4	40.000 38.000	2.000	122.56 166.91	289.47	7.051	2041.06
Sum				461.10		2842.17

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

4.4.2 Calculation on wall member forces

(1) result summery

1) calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	95.20	G.L. 43.000
max shear force Smax(kN/m)	49.81	G.L. 46.000
upper tension mbr rct R1(kN/m)	53.44	G.L. 46.000

2) load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss.
Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure'
effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	0.00 6.00	0.00 0.00	- - - - - - - -	- - - - - - - -	0.00 6.00	- - - - - - - -
2	46.000 44.000	6.00 18.00	0.00 0.00	- - - - - - - -	- - - - - - - -	6.00 18.00	- - - - - - - -
3	44.000 43.000	18.00 21.00	0.00 10.00	- - - - - - - -	- - - - - - - -	18.00 31.00	- - - - - - - -
4	43.000 42.000	27.58 33.91	10.00 8.00	38.04 50.82	8.26 15.70	29.31 26.21	29.77 35.12
5	42.000 41.000	33.91 40.25	8.00 6.00	50.82 63.60	15.70 23.14	26.21 23.11	35.12 40.46
6	41.000 40.000	40.25 46.59	6.00 4.00	63.60 76.39	23.14 30.58	23.11 20.01	40.46 45.81
7	40.000 38.000	23.79 31.09	4.00 0.00	122.56 166.91	21.36 31.76	6.42 0.00	101.20 135.15

Note: is non-effective for earth pressure in calculation.
other load

3) spring condition

passive spring is given by the following equation.

$$kH= Eta^* \frac{1}{0.3} * Alpha\ Eo^* \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	673
2	42.000	41.000	1.000	5600	1346
3	41.000	40.000	1.000	8400	2018
4	40.000	38.000	2.000	44800	10765
5	38.000	37.000	1.000	50400	12110
6	37.000	36.000	1.000	75600	18165
7	36.000	35.000	1.000	47600	11437
8	35.000	34.000	1.000	58800	14129
9	34.000	33.000	1.000	131600	31621
10	33.000	32.000	1.000	86800	20856
11	32.000	31.000	1.000	81200	19511
12	31.000	30.000	1.000	117600	28257
13	30.000	29.000	1.000	114800	27584
14	29.000	28.000	1.000	84000	20184
15	28.000	27.000	1.000	112000	26911

Note: in non-effective for spring constant.

4) table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks= \frac{Alp.^*(2^* number^* A^* E)}{(L^* s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]

L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.20	1.20	0.24	--------	--------	--------	--------
3	46.600	On excavation plane	2.40	2.40	0.48	--------	--------	--------	--------
4	46.400	On excavation plane	3.60	3.60	0.72	--------	--------	--------	--------
5	46.200	On excavation plane	4.80	4.80	0.96	--------	--------	--------	--------
6	46.000	Tensile member	6.00	6.00	1.20	--------	--------	--------	29787
7	45.800	On excavation plane	7.20	7.20	1.44	--------	--------	--------	--------
8	45.600	On excavation plane	8.40	8.40	1.68	--------	--------	--------	--------
9	45.400	On excavation plane	9.60	9.60	1.92	--------	--------	--------	--------
10	45.200	On excavation plane	10.80	10.80	2.16	--------	--------	--------	--------
11	45.000	On excavation plane	12.00	12.00	2.40	--------	--------	--------	--------
12	44.800	On excavation plane	13.20	13.20	2.64	--------	--------	--------	--------
13	44.600	On excavation plane	14.40	14.40	2.88	--------	--------	--------	--------
14	44.400	On excavation plane	15.60	15.60	3.12	--------	--------	--------	--------
15	44.200	On excavation plane	16.80	16.80	3.36	--------	--------	--------	--------
16	44.000	On excavation plane	18.00	18.00	3.64	--------	--------	--------	--------
17	43.800	On excavation plane	20.60	20.60	4.12	--------	--------	--------	--------
18	43.600	On excavation plane	23.20	23.20	4.64	--------	--------	--------	--------
19	43.400	On excavation plane	25.80	25.80	5.16	--------	--------	--------	--------
20	43.200	On excavation plane	28.40	28.40	5.68	--------	--------	--------	--------
21	43.000	Pas ela.	31.00	29.31	5.95	0.00	29.77	--------	67
22	42.800	Pas ela.	28.69	28.69	5.74	30.84	30.84	--------	135

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
23	42.600	Pas ela.	28.07	28.07	5.61	31.91	31.91	--------	135
24	42.400	Pas ela.	27.45	27.45	5.49	32.98	32.98	--------	135
25	42.200	Pas ela.	26.83	26.83	5.37	34.05	34.05	--------	135
26	42.000	Pas ela.	26.21	26.21	5.24	35.12	35.12	--------	202
27	41.800	Pas ela.	25.59	25.59	5.12	36.19	36.19	--------	269
28	41.600	Pas ela.	24.97	24.97	4.99	37.26	37.26	--------	269
29	41.400	Pas ela.	24.35	24.35	4.87	38.33	38.33	--------	269
30	41.200	Pas ela.	23.73	23.73	4.75	39.40	39.40	--------	269
31	41.000	Pas ela.	23.11	23.11	4.62	40.46	40.46	--------	336
32	40.800	Pas ela.	22.49	22.49	4.50	41.53	41.53	--------	404
33	40.600	Pas ela.	21.87	21.87	4.37	42.60	42.60	--------	404
34	40.400	Pas ela.	21.25	21.25	4.25	43.67	43.67	--------	404
35	40.200	Pas ela.	20.63	20.63	4.13	44.74	44.74	--------	404
36	40.000	Pas ela.	20.01	6.42	2.64	45.81	101.20	--------	1278
37	39.800	Pas ela.	5.78	5.78	1.16	104.59	104.59	--------	2153
38	39.600	Pas ela.	5.14	5.14	1.03	107.99	107.99	--------	2153
39	39.400	Pas ela.	4.50	4.50	0.90	111.38	111.38	--------	2153
40	39.200	Pas ela.	3.85	3.85	0.77	114.78	114.78	--------	2153
41	39.000	Pas ela.	3.21	3.21	0.64	118.17	118.17	--------	2153
42	38.800	Pas ela.	2.57	2.57	0.51	121.57	121.57	--------	2153
43	38.600	Pas ela.	1.93	1.93	0.39	124.97	124.97	--------	2153
44	38.400	Pas ela.	1.28	1.28	0.26	128.36	128.36	--------	2153
45	38.200	Act ela.	0.64	0.64	0.13	131.76	131.76	--------	2153
46	38.000	Act ela.	0.00	0.00	0.02	135.15	0.00	--------	1076
Sum					131.91			0.00	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= -9.33mm(G.L. 42.600m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	1.70	- - - -	- - - -
2	46.800	on exv	- - - -	1.00	- - - -	- - - -
3	46.600	on exv	- - - -	0.30	- - - -	- - - -
4	46.400	on exv	- - - -	-0.40	- - - -	- - - -
5	46.200	on exv	- - - -	-1.10	- - - -	- - - -
6	46.000	on exv	29787	-1.79	- - - -	Note: 53.44
7	45.800	on exv	- - - -	-2.49	- - - -	- - - -
8	45.600	on exv	- - - -	-3.19	- - - -	- - - -
9	45.400	on exv	- - - -	-3.87	- - - -	- - - -
10	45.200	on exv	- - - -	-4.53	- - - -	- - - -
11	45.000	on exv	- - - -	-5.17	- - - -	- - - -
12	44.800	on exv	- - - -	-5.78	- - - -	- - - -
13	44.600	on exv	- - - -	-6.35	- - - -	- - - -
14	44.400	on exv	- - - -	-6.88	- - - -	- - - -
15	44.200	on exv	- - - -	-7.38	- - - -	- - - -
16	44.000	on exv	- - - -	-7.82	- - - -	- - - -
17	43.800	on exv	- - - -	-8.21	- - - -	- - - -
18	43.600	on exv	- - - -	-8.54	- - - -	- - - -
19	43.400	on exv	- - - -	-8.82	- - - -	- - - -
20	43.200	on exv	- - - -	-9.04	- - - -	- - - -
21	43.000	pssv el	67	-9.20	44.65	0.62
22	42.800	pssv el	135	-9.29	45.84	1.25
23	42.600	pssv el	135	-9.33	47.43	1.25
24	42.400	pssv el	135	-9.30	49.02	1.25

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	135	-9.21	50.61	1.24
26	42.000	pssv el	202	-9.06	34.80	1.83
27	41.800	pssv el	269	-8.86	26.89	2.39
28	41.600	pssv el	269	-8.61	27.69	2.32
29	41.400	pssv el	269	-8.30	28.48	2.23
30	41.200	pssv el	269	-7.95	29.28	2.14
31	41.000	pssv el	336	-7.56	24.06	2.54
32	40.800	pssv el	404	-7.12	20.58	2.88
33	40.600	pssv el	404	-6.66	21.11	2.69
34	40.400	pssv el	404	-6.16	21.64	2.49
35	40.200	pssv el	404	-5.64	22.17	2.28
36	40.000	pssv el	1278	-5.09	11.55	6.51
37	39.800	pssv el	2153	-4.54	9.72	9.77
38	39.600	pssv el	2153	-3.97	10.03	8.54
39	39.400	pssv el	2153	-3.39	10.35	7.31
40	39.200	pssv el	2153	-2.82	10.66	6.07
41	39.000	pssv el	2153	-2.24	10.98	4.82
42	38.800	pssv el	2153	-1.66	11.29	3.57
43	38.600	pssv el	2153	-1.08	11.61	2.32
44	38.400	pssv el	2153	-0.50	11.92	1.07
45	38.200	actv el	2153	0.08	12.24	-0.18
46	38.000	actv el	1076	0.66	12.48	-0.71
Sum						131.91

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

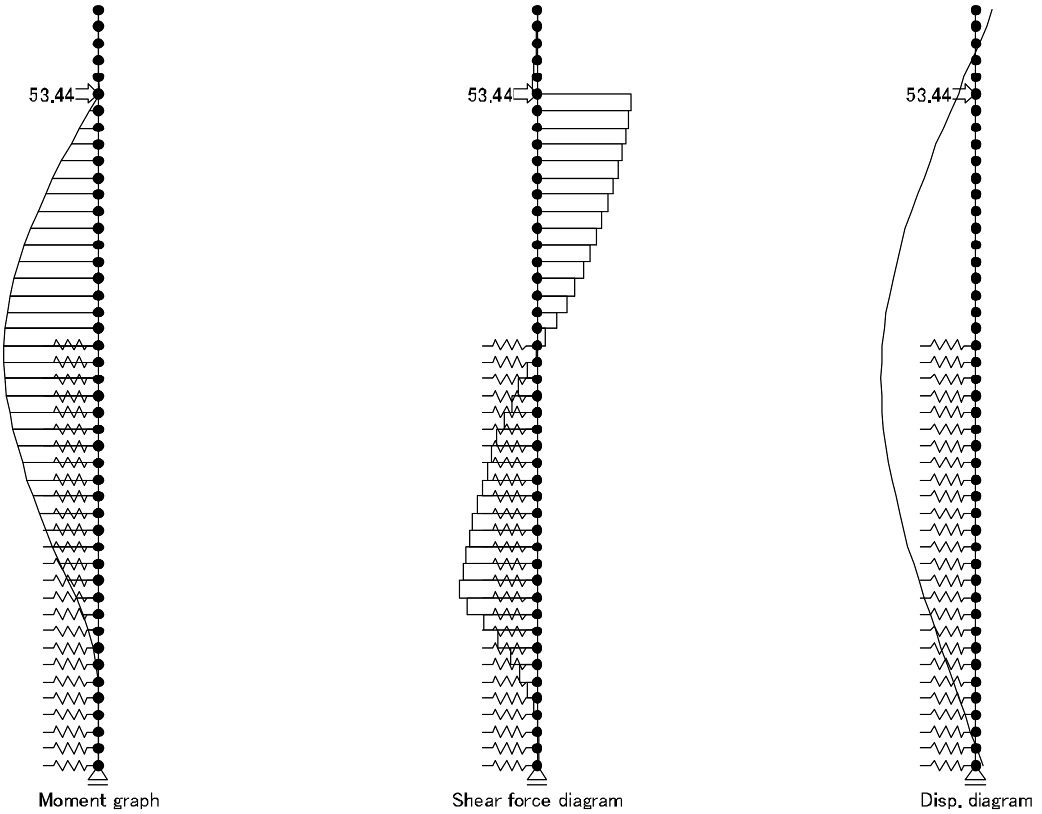
max bending moment Mmax= 95.20kN m/m(G.L. 43.000m)
max shear force Smax= 49.81kN/m (G.L. 46.000m)
max displacement Del.xmax= -9.33mm (G.L. 42.600m)

node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-0.03	1.70	------------
2	46.800	-0.01	-0.01	-0.03	-0.27	1.00	------------
3	46.600	-0.06	-0.06	-0.27	-0.75	0.30	------------
4	46.400	-0.21	-0.21	-0.75	-1.47	-0.40	------------
5	46.200	-0.50	-0.50	-1.47	-2.43	-1.10	------------
6	46.000	-0.99	-0.99	-2.43	49.81	-1.79	* 53.44
7	45.800	8.97	8.97	49.81	48.37	-2.49	------------
8	45.600	18.65	18.65	48.37	46.69	-3.19	------------
9	45.400	27.98	27.98	46.69	44.77	-3.87	------------
10	45.200	36.94	36.94	44.77	42.61	-4.53	------------
11	45.000	45.46	45.46	42.61	40.21	-5.17	------------
12	44.800	53.50	53.50	40.21	37.57	-5.78	------------
13	44.600	61.01	61.01	37.57	34.69	-6.35	------------
14	44.400	67.95	67.95	34.69	31.57	-6.88	------------
15	44.200	74.27	74.27	31.57	28.21	-7.38	------------
16	44.000	79.91	79.91	28.21	24.57	-7.82	------------
17	43.800	84.82	84.82	24.57	20.45	-8.21	------------
18	43.600	88.91	88.91	20.45	15.81	-8.54	------------
19	43.400	92.07	92.07	15.81	10.65	-8.82	------------
20	43.200	94.21	94.21	10.65	4.97	-9.04	------------
21	43.000	95.20	95.20	4.97	-0.36	-9.20	0.62
22	42.800	95.13	95.13	-0.36	-4.85	-9.29	1.25
23	42.600	94.16	94.16	-4.85	-9.21	-9.33	1.25
24	42.400	92.32	92.32	-9.21	-13.45	-9.30	1.25
25	42.200	89.63	89.63	-13.45	-17.57	-9.21	1.24
26	42.000	86.11	86.11	-17.57	-20.99	-9.06	1.83
27	41.800	81.92	81.92	-20.99	-23.72	-8.86	2.39
28	41.600	77.17	77.17	-23.72	-26.40	-8.61	2.32
29	41.400	71.89	71.89	-26.40	-29.03	-8.30	2.23
30	41.200	66.09	66.09	-29.03	-31.64	-7.95	2.14
31	41.000	59.76	59.76	-31.64	-33.72	-7.56	2.54
32	40.800	53.02	53.02	-33.72	-35.34	-7.12	2.88
33	40.600	45.95	45.95	-35.34	-37.03	-6.66	2.69
34	40.400	38.54	38.54	-37.03	-38.79	-6.16	2.49
35	40.200	30.78	30.78	-38.79	-40.64	-5.64	2.28
36	40.000	22.66	22.66	-40.64	-36.78	-5.09	6.51
37	39.800	15.30	15.30	-36.78	-28.17	-4.54	9.77
38	39.600	9.67	9.67	-28.17	-20.65	-3.97	8.54
39	39.400	5.54	5.54	-20.65	-14.24	-3.39	7.31
40	39.200	2.69	2.69	-14.24	-8.94	-2.82	6.07
41	39.000	0.90	0.90	-8.94	-4.77	-2.24	4.82
42	38.800	-0.05	-0.05	-4.77	-1.71	-1.66	3.57
43	38.600	-0.40	-0.40	-1.71	0.22	-1.08	2.32
44	38.400	-0.35	-0.35	0.22	1.03	-0.50	1.07
45	38.200	-0.15	-0.15	1.03	0.73	0.08	-0.18
46	38.000	0.00	----------	0.73	----------	0.66	-0.71

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= 95.20kN m/m (G.L. 43.000m)
max shear force Smax= 49.81kN/m (G.L. 46.000m)
max displacement Del.xmax= -9.33mm (G.L. 42.600m)



* in figure, number in arrow shows tensile reaction (kN/m)

4.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	95.20	0.00	49.81

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \le Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	53	180	OK

(4) shear stress

$$Tau = \frac{S}{A} \le Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	2	83	OK

4.4.4 Tensile member stress

(1) check on tensile member

1) member in use

diameter in use : Phi 32(mm)
material in use : ,’£–í |690
allowable stress : 176(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 32^2* (Pi/4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
53.44	1.800	96.19

3) stress

$$Sig. = \frac{P^* 10^3}{n^* A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
120	176	OK

4.4.5 Waling member stress

(1) Wailing check

1)member in use

steel material in use : m150 ~75 ~6.5 ~10
material in use : SS400
allowable stress : 140(N/mm2)
installation spacing : 1.800(m)

2)moment calculation

$$M= \frac{P^* L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
96.19	1.800	17.31

3)stress

$$Sig. = \frac{M^*10^6}{Z^*10^3} \quad <=Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
75	140	OK

5 Check case (earthquake time)

5.1 calculation of external forces

design seismicity during an earthquake : Kh= 0.04

design seismicity method: river standard equation

$$Kh' = \frac{Gam\,sat}{Gam\,sat - Gam\,w} * Kh$$

where,

Gam sat: soil saturated weight

Gam w : water unit weight

5.1.1 soil, water pressure magnitude table in stability calculation

soil, water pressure magnitude table in stability calculation are shown.

(1) water pressure table(riverside section: working external force)

H.W.L. 46.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	46.000 44.000	2.000	0.00 20.00
2	44.000 43.000	1.000	20.00 30.00
3	43.000 42.000	1.000	30.00 40.00
4	42.000 41.000	1.000	40.00 35.00
5	41.000 40.000	1.000	35.00 30.00
6	40.000 38.000	2.000	30.00 20.00

(2) active earth pressure magnitude table (riverside section: working external force)

pa= Ka(Sum(Gam h)+ q) - 2c*Sqrt(Ka)

$$Ka = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 + Sqrt\{\sin(Phi) * \sin(Phi - Theta) / \cos(Theta)\}]^2}$$

in case of clay, Kh= 0 in 10m below GL and active earth pressure is linearly estimated

Kh = 0 for clay in 10m below GL.

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 0.00
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 0.00
3	41.000 40.498	0.502	9.0	10.00	10.0 10.0	18.00 22.52	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 0.00
4	40.498 40.000	0.498	9.0	10.00	10.0 10.0	22.52 27.00	0.0844 0.0844	4.83 4.83	0.789 0.789	0.00 3.53
5	40.000 39.739	0.261	9.0	25.00	10.0 10.0	27.00 29.35	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 0.00
6	39.739 38.000	1.739	9.0	25.00	10.0 10.0	29.35 45.00	0.0844 0.0844	4.83 4.83	0.464 0.464	0.00 7.27
7	38.000 37.000	1.000	9.0	25.00	10.0 10.0	45.00 54.00	0.0844 0.0844	4.83 4.83	0.464 0.464	7.27 11.44
8	37.000 36.000	1.000	9.0	30.00	10.0 10.0	54.00 63.00	0.0844 0.0844	4.83 4.83	0.386 0.386	8.42 11.89
9	36.000 35.000	1.000	9.0	25.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	0.464 0.464	15.62 19.80
10	35.000 34.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.464 0.464	19.80 23.98
11	34.000 33.000	1.000	9.0	30.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	0.386 0.386	18.84 22.31
12	33.000 32.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	0.386 0.386	22.31 25.78
13	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	0.386 0.386	25.78 29.26
14	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	0.386 0.386	29.26 32.73
15	30.000 29.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	0.386 0.386	32.73 36.20
16	29.000 28.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	0.386 0.386	36.20 39.68
17	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.386 0.386	39.68 43.15

(3)passive earth pressure intensity table (landside section: working external force)

pp= Kp(Sum(Gam h) + q)+ 2c*Sqrt(Kp)

$$Kp = \frac{\cos^2(Phi - Theta)}{\cos^2(Theta) * [1 - Sqrt(\{sin(Phi) * sin(Phi - Theta) / cos(Theta)\})]^2}$$

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN m2)	srchg prsse Sum(rh)+q (kN m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN m2)
1	43.000 42.000	1.000	18.0	10.00	10.0 10.0	0.00 18.00	0.0400 0.0400	2.29 2.29	1.370 1.370	23.41 48.07
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	0.0844 0.0844	4.83 4.83	1.306 1.306	46.36 58.11
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	27.00 36.00	0.0844 0.0844	4.83 4.83	1.306 1.306	58.11 69.86
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	54.00 63.00	0.0844 0.0844	4.83 4.83	2.327 2.327	156.15 177.09
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	2.850 2.850	213.31 238.95
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	2.327 2.327	198.03 218.97
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	2.327 2.327	218.97 239.91
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	2.850 2.850	290.25 315.90
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	2.850 2.850	367.20 392.85
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.850 2.850	392.85 418.50
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	2.850 2.850	444.15 469.80

(4)active earth pressure intensity table(embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric agl Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ka	active e-prss pa (kN/m2)	e-prss in use pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.333	0.00 6.00	0.00 6.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.333	6.00 18.00	6.00 18.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.333	18.00 21.00	18.00 21.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.704	27.58 33.91	27.58 33.91
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.704	33.91 40.25	33.91 40.25
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.704	40.25 46.59	40.25 46.59
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.406	23.79 31.09	23.79 31.09
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.406	31.09 34.74	31.09 34.74
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.333	27.45 30.45	27.45 30.45
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.406	38.40 42.05	38.40 42.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.406	42.05 45.70	42.05 45.70
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.333	36.45 39.45	36.45 39.45
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.333	39.45 42.45	39.45 42.45
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.333	42.45 45.45	42.45 45.45
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.333	45.45 48.45	45.45 48.45
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.333	48.45 51.45	48.45 51.45
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.333	51.45 54.45	51.45 54.45
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.333	54.45 57.45	54.45 57.45

(5)passive earth pressure intensity table (embankment section: resistant moment calculation)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	3.000	0.00 54.00
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	3.000	54.00 162.00
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	3.000	162.00 189.00
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	1.420	113.31 126.09
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	1.420	126.09 138.88
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	1.420	138.88 151.66
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	2.464	253.15 297.50
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	2.464	297.50 319.67
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	3.000	385.64 412.64
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	2.464	341.85 364.02
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	2.464	364.02 386.20
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	3.000	466.64 493.64
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	3.000	493.64 520.64
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	3.000	520.64 547.64
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	3.000	547.64 574.64
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	3.000	574.64 601.64
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	3.000	601.64 628.64
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	3.000	628.64 655.64

(6)passive earth pressure intensity table (out of embankment: passive resistant moment below)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	0.0844 0.0844	4.83 4.83	1.306 1.306	46.36 58.11
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	0.0844 0.0844	4.83 4.83	2.327 2.327	93.33 135.21
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	45.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	135.21 156.15
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	54.00 63.00	0.0844 0.0844	4.83 4.83	2.850 2.850	187.66 213.31
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	2.327 2.327	177.09 198.03
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	2.327 2.327	198.03 218.97
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	2.850 2.850	264.60 290.25
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	2.850 2.850	290.25 315.90
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	2.850 2.850	367.20 392.85
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.850 2.850	392.85 418.50
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15

(7)seismicity for inertia force, H-force distribution table(embankment section: for inertia moment)

seismicity for inertia force is linearly distributed from GL to 10m depth, calculate with reducing seismicity. Regardless WT, design seismicity is considered using next equation. Basic design seismicity is applied with input design seismicity for the case of earthquake.

pe= Gam * B* Kh

where,

pe : inertia force intensity, H-force, for each layer (top and bottom)

Gam: wet weight of each layer

B : embankment width in use (6.000)m

Kh : design seismicity for each layer (top and bottom)

No	depth GL(m)	layer thick. h (m)	soil unit weight			seis-micity Kh	inertia H-compo pe=Gam.B.Kh
			wet Gamt	sub Gam'	sat Gamsat		
1	47.000 46.000	1.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
2	46.000 44.000	2.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
3	44.000 43.000	1.000	18.0	9.0	19.0	0.0400 0.0400	4.32 4.32
4	43.000 42.000	1.000	18.0	9.0	19.0	0.0400 0.0360	* 4.32 * 3.89
5	42.000 41.000	1.000	18.0	9.0	19.0	0.0360 0.0320	* 3.89 * 3.46
6	41.000 40.000	1.000	18.0	9.0	19.0	0.0320 0.0280	* 3.46 * 3.02
7	40.000 38.000	2.000	18.0	9.0	19.0	0.0280 0.0200	* 3.02 * 2.16
8	38.000 37.000	1.000	18.0	9.0	19.0	0.0200 0.0160	* 2.16 * 1.73
9	37.000 36.000	1.000	18.0	9.0	19.0	0.0160 0.0120	* 1.73 * 1.30
10	36.000 35.000	1.000	18.0	9.0	19.0	0.0120 0.0080	* 1.30 * 0.86
11	35.000 34.000	1.000	18.0	9.0	19.0	0.0080 0.0040	* 0.86 * 0.43
12	34.000 33.000	1.000	18.0	9.0	19.0	0.0040 0.0000	* 0.43 * 0.00
13	33.000 32.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
14	32.000 31.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
15	31.000 30.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
16	30.000 29.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
17	29.000 28.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00
18	28.000 27.000	1.000	18.0	9.0	19.0	0.0000 0.0000	* 0.00 * 0.00

Note:* character shows a section where linearly reduced seismicity.

5.1.2 earth pressure, water pressure intensity for landside sheet pile calculation

side pressure intensity table for landside sheet pile calculation is shown.

(1) water pressure intensity table (embankment section)

R.W.L. 44.000(m)

L.W.L. 42.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 20.00
3	42.000 41.000	1.000	20.00 15.00
4	41.000 40.000	1.000	15.00 10.00
5	40.000 38.000	2.000	10.00 0.00

(2) active earth pressure intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 6.43
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.0400 0.0400	2.29 2.29	0.357 0.357	6.43 19.29
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.0844 0.0844	4.83 4.83	0.386 0.386	20.84 24.31
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	0.789 0.789	31.93 39.03
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.789 0.789	39.03 46.13
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	0.789 0.789	46.13 53.23
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.0844 0.0844	4.83 4.83	0.464 0.464	28.16 36.52
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	0.464 0.464	36.52 40.70
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	0.386 0.386	32.73 36.20
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	0.464 0.464	44.87 49.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.464 0.464	49.05 53.23
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	0.386 0.386	43.15 46.62
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	0.386 0.386	46.62 50.10
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.0844 0.0844	4.83 4.83	0.386 0.386	50.10 53.57
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.0844 0.0844	4.83 4.83	0.386 0.386	53.57 57.04
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.0844 0.0844	4.83 4.83	0.386 0.386	57.04 60.52
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.0844 0.0844	4.83 4.83	0.386 0.386	60.52 63.99
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.0844 0.0844	4.83 4.83	0.386 0.386	63.99 67.46

(3)passive earth pressure intensity table (landside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prsse Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN/m2)
1	43.000 42.000	1.000	18.0	10.00	10.0 10.0	0.00 18.00	0.0400 0.0400	2.29 2.29	1.370 1.370	23.41 48.07
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	0.0844 0.0844	4.83 4.83	1.306 1.306	46.36 58.11
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	27.00 36.00	0.0844 0.0844	4.83 4.83	1.306 1.306	58.11 69.86
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	36.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	114.27 156.15
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	54.00 63.00	0.0844 0.0844	4.83 4.83	2.327 2.327	156.15 177.09
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	2.850 2.850	213.31 238.95
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	2.327 2.327	198.03 218.97
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	2.327 2.327	218.97 239.91
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	2.850 2.850	290.25 315.90
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	2.850 2.850	367.20 392.85
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.850 2.850	392.85 418.50
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	2.850 2.850	444.15 469.80

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN/m2)	e-prss coeff Ko	active e-prss po (kN/m2)
1	43.000 42.000	1.000	18.0	0.00 18.00	0.826	0.00 14.87
2	42.000 41.000	1.000	9.0	18.00 27.00	0.826	14.87 22.31
3	41.000 40.000	1.000	9.0	27.00 36.00	0.826	22.31 29.75
4	40.000 38.000	2.000	9.0	36.00 54.00	0.577	20.79 31.18
5	38.000 37.000	1.000	9.0	54.00 63.00	0.577	31.18 36.38
6	37.000 36.000	1.000	9.0	63.00 72.00	0.500	31.50 36.00
7	36.000 35.000	1.000	9.0	72.00 81.00	0.577	41.57 46.77
8	35.000 34.000	1.000	9.0	81.00 90.00	0.577	46.77 51.96
9	34.000 33.000	1.000	9.0	90.00 99.00	0.500	45.00 49.50
10	33.000 32.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
11	32.000 31.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
12	31.000 30.000	1.000	9.0	117.00 126.00	0.500	58.50 63.00
13	30.000 29.000	1.000	9.0	126.00 135.00	0.500	63.00 67.50
14	29.000 28.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00
15	28.000 27.000	1.000	9.0	144.00 153.00	0.500	72.00 76.50

Note:is a layer without earth pressure in calculation.

5.1.3 earth pressure, water pressure intensity for riverside sheet pile calculation

side pressure intensity table for riverside sheet pile calculation is shown.

(1) water pressure table (embankment section)

H.W.L. 44.000(m)

L.W.L. 43.000(m)

soil type at wall tip ground: Sandy soil

No	depth GL(m)	layer thick. h (m)	wtr prss pw (kN/m2)
1	44.000 43.000	1.000	0.00 10.00
2	43.000 42.000	1.000	10.00 8.00
3	42.000 41.000	1.000	8.00 6.00
4	41.000 40.000	1.000	6.00 4.00
5	40.000 38.000	2.000	4.00 0.00

(2) active earth pressure magnitude table (embankment section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN/m2)	srchg prss Sum(rh)+q (kN/m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Ka	active e-prss pa (kN/m2)
1	47.000 46.000	1.000	18.0	30.00	0.0 0.0	0.00 18.00	0.0400 0.0400	2.29 2.29	0.357 0.357	0.00 6.43
2	46.000 44.000	2.000	18.0	30.00	0.0 0.0	18.00 54.00	0.0400 0.0400	2.29 2.29	0.357 0.357	6.43 19.29
3	44.000 43.000	1.000	9.0	30.00	0.0 0.0	54.00 63.00	0.0844 0.0844	4.83 4.83	0.386 0.386	20.84 24.31
4	43.000 42.000	1.000	9.0	10.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	0.789 0.789	31.93 39.03
5	42.000 41.000	1.000	9.0	10.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	0.789 0.789	39.03 46.13
6	41.000 40.000	1.000	9.0	10.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	0.789 0.789	46.13 53.23
7	40.000 38.000	2.000	9.0	25.00	10.0 10.0	90.00 108.00	0.0844 0.0844	4.83 4.83	0.464 0.464	28.16 36.52
8	38.000 37.000	1.000	9.0	25.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	0.464 0.464	36.52 40.70
9	37.000 36.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	0.386 0.386	32.73 36.20
10	36.000 35.000	1.000	9.0	25.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	0.464 0.464	44.87 49.05
11	35.000 34.000	1.000	9.0	25.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	0.464 0.464	49.05 53.23
12	34.000 33.000	1.000	9.0	30.00	10.0 10.0	144.00 153.00	0.0844 0.0844	4.83 4.83	0.386 0.386	43.15 46.62
13	33.000 32.000	1.000	9.0	30.00	10.0 10.0	153.00 162.00	0.0844 0.0844	4.83 4.83	0.386 0.386	46.62 50.10
14	32.000 31.000	1.000	9.0	30.00	10.0 10.0	162.00 171.00	0.0844 0.0844	4.83 4.83	0.386 0.386	50.10 53.57
15	31.000 30.000	1.000	9.0	30.00	10.0 10.0	171.00 180.00	0.0844 0.0844	4.83 4.83	0.386 0.386	53.57 57.04
16	30.000 29.000	1.000	9.0	30.00	10.0 10.0	180.00 189.00	0.0844 0.0844	4.83 4.83	0.386 0.386	57.04 60.52
17	29.000 28.000	1.000	9.0	30.00	10.0 10.0	189.00 198.00	0.0844 0.0844	4.83 4.83	0.386 0.386	60.52 63.99
18	28.000 27.000	1.000	9.0	30.00	10.0 10.0	198.00 207.00	0.0844 0.0844	4.83 4.83	0.386 0.386	63.99 67.46

(3)passive earth pressure intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	inter fric Phi (deg)	coh c (kN m2)	srchg prsse Sum(rh)+q (kN m2)	seis-micity k'	seis-angle Theta (deg)	e-prss coeff Kp	passive e-prss pp (kN m2)
1	43.000 42.000	1.000	9.0	10.00	10.0 10.0	0.00 9.00	0.0844 0.0844	4.83 4.83	1.306 1.306	22.85 34.61
2	42.000 41.000	1.000	9.0	10.00	10.0 10.0	9.00 18.00	0.0844 0.0844	4.83 4.83	1.306 1.306	34.61 46.36
3	41.000 40.000	1.000	9.0	10.00	10.0 10.0	18.00 27.00	0.0844 0.0844	4.83 4.83	1.306 1.306	46.36 58.11
4	40.000 38.000	2.000	9.0	25.00	10.0 10.0	27.00 45.00	0.0844 0.0844	4.83 4.83	2.327 2.327	93.33 135.21
5	38.000 37.000	1.000	9.0	25.00	10.0 10.0	45.00 54.00	0.0844 0.0844	4.83 4.83	2.327 2.327	135.21 156.15
6	37.000 36.000	1.000	9.0	30.00	10.0 10.0	54.00 63.00	0.0844 0.0844	4.83 4.83	2.850 2.850	187.66 213.31
7	36.000 35.000	1.000	9.0	25.00	10.0 10.0	63.00 72.00	0.0844 0.0844	4.83 4.83	2.327 2.327	177.09 198.03
8	35.000 34.000	1.000	9.0	25.00	10.0 10.0	72.00 81.00	0.0844 0.0844	4.83 4.83	2.327 2.327	198.03 218.97
9	34.000 33.000	1.000	9.0	30.00	10.0 10.0	81.00 90.00	0.0844 0.0844	4.83 4.83	2.850 2.850	264.60 290.25
10	33.000 32.000	1.000	9.0	30.00	10.0 10.0	90.00 99.00	0.0844 0.0844	4.83 4.83	2.850 2.850	290.25 315.90
11	32.000 31.000	1.000	9.0	30.00	10.0 10.0	99.00 108.00	0.0844 0.0844	4.83 4.83	2.850 2.850	315.90 341.55
12	31.000 30.000	1.000	9.0	30.00	10.0 10.0	108.00 117.00	0.0844 0.0844	4.83 4.83	2.850 2.850	341.55 367.20
13	30.000 29.000	1.000	9.0	30.00	10.0 10.0	117.00 126.00	0.0844 0.0844	4.83 4.83	2.850 2.850	367.20 392.85
14	29.000 28.000	1.000	9.0	30.00	10.0 10.0	126.00 135.00	0.0844 0.0844	4.83 4.83	2.850 2.850	392.85 418.50
15	28.000 27.000	1.000	9.0	30.00	10.0 10.0	135.00 144.00	0.0844 0.0844	4.83 4.83	2.850 2.850	418.50 444.15

Note: is a layer without earth pressure in calculation.

(4)earth pressure at rest intensity table (riverside section)

No	depth GL(m)	layer thick. h (m)	soil unit wt Gam	effsrchg pressure Sum(rh)+q (kN m2)	e-prss coeff Ko	active e-prss po (kN m2)
1	43.000 42.000	1.000	9.0	0.00 9.00	0.826	0.00 7.44
2	42.000 41.000	1.000	9.0	9.00 18.00	0.826	7.44 14.87
3	41.000 40.000	1.000	9.0	18.00 27.00	0.826	14.87 22.31
4	40.000 38.000	2.000	9.0	27.00 45.00	0.577	15.59 25.98
5	38.000 37.000	1.000	9.0	45.00 54.00	0.577	25.98 31.18
6	37.000 36.000	1.000	9.0	54.00 63.00	0.500	27.00 31.50
7	36.000 35.000	1.000	9.0	63.00 72.00	0.577	36.38 41.57
8	35.000 34.000	1.000	9.0	72.00 81.00	0.577	41.57 46.77
9	34.000 33.000	1.000	9.0	81.00 90.00	0.500	40.50 45.00
10	33.000 32.000	1.000	9.0	90.00 99.00	0.500	45.00 49.50
11	32.000 31.000	1.000	9.0	99.00 108.00	0.500	49.50 54.00
12	31.000 30.000	1.000	9.0	108.00 117.00	0.500	54.00 58.50
13	30.000 29.000	1.000	9.0	117.00 126.00	0.500	58.50 63.00
14	29.000 28.000	1.000	9.0	126.00 135.00	0.500	63.00 67.50
15	28.000 27.000	1.000	9.0	135.00 144.00	0.500	67.50 72.00

Note: is a layer without earth pressure in calculation.

5.2 Stability analysis

5.2.1 Check shear deformation failure of wall

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m) are examined using next equation.

$$\frac{Mr}{Md} >= FS$$

where,

FS: required factor of safety(1.00)
Md: shear deformation moment on check plane(kN* m/m)
Mr: shear resistant moment on check plane(kN* m/m)

$$Mr = Mro* (1+ \frac{d}{H})+ Msp$$

$$Mro = \int_{0}^{yo} (pRP- pRA)ydy$$

where,

Mro: basic shear resistant moment of filling soil
d : depth from current ground surface to check level
H : wall height(from top of wall to ground level in embankment range)
pRP: passive earth pressure above check level with a distance y(kN/m2)
pRA: active earth pressure above check level with a distance y(kN/m2)
y : a distance from the location of pRP, pRA working(m)
yo : cross point coordinates of the failure plane in filling soil
Msp: resistant moment caused by two rows sheet piles
smaller resistance either landside or riverside and make double to evaluate
Msp= 2* (smaller value either Msp1 or Msp2)
Msp1: resistant moment derived from sheet pile
Msp1= Sig.a* Zsp
Sig.a: allowable stress of sheet pile in use(N/mm2)
Zsp : section modulus considering joint(splice) of sheet pile in use(mm^3/ m)
Msp2: resistant moment allowed by embedment deeper than check level.
Msp2= Ppu* hpu
Ppu: passive resultant force from check elevation to sheet pile tip
hpu: distance from Ppu check level

2)check result for each level

position	check lv G.L.(m)	check depth d	deform moment Md (kN.m/m)	rsst moment Mr (kN.m/m)	Factor of safety F
Embedment tip	38.000	5.000	121.82	1517.92	12.46>=1.00
Layer boundary surface	40.000	3.000	257.18	1190.35	4.63>=1.00
Layer boundary surface	41.000	2.000	213.05	1721.22	8.08>=1.00
Layer boundary surface	42.000	1.000	149.40	1583.47	10.60>=1.00
Min safety factor	39.000	4.000	241.76	1071.93	4.43>=1.00
Current ground level	43.000	0.000	82.08	1335.39	16.27>=1.00

(2)check level(Embedment tip: G.L. 38.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	121.82
resistant moment	Mr(kN.m/m)	1517.92
factor of safety	Mr/ Md	12.46>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	693.33
active earth-prss moment	Ma	5.57
pssv earth-prss moment	- Mp	756.06
other load moment	Mc	0.00
inertia force moment	Me	165.96
dynamic hydraulic moment	Mwd	13.02
deformation moment	Md(kN.m/m)	121.82

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	6.667	133.33
2	44.000 43.000	1.000	20.00 30.00	25.00	5.467	136.67
3	43.000 42.000	1.000	30.00 40.00	35.00	4.476	156.67
4	42.000 41.000	1.000	40.00 35.00	37.50	3.511	131.67
5	41.000 40.000	1.000	35.00 30.00	32.50	2.513	81.67
6	40.000 38.000	2.000	30.00 20.00	50.00	1.067	53.33
Sum				200.00		693.33

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	4.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	3.500	0.00
3	41.000 40.498	0.502	0.00 0.00	0.00	2.749	0.00
4	40.498 40.000	0.498	0.00 3.53	0.88	2.166	1.91
5	40.000 39.739	0.261	0.00 0.00	0.00	1.869	0.00
6	39.739 38.000	1.739	0.00 7.27	6.32	0.580	3.66
Sum				7.20		5.57

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	4.443	158.77
2	42.000 41.000	1.000	46.36 58.11	52.23	3.481	181.84
3	41.000 40.000	1.000	58.11 69.86	63.99	2.485	158.99
4	40.000 38.000	2.000	114.27 156.15	270.42	0.948	256.46
Sum				422.38		756.06

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)
* Sum(Mc) = 0.00(kN.m/m)

e.inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew

= 33.48(kN/m)

Me = Sum(Me)+ Mew

= 165.96(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	8.500	36.72
2	46.000 44.000	2.000	4.32 4.32	8.64	7.000	60.48
3	44.000 43.000	1.000	4.32 4.32	4.32	5.500	23.76
4	43.000 42.000	1.000	4.32 3.89	4.10	4.509	18.50
5	42.000 41.000	1.000	3.89 3.46	3.67	3.510	12.89
6	41.000 40.000	1.000	3.46 3.02	3.24	2.511	8.14
7	40.000 38.000	2.000	3.02 2.16	5.18	1.056	5.47
Sum				33.48		165.96

f.dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 13.02(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	6.200	13.02

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	1517.92 0.00 486.00 0.00
rsst moment Mr(kN.m/m)	1517.92

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 674.63* (1+ 1.250)= 1517.92(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	40.781 40.000	0.781	141.68 151.66	41.64 46.59	100.04 105.07	80.10	2.387	191.22
2	40.000 38.000	2.000	253.15 297.50	23.79 31.09	229.36 266.40	495.76	0.975	483.42
Sum						575.86		674.63

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	40.781	40.000	0.781	10.00	0.00	40.00	0.931	50.00	0.655	1.586
2	40.000	38.000	2.000	25.00	0.00	32.50	3.139	57.50	1.274	4.414
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)= \tan(Phi)+\sec(Phi)*\mathrm{Sqrt}(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

$xip= 90.0- \tan^{-1} (\cot(xip))$

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)= -\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)})$$

$xia= 90.0- \tan^{-1} (\cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 0.00)= 0.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m³/m - - - - - - - - $* 10^{-6}$ m³/m $* 10^{3}$ kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Because check level is at tip of embedment, Msp2= 0.0(kN* m/m).

(3)check level(Layer boundary surface: G.L. 40.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	257.18
resistant moment	Mr(kN.m/m)	1190.35
factor of safety	Mr/ Md	4.63>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	340.00
active earth-prss moment	Ma	0.15
pssv earth-prss moment	- Mp	195.68
other load moment	Mc	0.00
inertia force moment	Me	103.90
dynamic hydraulic moment	Mwd	8.82
deformation moment	Md(kN.m/m)	257.18

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	4.667	93.33
2	44.000 43.000	1.000	20.00 30.00	25.00	3.467	86.67
3	43.000 42.000	1.000	30.00 40.00	35.00	2.476	86.67
4	42.000 41.000	1.000	40.00 35.00	37.50	1.511	56.67
5	41.000 40.000	1.000	35.00 30.00	32.50	0.513	16.67
Sum				150.00		340.00

b.active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	2.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	1.500	0.00
3	41.000 40.498	0.502	0.00 0.00	0.00	0.749	0.00
4	40.498 40.000	0.498	0.00 3.53	0.88	0.166	0.15
Sum				0.88		0.15

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	2.443	87.29
2	42.000 41.000	1.000	46.36 58.11	52.23	1.481	77.37
3	41.000 40.000	1.000	58.11 69.86	63.99	0.485	31.01
Sum				151.96		195.68

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 28.30(kN/m)

Me = Sum(Me) + Mew

= 103.90(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	6.500	28.08
2	46.000 44.000	2.000	4.32 4.32	8.64	5.000	43.20
3	44.000 43.000	1.000	4.32 4.32	4.32	3.500	15.12
4	43.000 42.000	1.000	4.32 3.89	4.10	2.509	10.30
5	42.000 41.000	1.000	3.89 3.46	3.67	1.510	5.54
6	41.000 40.000	1.000	3.46 3.02	3.24	0.511	1.66
Sum				28.30		103.90

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gam\,w * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.

Mwd: dynamic hydraulic moment on check level

Kh : design seismicity(0.04)

Gam w: water unit weight

he : distance from water level to current ground level

y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)

Mwd= 8.82(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	4.200	8.82

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).

Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro*(1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	705.36 485.00 486.00 242.50
rsst moment Mr(kN.m/m)	1190.35

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro*(1+ d/ H)= 403.06*(1+ 0.750)= 705.36(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)*(2* p1+ p2)/(p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	42.954 42.000	0.954	113.90 126.09	27.87 33.91	86.03 92.18	85.01	2.472	210.10
2	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	1.494	142.57
3	41.000 40.000	1.000	138.88 151.66	40.25 46.59	98.63 105.07	101.85	0.495	50.39
Sum						282.27		403.06

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2 3	42.954 42.000 41.000	42.000 41.000 40.000	0.954 1.000 1.000	10.00 10.00 10.00	0.00 0.00 0.00	40.00 40.00 40.00	1.137 1.192 1.192	50.00 50.00 50.00	0.801 0.839 0.839	1.937 2.031 2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane

Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*Sqrt\left(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

$xip= 90.0-\tan^{-1}(\cot(xip))$

* active failure plane

Ba= cot(xia)* h

$$\cot(xia)=-\tan(Phi)+\sec(Phi)*Sqrt\left(\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

$xia= 90.0-\tan^{-1}(\cot(xia))$

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)
= 2* min(486.00, 242.50)= 485.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m³/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m³/m	1800	1800
allowable stress Sig.a	* 10^{3} kN/m2	270.0	270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.
geological condition for calculation is represented by those of riverside section.
Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	40.000 38.000	2.000	93.33 135.21	228.54	1.061	242.50
Sum				228.54		242.50

(4)check level(Layer boundary surface: G.L. 41.000m)

1)check result

item	value
deformation moment Md(kN.m/m)	213.05
resistant moment Mr(kN.m/m)	1721.22
factor of safety Mr/ Md	8.08>=1.00

2)deformation moment(Md)calculation

deformation moment in detail	moment
water pressure moment Mw	205.83
active earth-prss moment Ma	0.00
pssv earth-prss moment - Mp	76.69
other load moment Mc	0.00
inertia force moment Me	77.18
dynamic hydraulic moment Mwd	6.72
deformation moment Md(kN.m/m)	213.05

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	3.667	73.33
2	44.000 43.000	1.000	20.00 30.00	25.00	2.467	61.67
3	43.000 42.000	1.000	30.00 40.00	35.00	1.476	51.67
4	42.000 41.000	1.000	40.00 35.00	37.50	0.511	19.17
Sum				117.50		205.83

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	1.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	1.443	51.55
2	42.000 41.000	1.000	46.36 58.11	52.23	0.481	25.14
Sum				87.97		76.69

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+Pew
= 25.06(kN/m)

Me = Sum(Me)+Mew
= 77.18(kN.m/m)

* surcharge load

Pew = q*B*Kh
= 0.00(kN/m)

Mew = Pew*(height from check level to top of wall)
= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/3)*(2*p1+p2)/(p1+p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	5.500	23.76
2	46.000 44.000	2.000	4.32 4.32	8.64	4.000	34.56
3	44.000 43.000	1.000	4.32 4.32	4.32	2.500	10.80
4	43.000 42.000	1.000	4.32 3.89	4.10	1.509	6.19
5	42.000 41.000	1.000	3.89 3.46	3.67	0.510	1.87
Sum				25.06		77.18

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)
where,
Fwd: resultant force of dynamic hydraulic pressure
Lwd: distance from water level to resultant force working position.
Mwd: dynamic hydraulic moment on check level
Kh : design seismicity(0.04)
Gam w: water unit weight
he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure
Fwd= 2.10(kN/m)
Mwd= 6.72(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	3.200	6.72

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure
Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	749.22 972.00 486.00 498.13
rsst moment Mr(kN.m/m)	1721.22

a.resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro* (1+ d/ H)= 499.48* (1+ 0.500)= 749.22(kN.m/m)
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	43.839 43.000	0.839	166.35 189.00	18.48 21.00	147.86 168.00	132.50	2.411	319.41
2	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	1.494	132.90
3	42.000 41.000	1.000	126.09 138.88	33.91 40.25	92.18 98.63	95.41	0.494	47.17
Sum						316.87		499.48

b.yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active
Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	43.839	43.000	0.839	30.00	0.00	30.00	1.453	60.00	0.484	1.938
2	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
3	42.000	41.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.999

* passive failure plane
Bp= cot(xip)* h

cot(xip)= tan(Phi)+sec(Phi)*Sqrt(- $\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}$)

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

cot(xia)= - tan(Phi)+sec(Phi)*Sqrt(- $\frac{\cos(Theta)\sin(Phi)}{\sin(Phi-Theta)}$ -)

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c. passive resistant moment below check level

Msp= 2* min(Msp1, Msp2)

= 2* min(486.00, 498.13)= 972.00(kN.m/m)

d. resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	-------- * 10^{-6} m³/m -------- * 10^{-6} m³/m * 10^{3} kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e. passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	41.000 40.000	1.000	46.36 58.11	52.23	0.519	27.10
2	40.000 38.000	2.000	93.33 135.21	228.54	2.061	471.04
Sum				280.77		498.13

(5) check level(Layer boundary surface: G.L. 42.000m)

1) check result

item		value
deformation moment	Md(kN.m/m)	149.40
resistant moment	Mr(kN.m/m)	1583.47
factor of safety	Mr/ Md	10.60>=1.00

2) deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	106.67
active earth-prss moment	Ma	0.00
pssv earth-prss moment	- Mp	15.81
other load moment	Mc	0.00
inertia force moment	Me	53.93
dynamic hydraulic moment	Mwd	4.62
deformation moment	Md(kN.m/m)	149.40

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	2.667	53.33
2	44.000 43.000	1.000	20.00 30.00	25.00	1.467	36.67
3	43.000 42.000	1.000	30.00 40.00	35.00	0.476	16.67
Sum				80.00		106.67

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	0.500	0.00
Sum				0.00		0.00

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	0.443	15.81
Sum				35.74		15.81

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)

* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew
= 21.38(kN/m)

Me = Sum(Me)+ Mew
= 53.93(kN.m/m)

* surcharge load

Pew = q* B* Kh
= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)
= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	4.500	19.44
2	46.000 44.000	2.000	4.32 4.32	8.64	3.000	25.92
3	44.000 43.000	1.000	4.32 4.32	4.32	1.500	6.48
4	43.000 42.000	1.000	4.32 3.89	4.10	0.509	2.09
Sum				21.38		53.93

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure
Lwd: distance from water level to resultant force working position.
Mwd: dynamic hydraulic moment on check level
Kh : design seismicity(0.04)
Gamw: water unit weight
he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)
Mwd= 4.62(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	2.200	4.62

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	611.47 972.00 486.00 800.12
rsst moment Mr(kN.m/m)	1583.47

a. resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 489.18* (1+ 0.250)= 611.47(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	44.718 44.000	0.718	123.23 162.00	13.69 18.00	109.54 144.00	91.02	2.343	213.23
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	1.487	232.00
3	43.000 42.000	1.000	113.31 126.09	27.58 33.91	85.74 92.18	88.96	0.494	43.94
Sum						335.98		489.18

b. yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall. If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+Ba (m)
1	44.718	44.000	0.718	30.00	0.00	30.00	1.244	60.00	0.415	1.658
2	44.000	43.000	1.000	30.00	0.00	30.00	1.732	60.00	0.577	2.309
3	43.000	42.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
Interval Sum(Bp) + Ba										5.998

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 800.12)= 972.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name	- - - - - - - -	PU28+1	PU28+1
section modulus before adjust Z	* 10^{-6} m^3/m	3000	3000
eff ratio for section modulus Alp.	- - - - - - - -	0.60	0.60
section modulus in use Alp.Z	* 10^{-6} m^3/m	1800	1800
allowable stress Sig.a	* 10^3 kN/m2	270.0	270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	42.000 41.000	1.000	34.61 46.36	40.48	0.524	21.22
2	41.000 40.000	1.000	46.36 58.11	52.23	1.519	79.33
3	40.000 38.000	2.000	93.33 135.21	228.54	3.061	699.57
Sum				321.25		800.12

(6)check level(Min safety factor: G.L. 39.000m)

1)check result

item		value
deformation moment	Md(kN.m/m)	241.76
resistant moment	Mr(kN.m/m)	1071.93
factor of safety	Mr/ Md	4.43>=1.00

2)deformation moment(Md)calculation

deformation moment in detail		moment
water pressure moment	Mw	504.17
active earth-prss moment	Ma	1.31
pssv earth-prss moment	- Mp	408.26
other load moment	Mc	0.00
inertia force moment	Me	133.63
dynamic hydraulic moment	Mwd	10.92
deformation moment	Md(kN.m/m)	241.76

a. water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	5.667	113.33
2	44.000 43.000	1.000	20.00 30.00	25.00	4.467	111.67
3	43.000 42.000	1.000	30.00 40.00	35.00	3.476	121.67
4	42.000 41.000	1.000	40.00 35.00	37.50	2.511	94.17
5	41.000 40.000	1.000	35.00 30.00	32.50	1.513	49.17
6	40.000 39.000	1.000	30.00 25.00	27.50	0.515	14.17
Sum				177.50		504.17

b. active earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	43.000 42.000	1.000	0.00 0.00	0.00	3.500	0.00
2	42.000 41.000	1.000	0.00 0.00	0.00	2.500	0.00
3	41.000 40.498	0.502	0.00 0.00	0.00	1.749	0.00
4	40.498 40.000	0.498	0.00 3.53	0.88	1.166	1.03
5	40.000 39.739	0.261	0.00 0.00	0.00	0.869	0.00
6	39.739 39.000	0.739	0.00 3.09	1.14	0.246	0.28
Sum				2.02		1.31

c. passive earth pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	3.443	123.03
2	42.000 41.000	1.000	46.36 58.11	52.23	2.481	129.61
3	41.000 40.000	1.000	58.11 69.86	63.99	1.485	95.00
4	40.000 39.000	1.000	114.27 135.21	124.74	0.486	60.62
Sum				276.70		408.26

d. other load moment

* Sum(Pc) = 0.00(kN.m/m)

* Sum(Mc) = 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe) + Pew

= 31.10(kN/m)

Me = Sum(Me) + Mew

= 133.63(kN.m/m)

* surcharge load

Pew = q* B* Kh

= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)

= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	7.500	32.40
2	46.000 44.000	2.000	4.32 4.32	8.64	6.000	51.84
3	44.000 43.000	1.000	4.32 4.32	4.32	4.500	19.44
4	43.000 42.000	1.000	4.32 3.89	4.10	3.509	14.40
5	42.000 41.000	1.000	3.89 3.46	3.67	2.510	9.22
6	41.000 40.000	1.000	3.46 3.02	3.24	1.511	4.90
7	40.000 39.000	1.000	3.02 2.59	2.81	0.513	1.44
Sum				31.10		133.63

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh * Gamw * he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure

Lwd: distance from water level to resultant force working position.
Mwd: dynamic hydraulic moment on check level
Kh : design seismicity(0.04)
Gam w: water unit weight
he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure
  Fwd= 2.10(kN/m)
  Mwd= 10.92(kN.m/m)
* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	5.200	10.92

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure
  Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	943.70 128.23 486.00 64.11
rsst moment Mr(kN.m/m)	1071.93

a.resistant moment above check level
Ground condition for calculation is taken for wall section.
Mro* (1+ d/ H)= 471.85* (1+ 1.000)= 943.70(kN.m/m)
Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	41.867 41.000	0.867	127.80 138.88	34.76 40.25	93.04 98.63	83.09	2.429	201.85
2	41.000 40.000	1.000	138.88 151.66	40.25 46.59	98.63 105.07	101.85	1.495	152.24
3	40.000 39.000	1.000	253.15 275.32	23.79 27.44	229.36 247.88	238.62	0.494	117.77
Sum						423.56		471.85

b.yo calculation process
Starting point is a cross point of check level and riverside sheet pile. passive failure
is considered above. In the same way, take a cross point of riverside and consider active
Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top
height of cross point is limited at top, and width is less than wall width
Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.
If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1	41.867	41.000	0.867	10.00	0.00	40.00	1.033	50.00	0.727	1.761
2	41.000	40.000	1.000	10.00	0.00	40.00	1.192	50.00	0.839	2.031
3	40.000	39.000	1.000	25.00	0.00	32.50	1.570	57.50	0.637	2.207
Interval Sum(Bp) + Ba										5.998

* passive failure plane
  Bp= cot(xip)* h

$$\cot(xip)=\tan(Phi)+\sec(Phi)*\mathrm{Sqrt}\left(\frac{\cos(-Theta)\sin(Phi)}{\sin(Phi-Theta)}\right)$$

xip= 90.0- $\tan^{-1}$ (cot(xip))

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* active failure plane

Ba= cot(xia)* h

$$cot(xia) = -tan(Phi)+sec(Phi)*Sqrt(-\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan^{-1} (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 64.11)= 128.23(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - * 10^{-6} m^3/m - - - - - - - - * 10^{-6} m^3/m * 10^3 kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	39.000 38.000	1.000	114.27 135.21	124.74	0.514	64.11
Sum				124.74		64.11

(7)check level(Current ground level: G.L. 43.000m)

1)check result

item	value
deformation moment MH(kN.m/m)	82.08
resistant moment Mr(kN.m/m)	1335.39
factor of safety Mr/ MH	16.27>=1.00

2)deformation moment(MH)calculation

deformation moment in detail	moment
water pressure moment Mw active earth-prss moment Ma pssv earth-prss moment - Mp other load moment Mc inertia force moment Me dynamic hydraulic moment Mwd	45.00 0.00 0.00 0.00 34.56 2.52
deformation moment MH(kN.m/m)	82.08

a.water pressure moment

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	46.000 44.000	2.000	0.00 20.00	20.00	1.667	33.33
2	44.000 43.000	1.000	20.00 30.00	25.00	0.467	11.67
Sum				45.00		45.00

b.active earth pressure moment

Sum(Pa) = 0.00kN/m Sum(Ma) = 0.00kN.m/m

c. passive earth pressure moment

Sum(Pp) = 0.00kN/m Sum(Mp) = 0.00kN.m/m

d. other load moment

* Sum(Pc)= 0.00(kN.m/m)
* Sum(Mc)= 0.00(kN.m/m)

e. inertia force moment

Inertia force moment is given by sum of surcharge load and wall self-weight.

* all inertia force

Fe = Sum(Pe)+ Pew
= 17.28(kN/m)

Me = Sum(Me)+ Mew
= 34.56(kN.m/m)

* surcharge load

Pew = q* B* Kh
= 0.00(kN/m)

Mew = Pew* (height from check level to top of wall)
= 0.00(kN.m/m)

* wall self-weight

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	inertia frc pe (kN/m2)	H-frc Pe (kN/m)	arm L y (m)	moment Me (kN.m/m)
1	47.000 46.000	1.000	4.32 4.32	4.32	3.500	15.12
2	46.000 44.000	2.000	4.32 4.32	8.64	2.000	17.28
3	44.000 43.000	1.000	4.32 4.32	4.32	0.500	2.16
Sum				17.28		34.56

f. dynamic hydraulic pressure moment

* resultant force by dynamic hydraulic pressure, work position general equation

If outside WT, inside WT exist, dynamic hydraulic prss as ext frc works at free water, working force and moment are given by sum of both.

$$Fwd = \frac{7}{12} * Kh* Gamw* he^{(1/2)} * y^{(3/2)}$$

$$Lwd = \frac{3}{5} * y$$

Mwd = Fwd* (distance from check level to resultant force position)

where,

Fwd: resultant force of dynamic hydraulic pressure
Lwd: distance from water level to resultant force working position.
Mwd: dynamic hydraulic moment on check level
Kh : design seismicity(0.04)
Gamw: water unit weight
he : distance from water level to current ground level
y : distance from water level to check level(y<=he)

* total dynamic hydraulic pressure

Fwd= 2.10(kN/m)
Mwd= 2.52(kN.m/m)

* outside dynamic hydraulic pressure

water table GL(m)	current GL(m)	current WT he (m)	check lv WT y (m)	rslt ps Lwd (m)	rslt frc Fwd kN/m	arm length L (m)	moment Mwd kN.m/m
46.000	43.000	3.000	3.000	1.800	2.10	1.200	2.52

Note: Lwd is a distance from water level, resultant force works at G.L. 44.200(m).
Note: Arm length is a distance from check level to resultant force point.

* inside dynamic hydraulic pressure

Dynamic hydraulic pressure does not work.

3)resistant moment(Mr)calculation

resistant moment in detail	moment
Mro* (1+ d/ H) Msp= 2* min(Msp1, Msp2) Msp1 Msp2	363.39 972.00 486.00 1136.72
rsst moment Mr(kN.m/m)	1335.39

a.resistant moment above check level

Ground condition for calculation is taken for wall section.

Mro* (1+ d/ H)= 363.39* (1+ 0.000)= 363.39(kN.m/m)

Arm length = distance from check level to layer bottom + (h/ 3)* (2* p1+ p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	passive pRP (kN/m2)	active pRA (kN/m2)	side pRP-pRA (kN/m2)	H-frc Pr (kN/m)	arm L y (m)	moment Mro kN.m/m
1	45.598 44.000	1.598	75.71 162.00	8.41 18.00	67.30 144.00	168.83	1.702	287.39
2	44.000 43.000	1.000	162.00 189.00	18.00 21.00	144.00 168.00	156.00	0.487	76.00
Sum						324.83		363.39

b.yo calculation process

Starting point is a cross point of check level and riverside sheet pile. passive failure is considered above. In the same way, take a cross point of riverside and consider active Both failure cross at yo. Width of cross point is wall width. If yo is higher than wall top height of cross point is limited at top, and width is less than wall width

Hence, if sum of failure(decay) width and wall width are same, yo is lower than top of wall.

If less than wall width, yo is up to top of wall.

No	depth		thick. h (m)	inter fric Phi (deg)	seis-angle Theta (deg)	passive failure		active failure		failure W
	top GL(m)	bottom GL(m)				angle xip	width Bp (m)	angle xia	width Ba (m)	Bp+ Ba (m)
1 2	45.598 44.000	44.000 43.000	1.598 1.000	30.00 30.00	0.00 0.00	30.00 30.00	2.768 1.732	60.00 60.00	0.923 0.577	3.690 2.309
Interval Sum(Bp) + Ba										6.000

* passive failure plane

Bp= cot(xip)* h

$$cot(xip)= tan(Phi)+sec(Phi)*Sqrt(\frac{cos(-Theta)sin(Phi)}{sin(Phi-Theta)})$$

xip= 90.0- tan-1 (cot(xip))

* active failure plane

Ba= cot(xia)* h

$$cot(xia)= -tan(Phi)+sec(Phi)*Sqrt(\frac{cos(Theta)sin(Phi)}{sin(Phi-Theta)})$$

xia= 90.0- tan-1 (cot(xia))

* If sin(Phi- Theta)<=0, cot(xip)= cot(xia)= tan(Phi)+sec(Phi)

c.passive resistant moment below check level

Msp= 2* min(Msp1,Msp2)

= 2* min(486.00, 1136.72)= 972.00(kN.m/m)

d.resistant moment (Msp1) of sheet pile

It is represented by either landside or riverside smaller one.

item	unit	landside	riverside
Steel material name section modulus before adjust Z eff ratio for section modulus Alp. section modulus in use Alp.Z allowable stress Sig.a	- - - - - - - - $* 10^{-6}$ m^3/m - - - - - - - - $* 10^{-6}$ m^3/m $* 10^3$ kN/m2	PU28+1 3000 0.60 1800 270.0	PU28+1 3000 0.60 1800 270.0
resistant mt Msp1 = Sig.a* Alp.Z	kN* m/m	486.00	486.00

e.passive earth pressure moment below check level (Msp2)

Resistant moment of sheet pile is given as passive earth press moment at check level, for it does not exceed passive resistant moment.

geological condition for calculation is represented by those of riverside section.

Arm length = distance from check level to layer bottom + (h/ 3)* (p1+ 2* p2)/ (p1+ p2)

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	22.85 34.61	28.73	0.534	15.34
2	42.000 41.000	1.000	34.61 46.36	40.48	1.524	61.70
3	41.000 40.000	1.000	46.36 58.11	52.23	2.519	131.57
4	40.000 38.000	2.000	93.33 135.21	228.54	4.061	928.11
Sum				349.98		1136.72

5.2.2 Check on wall slide

(1)result summery

1)check equation

wall width B= 6.000, height H= 4.000(m), check the dimensions using the next equation.

$$\frac{Fr}{Fd} >= FS$$

where,

FS: required factor of safety(1.00)

Fd: sum of H force on wall(kN/m)

Fr: sum of sliding resistance(kN/m)

Fr= Fpp+ Fs

where,

Fpp: horizontal force by passive earth pressure

Fs : horizontal shear resistant force of ground below check level

Fs= c* B+ W* tan(Phi)

W : soil weight in wall(kN/m)

Phi: soil internal friction angle below check level (degree)

c : soil cohesion below check level(kN/m2)

2)check result

check at the tip of embedment

check position	check lv G.L.(m)	check depth d	sum H-frc Fd(kN/m)	sum rsst Fr(kN/m)	Factor of safety F
embed tip	38.000	5.000	242.78	784.55	3.23>=1.00

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item	value
sum of H-force Fd(kN/m)	242.78
sum of rsst Fr(kN/m)	784.55
factor of safety Fr/ Fd	3.23>=1.00

2)sum of horizontal force(Fd)

horizontal force in detail		H-force
water pressure	Fw	200.00
active earth pressure	Fa	7.20
other load	Fc	0.00
inertia force	Fe	33.48
dynamic hydraulic prrs	Fwd	2.10
sum of H-force	Fd(kN/m)	242.78

a.water pressure

table of water pressure moment when shear deformation failures is check at tip of embedment.

b.active earth pressure

table of active earth pressure when shear deformation failures is check at tip of embedment.

c.other load

table of other load when shear deformation failures is check at tip of embedment.

d.inertia force

table of inertia force when shear deformation failures is check at tip of embedment.

e.dynamic hydraulic pressure

table of dynamic hydraulic press. when shear deform failures is checked at tip of embedment.

3)calculation on sum of sliding resistance(Fr)

resistance in detail		H-force
ground H resistance	Fs	362.17
passive earth pressure	Fp	422.38
sum of resistance	Fr(kN/m)	784.55

a.calculation on ground horizontal resistance (Fs)

Fs= c* B+ W* tan(Phi)

= 10.00* 6.000+ 648.00* tan(25.00) Deg.

= 362.17(kN/m)

b. soil weight in wall(W)

range to calculate weight is from top of wall to check level (with filling). Use wall section.

W = (Sum(Gami hi) + q)* B

= (108.00+ 0.00)* 6.000= 648.00(kN/m)

where, q is surcharge load.

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gami* hi (kN/m2)
1	47.000	46.000	1.000	18.0	18.00
2	46.000	44.000	2.000	18.0	36.00
3	44.000	43.000	1.000	9.0	9.00
4	43.000	42.000	1.000	9.0	9.00
5	42.000	41.000	1.000	9.0	9.00
6	41.000	40.000	1.000	9.0	9.00
7	40.000	38.000	2.000	9.0	18.00
Sum			9.000		108.00

c. passive earth pressure

table of passive earth pressure when shear deformation failures is check at tip of embedment.

5.2.3 Check bearing capacity of foundation ground

(1)result summery

1)check equation

Examined wall width B= 6.000, height H= 4.000(m) using the next equation.

$$\frac{Qu}{V-Gam2*Df*Be} >= FS$$

$$Qu = Be\{ k*c*Nc+k*Gam2*Df*(Nq-1)+\frac{1}{2}*Gam1*Be*NGam \}$$

where,

FS : required factor of safety(1.00)

Qu : ground ultimate bearing capacity considering load eccentricity and inclination(kN/m)

V : vertical component on check level(weight inside wall above the level)(kN/m)

Be : effective loading width considering eccentricity (m)

Be= B-2e

B: wall width

e: eccentricity(e= Mb/V)

Mb : moment working on check level

k : overdesign coefficient for embedment effect(= 1.0)

c : cohesion below check level

Df : distance from ground level to check level

Gam2: average unit weight of soil from ground level to check level (Df). submerged below WT.

Gam1: unit weight of soil in foundation ground below check level. submerged weight below WT.

Nc,Nq,NGam : bearing capacity factor considering load eccentricity(design manual fig.8.10 to 12)

tan(Alpha) = Hb/V

Hb: horizontal component of resultant force on check level

2)check result

only check at tip of embedment

check point	check lv G.L.(m)	check depth d	ult bear cap Qu(kN/m)	V-Gam2.Df.Be (kN/m)	Factor of safety F
ebd tip	38.000	5.000	4595.77	394.92	11.64>=1.00

(2)check level(embedment tip: G.L. 38.000m)

1)check result

item		symbol	value
V	soil weight filling (with srchg ld)	V	648.00
	distance from ground to check level	Df	5.000
	ave ut wt from ground to check level	Gam2	9.00
	eff loading width w/ eccentricity	Be	5.624
	v-compo sum V-Gam2.Df.Be (kN/m)		394.92
Qu	moment on check level	Mb	121.82
	H-compo of resultant force on level	Hb	0.00
	eccentricity distance	e	0.188
	resultant frc inclination(Hb/V)	tanAlp.	0.000
	internal friction angle at bottom	Phi	25.00
	cohesion at bottom	c	10.00
	unit weight of soil bottom	Gam1	9.00
	bearing capacity factor	Nc	20.721
	bearing capacity factor	Nq	10.662
	bearing capacity factor	NGam	6.921
	ult bear cap of ground Qu (kN/m)		4595.77
factor of safety			11.64>=1.00

2)summery of external force

external force detail		moment Mb(kN.m/m)	H force Hb(kN/m)
water pressure	Mw(Fw)	693.33	200.00
active earth pressure	Ma(Fa)	5.57	7.20
passive earth pressure-	Mp(Fp)	756.06	422.38
other load	Mc(Fc)	0.00	0.00
inertia force	Me(Fe)	165.96	33.48
dynamic water prss	Mwd(Fwd)	13.02	2.10
external force sum		121.82	0.00

a.water pressure

refer to water pressure in checking shear failure at embedment tip

b. active earth pressure

refer to active earth pressure in checking shear failure at embedment tip

c. passive earth pressure

refer to passive earth pressure in checking shear failure at embedment tip

d. other load

refer to other load in checking shear failure at embedment tip

e. inertia load

refer to inertia force in checking shear failure at embedment tip

f. dynamic water pressure

refer to dynamic water pressure in checking shear failure at embedment tip

3) weight of filling soil(V)

refer to 'b. weight of filling soil' in 'sum of sliding resistance' under 'result on slide'.

V = 648.00(kN/m)

4) eccentricity distance(e) calculation

e = Mb/ V

= 121.82/ 648.00

= 0.188(m)

Be= B- 2e

= 6.000- 2.0* 0.188

= 5.624(m)

5) calculation on inclination of resultant force

tan(Alpha) = Hb/ V

= 0.00/ 648.00

= 0.000

6) calculation of Gam 2

average unit weight of soil from ground level to check level (Df). submerged below water level.

for simplicity, use geological data in embankment

$$Gam\ 2 = \frac{Sum(Gam\ i\ hi)}{Sum(hi)}$$

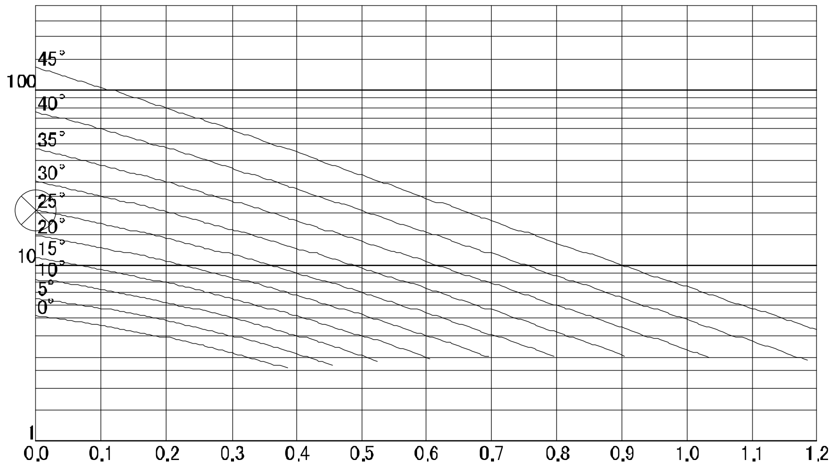
= 9.00(kN/m³)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. hi (m)	soil ut weight Gam (kN/m3)	soil eff weight Gam i* hi (kN/m2)
1	43.000	42.000	1.000	9.0	9.00
2	42.000	41.000	1.000	9.0	9.00
3	41.000	40.000	1.000	9.0	9.00
4	40.000	38.000	2.000	9.0	18.00
Sum			5.000		45.00

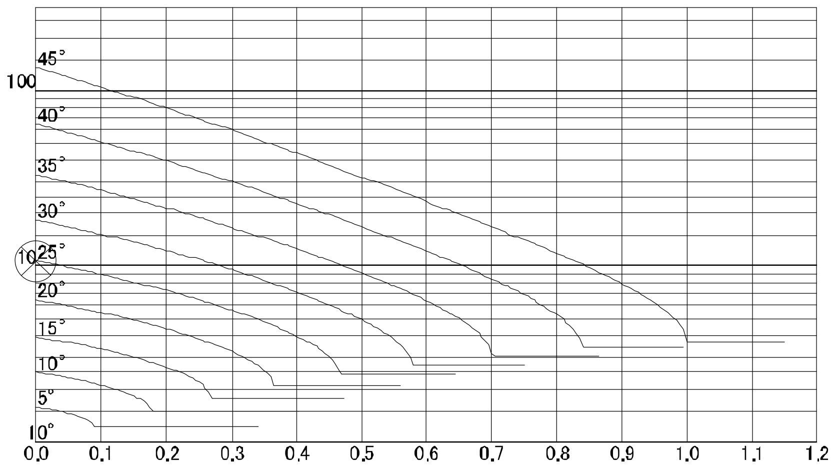
(3) bearing capacity factor calculation diagram

inclination of resultant force(Mo/ Ho)	tan(Alpha)	=	0.000
internal friction angle below check level	Phi	=	25.00
bearing capacity factor	Nc	=	20.721
bearing capacity factor	Nq	=	10.662
bearing capacity factor	NGam	=	6.921

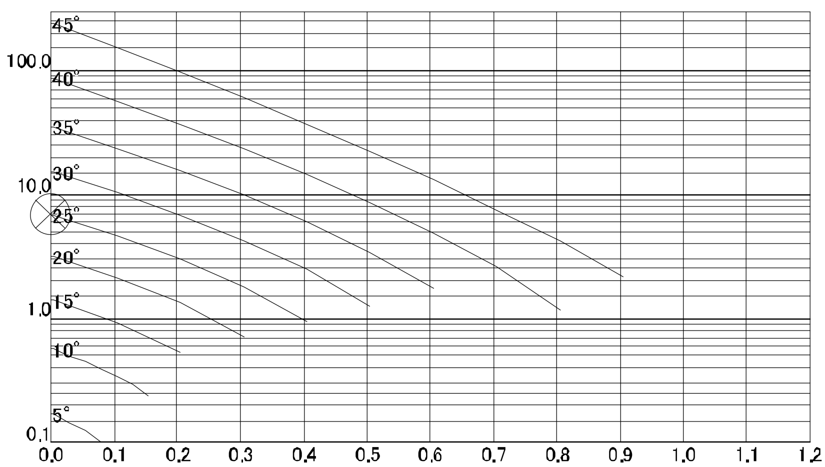
1) Nc calculation diagram



2) Nq calculation diagram



3) NGam calculation diagram



5.3 landside sheet pile

5.3.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 42.000(m)

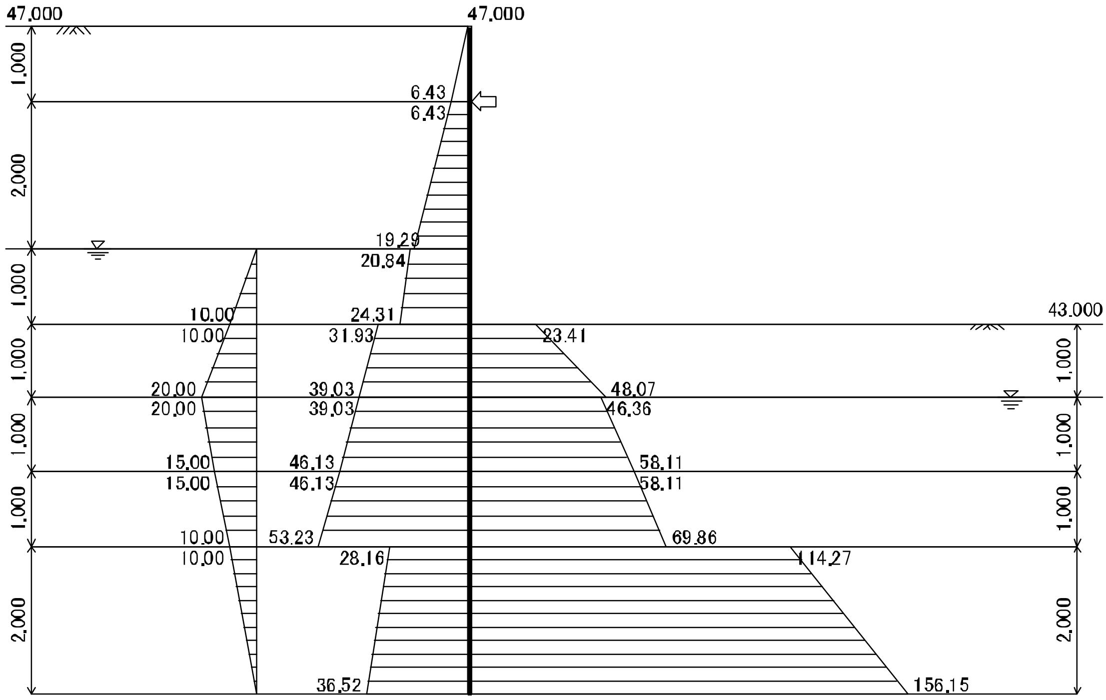
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	39.380	38.000
active sd	Ma+Mw+Mac(kN.m/m)	987.21	1413.07
passive sd	Mp+Mpc(kN.m/m)	1188.94	2622.97
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.204>=1.20	1.856>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.43 19.29	25.72	1.167	30.01
2	44.000 43.000	1.000	20.84 24.31	22.58	2.513	56.73
3	43.000 42.000	1.000	31.93 39.03	35.48	3.517	124.77
4	42.000 41.000	1.000	39.03 46.13	42.58	4.514	192.20
5	41.000 40.000	1.000	46.13 53.23	49.68	5.512	273.83
6	40.000 38.000	2.000	28.16 36.52	64.68	7.043	455.52
Sum				240.72		1133.07

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 20.00	15.00	3.556	53.33
3	42.000 41.000	1.000	20.00 15.00	17.50	4.476	78.33
4	41.000 40.000	1.000	15.00 10.00	12.50	5.467	68.33
5	40.000 38.000	2.000	10.00 0.00	10.00	6.667	66.67
Sum				60.00		280.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	23.41 48.07	35.74	3.557	127.14
2	42.000 41.000	1.000	46.36 58.11	52.23	4.519	236.03
3	41.000 40.000	1.000	58.11 69.86	63.99	5.515	352.91
4	40.000 38.000	2.000	114.27 156.15	270.42	7.052	1906.89
Sum				422.38		2622.97

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

5.3.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	-108.97	G.L. 42.800
max shear force Smax(kN/m)	-55.90	G.L. 46.000
upper tension mbr rct R1(kN/m)	-59.79	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss. Earth and water pressure of clay as well as sand separately works on sheet pile. Active, water, passive, at rest pressure should be referred to 'Table of earth & water pressure' effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	0.00 6.43	0.00 0.00	---- ----	---- ----	0.00 6.43	---- ----
2	46.000 44.000	6.43 19.29	0.00 0.00	---- ----	---- ----	6.43 19.29	---- ----
3	44.000 43.000	20.84 24.31	0.00 10.00	---- ----	---- ----	20.84 34.31	---- ----
4	43.000 42.000	31.93 39.03	10.00 20.00	23.41 48.07	0.00 14.87	41.93 44.16	23.41 33.20
5	42.000 41.000	39.03 46.13	20.00 15.00	46.36 58.11	14.87 22.31	44.16 38.82	31.48 35.80
6	41.000 40.000	46.13 53.23	15.00 10.00	58.11 69.86	22.31 29.75	38.82 33.48	35.80 40.11
7	40.000 38.000	28.16 36.52	10.00 0.00	114.27 156.15	20.79 31.18	17.37 5.34	93.48 124.97

Note: is non-effective for earth pressure in calculation.

other load

3)spring condition

passive spring is given by the following equation.

$$kH = Eta * \frac{1}{0.3} * Alpha\ Eo * \left(\frac{BH}{0.3}\right)^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	1346
2	42.000	41.000	1.000	5600	2691
3	41.000	40.000	1.000	8400	4037
4	40.000	38.000	2.000	44800	21529
5	38.000	37.000	1.000	50400	24220
6	37.000	36.000	1.000	75600	36331
7	36.000	35.000	1.000	47600	22875
8	35.000	34.000	1.000	58800	28257
9	34.000	33.000	1.000	131600	63242
10	33.000	32.000	1.000	86800	41713
11	32.000	31.000	1.000	81200	39022
12	31.000	30.000	1.000	117600	56514
13	30.000	29.000	1.000	114800	55169
14	29.000	28.000	1.000	84000	40367
15	28.000	27.000	1.000	112000	53823

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks = \frac{Alp. * (2 * number * A * E)}{(L * s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]

L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area

* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.

5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)

1)description on condition

* above excavated surface
  wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
  in embedment section, displacement on excavation side is within limit displacement.
  effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
  in embedment section, displacement on excavation side exceeds limit displacement.
  effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
  in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic

2)table of load conditions

node No	Y co GL(m)	state	back side load above nd kN/m2	back side load below nd kN/m2	back side load cntrt ld kN/m2	excavation side load above nd kN/m2	excavation side load below nd kN/m2	excavation side load cntrt ld kN/m2	soil spring kN/m
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	29787
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	20.84	4.05	--------	--------	--------	--------
17	43.800	On excavation plane	23.54	23.54	4.71	--------	--------	--------	--------
18	43.600	On excavation plane	26.23	26.23	5.25	--------	--------	--------	--------
19	43.400	On excavation plane	28.92	28.92	5.78	--------	--------	--------	--------
20	43.200	On excavation plane	31.62	31.62	6.32	--------	--------	--------	--------
21	43.000	Pas ela.	34.31	41.93	7.57	0.00	23.41	--------	135
22	42.800	Pas ela.	42.38	42.38	8.48	25.37	25.37	--------	269

node No	Y co GL(m)	state	back side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	excavation side load above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	soil spring kN/m
23	42.600	Pas ela.	42.82	42.82	8.56	27.32	27.32	--------	269
24	42.400	Pas ela.	43.27	43.27	8.65	29.28	29.28	--------	269
25	42.200	Pas ela.	43.71	43.71	8.74	31.24	31.24	--------	269
26	42.000	Pas ela.	44.16	44.16	8.79	33.20	31.48	--------	404
27	41.800	Pas ela.	43.09	43.09	8.62	32.35	32.35	--------	538
28	41.600	Pas ela.	42.02	42.02	8.40	33.21	33.21	--------	538
29	41.400	Pas ela.	40.95	40.95	8.19	34.07	34.07	--------	538
30	41.200	Pas ela.	39.89	39.89	7.98	34.94	34.94	--------	538
31	41.000	Pas ela.	38.82	38.82	7.76	35.80	35.80	--------	673
32	40.800	Pas ela.	37.75	37.75	7.55	36.66	36.66	--------	807
33	40.600	Pas ela.	36.68	36.68	7.34	37.52	37.52	--------	807
34	40.400	Pas ela.	35.62	35.62	7.12	38.39	38.39	--------	807
35	40.200	Pas ela.	34.55	34.55	6.91	39.25	39.25	--------	807
36	40.000	Pas ela.	33.48	17.37	5.08	40.11	93.48	--------	2557
37	39.800	Pas ela.	16.17	16.17	3.23	96.63	96.63	--------	4306
38	39.600	Pas ela.	14.97	14.97	2.99	99.78	99.78	--------	4306
39	39.400	Pas ela.	13.76	13.76	2.75	102.93	102.93	--------	4306
40	39.200	Pas ela.	12.56	12.56	2.51	106.08	106.08	--------	4306
41	39.000	Pas ela.	11.36	11.36	2.27	109.23	109.23	--------	4306
42	38.800	Pas ela.	10.15	10.15	2.03	112.38	112.38	--------	4306
43	38.600	Pas ela.	8.95	8.95	1.79	115.52	115.52	--------	4306
44	38.400	Act ela.	7.75	7.75	1.55	118.67	118.67	--------	4306
45	38.200	Act ela.	6.54	6.54	1.31	121.82	121.82	--------	4306
46	38.000	Act ela.	5.34	0.00	0.56	124.97	0.00	--------	2153
Sum					199.91			0.00	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)

max displacement Del.xmax= 10.03mm(G.L. 42.600m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	-1.80	- - - -	- - - -
2	46.800	on exv	- - - -	-1.04	- - - -	- - - -
3	46.600	on exv	- - - -	-0.28	- - - -	- - - -
4	46.400	on exv	- - - -	0.48	- - - -	- - - -
5	46.200	on exv	- - - -	1.25	- - - -	- - - -
6	46.000	on exv	29787	2.01	- - - -	Note: -59.79
7	45.800	on exv	- - - -	2.77	- - - -	- - - -
8	45.600	on exv	- - - -	3.52	- - - -	- - - -
9	45.400	on exv	- - - -	4.26	- - - -	- - - -
10	45.200	on exv	- - - -	4.98	- - - -	- - - -
11	45.000	on exv	- - - -	5.68	- - - -	- - - -
12	44.800	on exv	- - - -	6.34	- - - -	- - - -
13	44.600	on exv	- - - -	6.96	- - - -	- - - -
14	44.400	on exv	- - - -	7.53	- - - -	- - - -
15	44.200	on exv	- - - -	8.06	- - - -	- - - -
16	44.000	on exv	- - - -	8.53	- - - -	- - - -
17	43.800	on exv	- - - -	8.95	- - - -	- - - -
18	43.600	on exv	- - - -	9.30	- - - -	- - - -
19	43.400	on exv	- - - -	9.58	- - - -	- - - -
20	43.200	on exv	- - - -	9.80	- - - -	- - - -
21	43.000	pssv el	135	9.94	17.76	-1.34
22	42.800	pssv el	269	10.02	18.85	-2.70
23	42.600	pssv el	269	10.03	20.31	-2.70
24	42.400	pssv el	269	9.96	21.76	-2.68

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	269	9.83	23.22	-2.64
26	42.000	pssv el	404	9.63	15.95	-3.89
27	41.800	pssv el	538	9.37	12.02	-5.04
28	41.600	pssv el	538	9.04	12.34	-4.87
29	41.400	pssv el	538	8.67	12.66	-4.66
30	41.200	pssv el	538	8.24	12.98	-4.43
31	41.000	pssv el	673	7.76	10.64	-5.22
32	40.800	pssv el	807	7.25	9.08	-5.85
33	40.600	pssv el	807	6.70	9.30	-5.41
34	40.400	pssv el	807	6.12	9.51	-4.94
35	40.200	pssv el	807	5.52	9.72	-4.46
36	40.000	pssv el	2557	4.90	5.25	-12.54
37	39.800	pssv el	4306	4.28	4.49	-18.42
38	39.600	pssv el	4306	3.65	4.63	-15.72
39	39.400	pssv el	4306	3.02	4.78	-13.02
40	39.200	pssv el	4306	2.40	4.93	-10.33
41	39.000	pssv el	4306	1.78	5.07	-7.67
42	38.800	pssv el	4306	1.17	5.22	-5.02
43	38.600	pssv el	4306	0.55	5.37	-2.39
44	38.400	actv el	4306	-0.05	5.51	0.24
45	38.200	actv el	4306	-0.66	5.66	2.85
46	38.000	actv el	2153	-1.27	5.77	2.73
Sum						-199.91

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

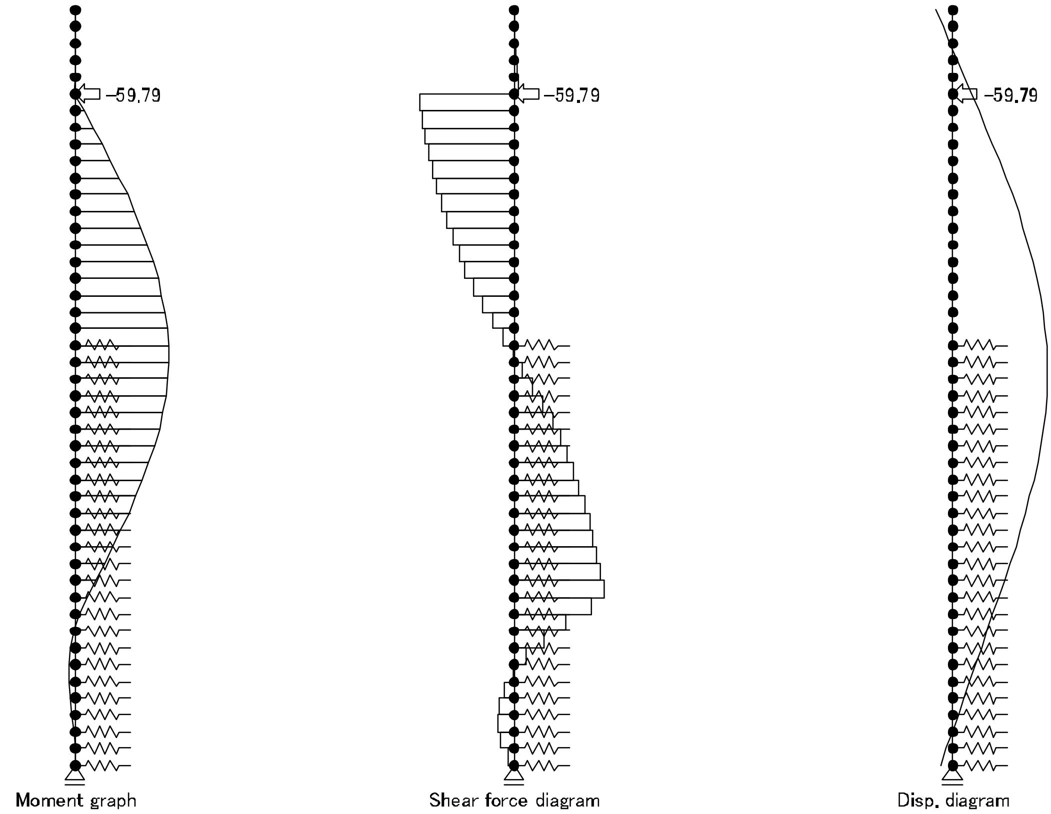
max bending moment Mmax= -108.97kN m/m(G.L. 42.800m)
max shear force Smax= -55.90kN/m (G.L. 46.000m)
max displacement Del.xmax= 10.03mm (G.L. 42.600m)

node No	Y co GL(m)	moment kN m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	0.03	-1.80	------------
2	46.800	0.01	0.01	0.03	0.29	-1.04	------------
3	46.600	0.06	0.06	0.29	0.80	-0.28	------------
4	46.400	0.23	0.23	0.80	1.58	0.48	------------
5	46.200	0.54	0.54	1.58	2.60	1.25	------------
6	46.000	1.06	1.06	2.60	-55.90	2.01	* -59.79
7	45.800	-10.12	-10.12	-55.90	-54.36	2.77	------------
8	45.600	-20.99	-20.99	-54.36	-52.56	3.52	------------
9	45.400	-31.50	-31.50	-52.56	-50.50	4.26	------------
10	45.200	-41.60	-41.60	-50.50	-48.19	4.98	------------
11	45.000	-51.24	-51.24	-48.19	-45.61	5.68	------------
12	44.800	-60.36	-60.36	-45.61	-42.78	6.34	------------
13	44.600	-68.92	-68.92	-42.78	-39.70	6.96	------------
14	44.400	-76.86	-76.86	-39.70	-36.35	7.53	------------
15	44.200	-84.13	-84.13	-36.35	-32.75	8.06	------------
16	44.000	-90.68	-90.68	-32.75	-28.70	8.53	------------
17	43.800	-96.42	-96.42	-28.70	-24.00	8.95	------------
18	43.600	-101.22	-101.22	-24.00	-18.75	9.30	------------
19	43.400	-104.97	-104.97	-18.75	-12.97	9.58	------------
20	43.200	-107.56	-107.56	-12.97	-6.64	9.80	------------
21	43.000	-108.89	-108.89	-6.64	-0.41	9.94	-1.34
22	42.800	-108.97	-108.97	-0.41	5.37	10.02	-2.70
23	42.600	-107.90	-107.90	5.37	11.23	10.03	-2.70
24	42.400	-105.65	-105.65	11.23	17.21	9.96	-2.68
25	42.200	-102.21	-102.21	17.21	23.30	9.83	-2.64
26	42.000	-97.55	-97.55	23.30	28.21	9.63	-3.89
27	41.800	-91.91	-91.91	28.21	31.79	9.37	-5.04
28	41.600	-85.55	-85.55	31.79	35.32	9.04	-4.87
29	41.400	-78.49	-78.49	35.32	38.85	8.67	-4.66
30	41.200	-70.72	-70.72	38.85	42.39	8.24	-4.43
31	41.000	-62.24	-62.24	42.39	44.93	7.76	-5.22
32	40.800	-53.25	-53.25	44.93	46.63	7.25	-5.85
33	40.600	-43.93	-43.93	46.63	48.56	6.70	-5.41
34	40.400	-34.21	-34.21	48.56	50.74	6.12	-4.94
35	40.200	-24.06	-24.06	50.74	53.20	5.52	-4.46
36	40.000	-13.43	-13.43	53.20	45.74	4.90	-12.54
37	39.800	-4.28	-4.28	45.74	30.55	4.28	-18.42
38	39.600	1.83	1.83	30.55	17.83	3.65	-15.72
39	39.400	5.40	5.40	17.83	7.56	3.02	-13.02
40	39.200	6.91	6.91	7.56	-0.26	2.40	-10.33
41	39.000	6.86	6.86	-0.26	-5.66	1.78	-7.67
42	38.800	5.73	5.73	-5.66	-8.64	1.17	-5.02
43	38.600	4.00	4.00	-8.64	-9.24	0.55	-2.39
44	38.400	2.15	2.15	-9.24	-7.46	-0.05	0.24
45	38.200	0.66	0.66	-7.46	-3.30	-0.66	2.85
46	38.000	0.00	----------	-3.30	----------	-1.27	2.73

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= -108.97kN m/m (G.L. 42.800m)
max shear force Smax= -55.90kN/m (G.L. 46.000m)
max displacement Del.xmax= 10.03mm (G.L. 42.600m)



* in figure, number in arrow shows tensile reaction (kN/m)

5.3.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	108.97	0.00	55.90

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} \quad <= \quad Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	61	270	OK

(4) shear stress

$$Tau = \frac{S}{A} \quad <= \quad Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	2	125	OK

5.3.4 Tensile member stress

(1) check on tensile member

1) member in use

diameter in use : Phi 32(mm)

material in use : ,’£–í |690

allowable stress : 264(N/mm2)

tensile member layout pitch L : 1.800(m)

number of tensile member in use : 1

tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
59.79	1.800	107.63

3) stress

$$Sig. = \frac{P^* 10^3}{n^* A} \quad <= Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
134	264	OK

5.3.5 Waling member stress

(1) Wailing check

1) member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 210(N/mm2)

installation spacing : 1.800(m)

2) moment calculation

$$M= \frac{P* L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
107.63	1.800	19.37

3) stress

$$Sig. = \frac{M*10^6}{Z*10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
84	210	OK

5.4 riverside sheet pile

5.4.1 Calculation of embedment length

(1)result summery

steel name in use : PU28+1
total length in use : 9.000(m)
position of tensile member G.L. : 46.000(m)
external force above tensile member: Ignore
non effective layer in passive side: 0.000(m)
R.WL : 44.000(m)
L.WL : 43.000(m)

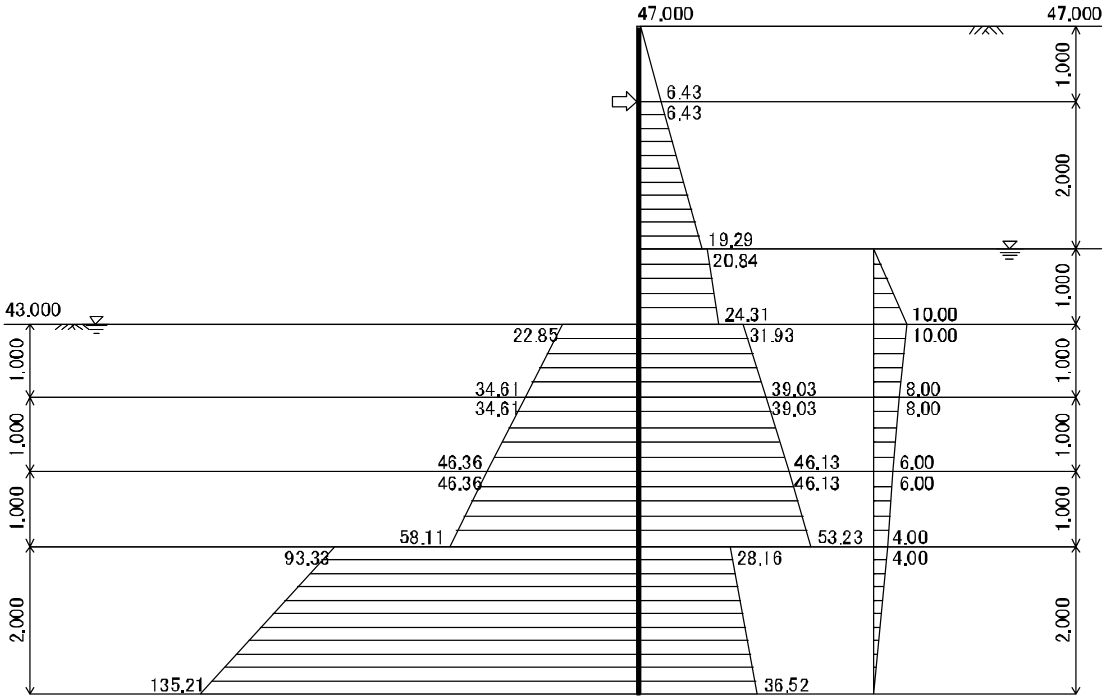
Embedment length must be satisfied with the next equation about actv and pssv moment at tensile mbr..

$$Fs = \frac{Mp + Mpc}{Ma + Mw + Mac} >= Fsa$$

where,

Fsa: required factor of safety(Sandy ground: 1.20)
Mp : moment at tensile member by passive earth pressure
Ma : moment at tensile member by active earth pressure
Mw : moment at tensile member by water pressure
Mac: active moment at tensile member by other loads
Mpc: passive moment at tensile member by other loads

item	embedment length	required	in use
tip depth	G.L.(m)	39.160	38.000
active sd	Ma+Mw+Mac(kN.m/m)	934.59	1263.07
passive sd	Mp+Mpc(kN.m/m)	1124.72	2186.68
F.S.	(Mp+Mpc)/(Ma+Mw+Mac)	1.203>=1.20	1.731>=1.20



FORUM8

(2)external force summery table

1)active earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pa (kN/m2)	H-frc Pa (kN/m)	arm L y (m)	moment Ma (kN.m/m)
1	46.000 44.000	2.000	6.43 19.29	25.72	1.167	30.01
2	44.000 43.000	1.000	20.84 24.31	22.58	2.513	56.73
3	43.000 42.000	1.000	31.93 39.03	35.48	3.517	124.77
4	42.000 41.000	1.000	39.03 46.13	42.58	4.514	192.20
5	41.000 40.000	1.000	46.13 53.23	49.68	5.512	273.83
6	40.000 38.000	2.000	28.16 36.52	64.68	7.043	455.52
Sum				240.72		1133.07

2)water pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pw (kN/m2)	H-frc Pw (kN/m)	arm L y (m)	moment Mw (kN.m/m)
1	44.000 43.000	1.000	0.00 10.00	5.00	2.667	13.33
2	43.000 42.000	1.000	10.00 8.00	9.00	3.481	31.33
3	42.000 41.000	1.000	8.00 6.00	7.00	4.476	31.33
4	41.000 40.000	1.000	6.00 4.00	5.00	5.467	27.33
5	40.000 38.000	2.000	4.00 0.00	4.00	6.667	26.67
Sum				30.00		130.00

3)passive earth pressure moment table

No	depth GL(m)	thick. h (m)	sd prss pp (kN/m2)	H-frc Pp (kN/m)	arm L y (m)	moment Mp (kN.m/m)
1	43.000 42.000	1.000	22.85 34.61	28.73	3.534	101.54
2	42.000 41.000	1.000	34.61 46.36	40.48	4.524	183.15
3	41.000 40.000	1.000	46.36 58.11	52.23	5.519	288.27
4	40.000 38.000	2.000	93.33 135.21	228.54	7.061	1613.72
Sum				349.98		2186.68

4)other load moment table(Mac:input load intensity has positive sign)

Sum(Pac) = 0.00kN/m

Sum(Mac)= 0.00kN.m/m

5)other load moment table(Mac:input load intensity has negative sign)

Sum(Ppc)= 0.00kN/m

Sum(Mpc)= 0.00kN.m/m

5.4.2 Calculation on wall member forces

(1)result summery

1)calculation result

Bending moment of sheet pile, reaction of tensile member are calculated elasto-plastic below.

calculation items	result	points
max bending moment Mmax(kN.m/m)	104.84	G.L. 43.000
max shear force Smax(kN/m)	54.55	G.L. 46.000
upper tension mbr rct R1(kN/m)	58.44	G.L. 46.000

2)load condition

Side pressures for elasto-plastic analysis are deducted at-rest pressure from earth & wtr prss.
Earth and water pressure of clay as well as sand separately works on sheet pile. Active,
water, passive, at rest pressure should be referred to 'Table of earth & water pressure'
effective side pressure distribution table is shown here,

No	depth GL(m)	back side pressure active (kN/m2)	back side pressure water (kN/m2)	exv side pressure passive (kN/m2)	exv side pressure at rest (kN/m2)	effectiv active (kN/m2)	effective passive (kN/m2)
1	47.000 46.000	0.00 6.43	0.00 0.00	---- ----	---- ----	0.00 6.43	---- ----
2	46.000 44.000	6.43 19.29	0.00 0.00	---- ----	---- ----	6.43 19.29	---- ----
3	44.000 43.000	20.84 24.31	0.00 10.00	---- ----	---- ----	20.84 34.31	---- ----
4	43.000 42.000	31.93 39.03	10.00 8.00	22.85 34.61	0.00 7.44	41.93 39.59	22.85 27.17
5	42.000 41.000	39.03 46.13	8.00 6.00	34.61 46.36	7.44 14.87	39.59 37.26	27.17 31.48
6	41.000 40.000	46.13 53.23	6.00 4.00	46.36 58.11	14.87 22.31	37.26 34.92	31.48 35.80
7	40.000 38.000	28.16 36.52	4.00 0.00	93.33 135.21	15.59 25.98	16.57 10.53	77.74 109.23

Note: is non-effective for earth pressure in calculation.
other load

3)spring condition

passive spring is given by the following equation.

$$kH= Eta*\frac{1}{0.3}*Alpha\ Eo*(\frac{BH}{0.3})^{(-3/4)}$$

where,

Eta: coefficient of wall type, continuous wall Eta= 1.0

BH: equivalent loading width(10.0m)

No	lyr top EL G.L.(m)	lyr btm EL G.L.(m)	thick. h (m)	stffns Alp.Eo (kN/m2)	spring kH (kN/m2)
1	43.000	42.000	1.000	2800	1346
2	42.000	41.000	1.000	5600	2691
3	41.000	40.000	1.000	8400	4037
4	40.000	38.000	2.000	44800	21529
5	38.000	37.000	1.000	50400	24220
6	37.000	36.000	1.000	75600	36331
7	36.000	35.000	1.000	47600	22875
8	35.000	34.000	1.000	58800	28257
9	34.000	33.000	1.000	131600	63242
10	33.000	32.000	1.000	86800	41713
11	32.000	31.000	1.000	81200	39022
12	31.000	30.000	1.000	117600	56514
13	30.000	29.000	1.000	114800	55169
14	29.000	28.000	1.000	84000	40367
15	28.000	27.000	1.000	112000	53823

Note: in non-effective for spring constant.

4)table for tensile member calculation in process

* equation for spring constant of tensile member

$$Ks=\frac{Alp.*(2*number*A*E)}{(L*s)}$$

where,

Alp.: coefficient for adjustment of strut [1.0]

L : tensile member set length(wall width) [6.000]m

s : tensile member horizontal pitch(spacing)
A : tensile member cross sectional area
* calculation table

tns mbr num	num n	dia Phi mm	crs area A m2	Young's modulus E kN/m2	H pitch s (m)	spring Ks (kN/m/m)
1	1	32	0.000804	200000000.0	1.800	29787

Note: is directly input spring constant.
5)properties of wall member for calculation

crs area A m2	modulus of inertia I m4	Young's modulus E kN/m2
0.022600	0.00030771	200000000.0

(2)calculation result (structural load condition in conversion)
1)description on condition
* above excavated surface
wall section (filling soil). back and active side pressure are considered. no ground spring.
* passive elastic
in embedment section, displacement on excavation side is within limit displacement.
effective active side prss from back is considered. ground springs exist. no exv load.
* passive plastic
in embedment section, displacement on excavation side exceeds limit displacement.
effective active side prss from back is considered. no ground spring. exv load exists
* active elastic
in embedment section, deformation state in back. no dfrm in calc, but assume actv elastic
2)table of load conditions

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
1	47.000	On excavation plane	0.00	0.00	0.03	--------	--------	--------	--------
2	46.800	On excavation plane	1.29	1.29	0.26	--------	--------	--------	--------
3	46.600	On excavation plane	2.57	2.57	0.51	--------	--------	--------	--------
4	46.400	On excavation plane	3.86	3.86	0.77	--------	--------	--------	--------
5	46.200	On excavation plane	5.14	5.14	1.03	--------	--------	--------	--------
6	46.000	Tensile member	6.43	6.43	1.29	--------	--------	--------	29787
7	45.800	On excavation plane	7.72	7.72	1.54	--------	--------	--------	--------
8	45.600	On excavation plane	9.00	9.00	1.80	--------	--------	--------	--------
9	45.400	On excavation plane	10.29	10.29	2.06	--------	--------	--------	--------
10	45.200	On excavation plane	11.58	11.58	2.32	--------	--------	--------	--------
11	45.000	On excavation plane	12.86	12.86	2.57	--------	--------	--------	--------
12	44.800	On excavation plane	14.15	14.15	2.83	--------	--------	--------	--------
13	44.600	On excavation plane	15.43	15.43	3.09	--------	--------	--------	--------
14	44.400	On excavation plane	16.72	16.72	3.34	--------	--------	--------	--------
15	44.200	On excavation plane	18.01	18.01	3.60	--------	--------	--------	--------
16	44.000	On excavation plane	19.29	20.84	4.05	--------	--------	--------	--------
17	43.800	On excavation plane	23.54	23.54	4.71	--------	--------	--------	--------
18	43.600	On excavation plane	26.23	26.23	5.25	--------	--------	--------	--------
19	43.400	On excavation plane	28.92	28.92	5.78	--------	--------	--------	--------
20	43.200	On excavation plane	31.62	31.62	6.32	--------	--------	--------	--------
21	43.000	Pas ela.	34.31	41.93	7.55	0.00	22.85	--------	135
22	42.800	Pas ela.	41.46	41.46	8.29	23.72	23.72	--------	269

node No	Y co GL(m)	state	back side load			excavation side load			soil spring kN/m
			above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	above nd kN/m2	below nd kN/m2	cntrt ld kN/m2	
23	42.600	Pas ela.	41.00	41.00	8.20	24.58	24.58	--------	269
24	42.400	Pas ela.	40.53	40.53	8.11	25.44	25.44	--------	269
25	42.200	Pas ela.	40.06	40.06	8.01	26.31	26.31	--------	269
26	42.000	Pas ela.	39.59	39.59	7.92	27.17	27.17	--------	404
27	41.800	Pas ela.	39.13	39.13	7.83	28.03	28.03	--------	538
28	41.600	Pas ela.	38.66	38.66	7.73	28.90	28.90	--------	538
29	41.400	Pas ela.	38.19	38.19	7.64	29.76	29.76	--------	538
30	41.200	Pas ela.	37.72	37.72	7.54	30.62	30.62	--------	538
31	41.000	Pas ela.	37.26	37.26	7.45	31.48	31.48	--------	673
32	40.800	Pas ela.	36.79	36.79	7.36	32.35	32.35	--------	807
33	40.600	Pas ela.	36.32	36.32	7.26	33.21	33.21	--------	807
34	40.400	Pas ela.	35.85	35.85	7.17	34.07	34.07	--------	807
35	40.200	Pas ela.	35.38	35.38	7.08	34.94	34.94	--------	807
36	40.000	Pa plas.	34.92	16.57	5.15	35.80	77.74	11.41	--------
37	39.800	Pa plas.	15.97	15.97	3.19	80.89	80.89	16.18	--------
38	39.600	Pas ela.	15.36	15.36	3.07	84.04	84.04	--------	4306
39	39.400	Pas ela.	14.76	14.76	2.95	87.19	87.19	--------	4306
40	39.200	Pas ela.	14.16	14.16	2.83	90.33	90.33	--------	4306
41	39.000	Pas ela.	13.55	13.55	2.71	93.48	93.48	--------	4306
42	38.800	Pas ela.	12.95	12.95	2.59	96.63	96.63	--------	4306
43	38.600	Pas ela.	12.35	12.35	2.47	99.78	99.78	--------	4306
44	38.400	Pas ela.	11.74	11.74	2.35	102.93	102.93	--------	4306
45	38.200	Act ela.	11.14	11.14	2.23	106.08	106.08	--------	4306
46	38.000	Act ela.	10.53	0.00	1.07	109.23	0.00	--------	2153
Sum					198.89			27.59	

In case tensile member is shown, soil spring is that of tensile member.

(3)calculation result (spring, displacement, reaction)
max displacement Del.xmax= -9.74mm(G.L. 42.600m)

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
1	47.000	on exv	- - - -	1.73	- - - -	- - - -
2	46.800	on exv	- - - -	0.99	- - - -	- - - -
3	46.600	on exv	- - - -	0.25	- - - -	- - - -
4	46.400	on exv	- - - -	-0.48	- - - -	- - - -
5	46.200	on exv	- - - -	-1.22	- - - -	- - - -
6	46.000	on exv	29787	-1.96	- - - -	Note: 58.44
7	45.800	on exv	- - - -	-2.70	- - - -	- - - -
8	45.600	on exv	- - - -	-3.43	- - - -	- - - -
9	45.400	on exv	- - - -	-4.15	- - - -	- - - -
10	45.200	on exv	- - - -	-4.85	- - - -	- - - -
11	45.000	on exv	- - - -	-5.52	- - - -	- - - -
12	44.800	on exv	- - - -	-6.16	- - - -	- - - -
13	44.600	on exv	- - - -	-6.77	- - - -	- - - -
14	44.400	on exv	- - - -	-7.32	- - - -	- - - -
15	44.200	on exv	- - - -	-7.83	- - - -	- - - -
16	44.000	on exv	- - - -	-8.29	- - - -	- - - -
17	43.800	on exv	- - - -	-8.69	- - - -	- - - -
18	43.600	on exv	- - - -	-9.03	- - - -	- - - -
19	43.400	on exv	- - - -	-9.31	- - - -	- - - -
20	43.200	on exv	- - - -	-9.52	- - - -	- - - -
21	43.000	pssv el	135	-9.66	17.15	1.30
22	42.800	pssv el	269	-9.73	17.63	2.62
23	42.600	pssv el	269	-9.74	18.27	2.62
24	42.400	pssv el	269	-9.68	18.91	2.61

node No	Y co GL(m)	state	soil spring kN/m	disp Del.x mm	limit disp Del.xmax mm	soil react Q kN/m
25	42.200	pssv el	269	-9.55	19.55	2.57
26	42.000	pssv el	404	-9.37	13.46	3.78
27	41.800	pssv el	538	-9.12	10.42	4.91
28	41.600	pssv el	538	-8.81	10.74	4.74
29	41.400	pssv el	538	-8.45	11.06	4.55
30	41.200	pssv el	538	-8.05	11.38	4.33
31	41.000	pssv el	673	-7.60	9.36	5.11
32	40.800	pssv el	807	-7.11	8.01	5.74
33	40.600	pssv el	807	-6.58	8.23	5.32
34	40.400	pssv el	807	-6.04	8.44	4.87
35	40.200	pssv el	807	-5.46	8.65	4.41
36	40.000	pssv pl	- - - -	-4.88	4.46	- - - -
37	39.800	pssv pl	- - - -	-4.28	3.76	- - - -
38	39.600	pssv el	4306	-3.68	3.90	15.86
39	39.400	pssv el	4306	-3.08	4.05	13.28
40	39.200	pssv el	4306	-2.49	4.20	10.72
41	39.000	pssv el	4306	-1.90	4.34	8.17
42	38.800	pssv el	4306	-1.31	4.49	5.64
43	38.600	pssv el	4306	-0.73	4.63	3.13
44	38.400	pssv el	4306	-0.15	4.78	0.63
45	38.200	actv el	4306	0.43	4.93	-1.86
46	38.000	actv el	2153	1.01	5.04	-2.18
Sum						171.30

Note: * mark shows reaction of tensile member, soil spring is that of tensile member.
If limit disp(Del.xmax=effective pssv e-prss/soil spring)exceeds disp(Del.x), plastic condition.

(4)calculation result(member force)

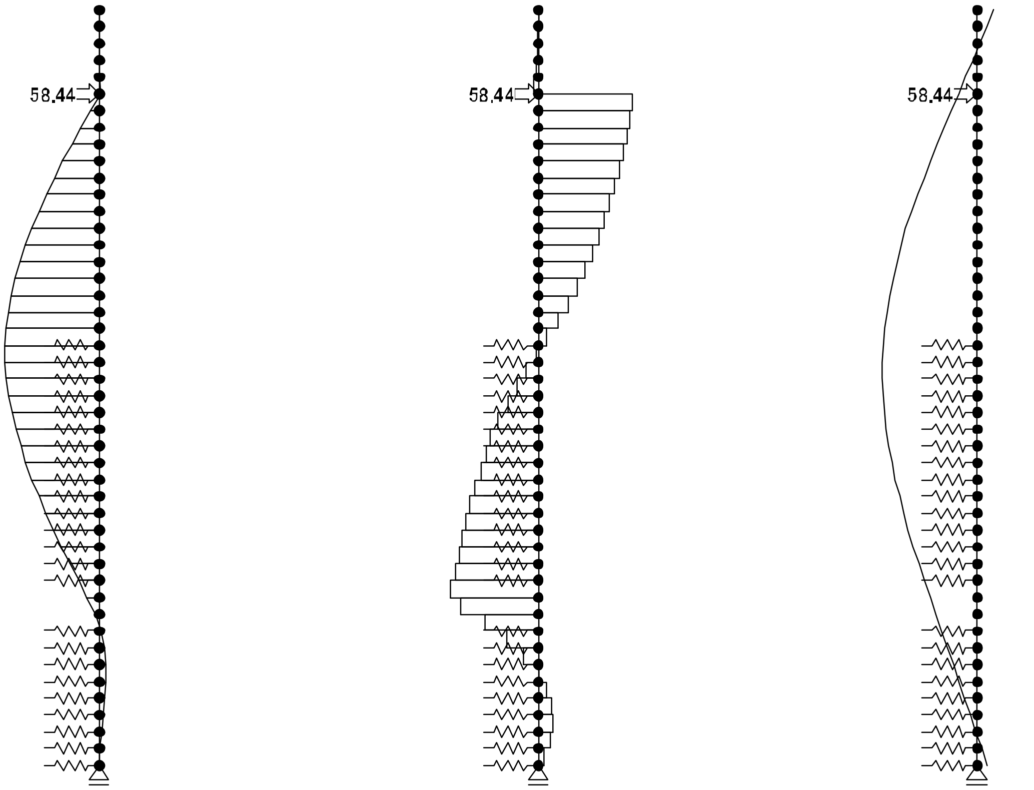
max bending moment Mmax= 104.84kN.m/m(G.L. 43.000m)
max shear force Smax= 54.55kN/m (G.L. 46.000m)
max displacement Del.xmax= -9.74mm (G.L. 42.600m)

node No	Y co GL(m)	moment kN.m/m		shear force kN/m		disp Del.x mm	reaction Q kN/m
		top	bottom	top	bottom		
1	47.000	----------	0.00	----------	-0.03	1.73	------------
2	46.800	-0.01	-0.01	-0.03	-0.29	0.99	------------
3	46.600	-0.06	-0.06	-0.29	-0.80	0.25	------------
4	46.400	-0.23	-0.23	-0.80	-1.58	-0.48	------------
5	46.200	-0.54	-0.54	-1.58	-2.60	-1.22	------------
6	46.000	-1.06	-1.06	-2.60	54.55	-1.96	* 58.44
7	45.800	9.85	9.85	54.55	53.01	-2.70	------------
8	45.600	20.45	20.45	53.01	51.21	-3.43	------------
9	45.400	30.69	30.69	51.21	49.15	-4.15	------------
10	45.200	40.52	40.52	49.15	46.83	-4.85	------------
11	45.000	49.89	49.89	46.83	44.26	-5.52	------------
12	44.800	58.74	58.74	44.26	41.43	-6.16	------------
13	44.600	67.03	67.03	41.43	38.35	-6.77	------------
14	44.400	74.70	74.70	38.35	35.00	-7.32	------------
15	44.200	81.70	81.70	35.00	31.40	-7.83	------------
16	44.000	87.98	87.98	31.40	27.35	-8.29	------------
17	43.800	93.45	93.45	27.35	22.64	-8.69	------------
18	43.600	97.98	97.98	22.64	17.40	-9.03	------------
19	43.400	101.46	101.46	17.40	11.61	-9.31	------------
20	43.200	103.78	103.78	11.61	5.29	-9.52	------------
21	43.000	104.84	104.84	5.29	-0.96	-9.66	1.30
22	42.800	104.65	104.65	-0.96	-6.63	-9.73	2.62
23	42.600	103.32	103.32	-6.63	-12.21	-9.74	2.62
24	42.400	100.88	100.88	-12.21	-17.71	-9.68	2.61
25	42.200	97.34	97.34	-17.71	-23.15	-9.55	2.57
26	42.000	92.71	92.71	-23.15	-27.29	-9.37	3.78
27	41.800	87.25	87.25	-27.29	-30.20	-9.12	4.91
28	41.600	81.21	81.21	-30.20	-33.19	-8.81	4.74
29	41.400	74.57	74.57	-33.19	-36.28	-8.45	4.55
30	41.200	67.31	67.31	-36.28	-39.50	-8.05	4.33
31	41.000	59.41	59.41	-39.50	-41.84	-7.60	5.11
32	40.800	51.05	51.05	-41.84	-43.46	-7.11	5.74
33	40.600	42.36	42.36	-43.46	-45.40	-6.58	5.32
34	40.400	33.28	33.28	-45.40	-47.70	-6.04	4.87
35	40.200	23.73	23.73	-47.70	-50.37	-5.46	4.41
36	40.000	13.66	13.66	-50.37	-44.10	-4.88	------------
37	39.800	4.84	4.84	-44.10	-31.12	-4.28	------------
38	39.600	-1.38	-1.38	-31.12	-18.33	-3.68	15.86
39	39.400	-5.05	-5.05	-18.33	-8.01	-3.08	13.28
40	39.200	-6.65	-6.65	-8.01	-0.12	-2.49	10.72
41	39.000	-6.68	-6.68	-0.12	5.34	-1.90	8.17
42	38.800	-5.61	-5.61	5.34	8.39	-1.31	5.64
43	38.600	-3.93	-3.93	8.39	9.06	-0.73	3.13
44	38.400	-2.12	-2.12	9.06	7.34	-0.15	0.63
45	38.200	-0.65	-0.65	7.34	3.25	0.43	-1.86
46	38.000	0.00	----------	3.25	----------	1.01	-2.18

Note: * mark shows reaction of tensile member

(5) Member force diagram

max bending moment Mmax= 104.84kN m/m (G.L. 43.000m)
max shear force Smax= 54.55kN/m (G.L. 46.000m)
max displacement Del.xmax= -9.74mm (G.L. 42.600m)



Moment graph Shear force diagram Disp. diagram

* in figure, number in arrow shows tensile reaction (kN/m)

5.4.3 Wall Stress

(1) member in use

section type : Steel sheet pile
steel in use : PU28+1
material in use: SY295

section properties	unit	value
section modulus Z	* 10^3(mm3/m)	3000
ditto eff ratio Alp.	--------	0.600
cross section area A	* 10^2(mm2/m)	226.00

(2) design member force

design member forces are shown in table below.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	104.84	0.00	54.55

(3) bending stress

$$Sig. = \frac{M}{Alpha*Z} + \frac{N}{A} <= Sig.sa$$

state	stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
Max.	58	270	OK

(4) shear stress

$$Tau = \frac{S}{A} <= Tau.a$$

state	stress Tau N/mm2	allowable stress Taua N/mm2	judge
Max.	2	125	OK

5.4.4 Tensile member stress

(1) check on tensile member

1) member in use

diameter in use : Phi 32(mm)
material in use : ,'£-í |690
allowable stress : 264(N/mm2)
tensile member layout pitch L : 1.800(m)
number of tensile member in use : 1
tensile member cross sectional area A : Phi 32^2* (Pi/ 4)(mm2)

2) calculation of tension force

P= R* L

tns mbr reaction R kN/m	tns mbr pitch L m	tns mbr tension P kN
58.44	1.800	105.19

3) stress

$$Sig. = \frac{P*10^3}{n*A} \le Sig.a$$

stress Sig. N/mm2	allw str Sig.sa N/mm2	judge
131	264	OK

5.4.5 Waling member stress

(1) Wailing check

1) member in use

steel material in use : m150 ~75 ~6.5 ~10

material in use : SS400

allowable stress : 210(N/mm2)

installation spacing : 1.800(m)

2) moment calculation

$$M = \frac{P * L}{10}$$

tns frc P kN	tns mbr pitch L m	moment M kN.m/m
105.19	1.800	18.93

3) stress

$$Sig. = \frac{M * 10^6}{Z * 10^3} \quad <= Sig.a$$

Z: section modulus (= 115* 2cm³)

Two make one set, doubly count the section modulus of registered steel material.

stress Sig. N/mm2	allowable stress Sig.sa N/mm2	judge
82	210	OK

6 Calculation on impermeability

(1)check method

impermeability effect (seepage pass) is checked through two passes.

water level condition is ordinary case for stability (and landside sheet pile as well).

1)seepage pass part 1 (along sheet pile)

$F1= \frac{L1}{h1} >= FS$

2)seepage pass part 2(pass through excavation bottom in land side: omit if no shape)

$F2= \frac{L2}{h2} >= FS$

where,

FS: required factor of safety(Sandy foundation: 3.25)

Fi: factor of safety

L1: seepage pass part 1(along sheet pile)

h1: water level difference part 1(from ordinal H.W.L. to landside ground surface)

L2: seepage pass part 2(pass through landside excavation bottom)

h2: water level difference part 2(from ordinal H.W.L. to landside ground surface)

(2)calculation result summery

Examined case	Seepage pass part1		
	L1(m)	h1(m)	Safety factor F1
nomal time	16.000	3.000	5.33>=3.25

(3)seepage pass part 1(along sheet pile)

L1= D1+ Lb+ D2

where,

D1: sheet pile embedment length on riverside(m)

D2: sheet pile embedment length on landside(m)

Lb: distance between sheet piles(m)

$Lb= Sqrt(B^2+ Del.L^2)$

B : embankment width (6.000m)

Del.L: difference of sheet pile between riverside and landside(0.000m)

L1= 5.000+ 6.000+ 5.000

= 16.000(m)

(4)seepage pass part 2(pass through landside excavation bottom)

Because of no excavation shape, omit calculation.

APPENDIX D-3

Structural Calculations of Revetment Works

Cover

(1) Bahr Yusef Canal

I Design condition

1.1 fundamental data

file : Bahr Yusef 1b1

title:

comment:

bracing type Raker pile tie rod type

wall type Steel sheet pile

type Normal

raker pile type H Beam pile(vertical)

applied standard- conventional method road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method: Wall inside-inside distance

plane shape type	Straight line
excavation width B (m) excavation length Le (m)	10.000 9.000

influence of water table	w/ Do
base water table(before excavation) G.L.(m)	45.000

erection planning

final excavation depth G.L. 43.000(m)

excavation for installation strut 1.000(m)

tie rod setting point G.L. 46.500(m)

tie rod horizontal spacing 1.800(m)

1.2 shape

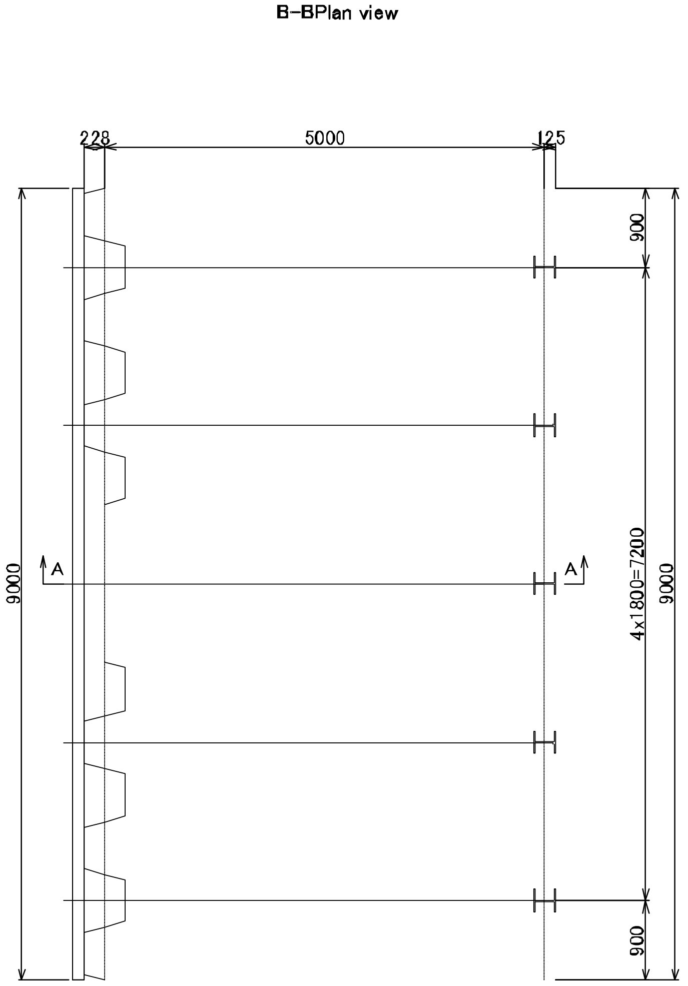
Design wall right wall

plane shape

	interval mm
wall to 1	900
1 to 2	1800
2 to 3	1800
3 to 4	1800
4 to 5	1800
5 to wall	900

tie rod and raker pile relationship: Direct connect

plan



side section shape

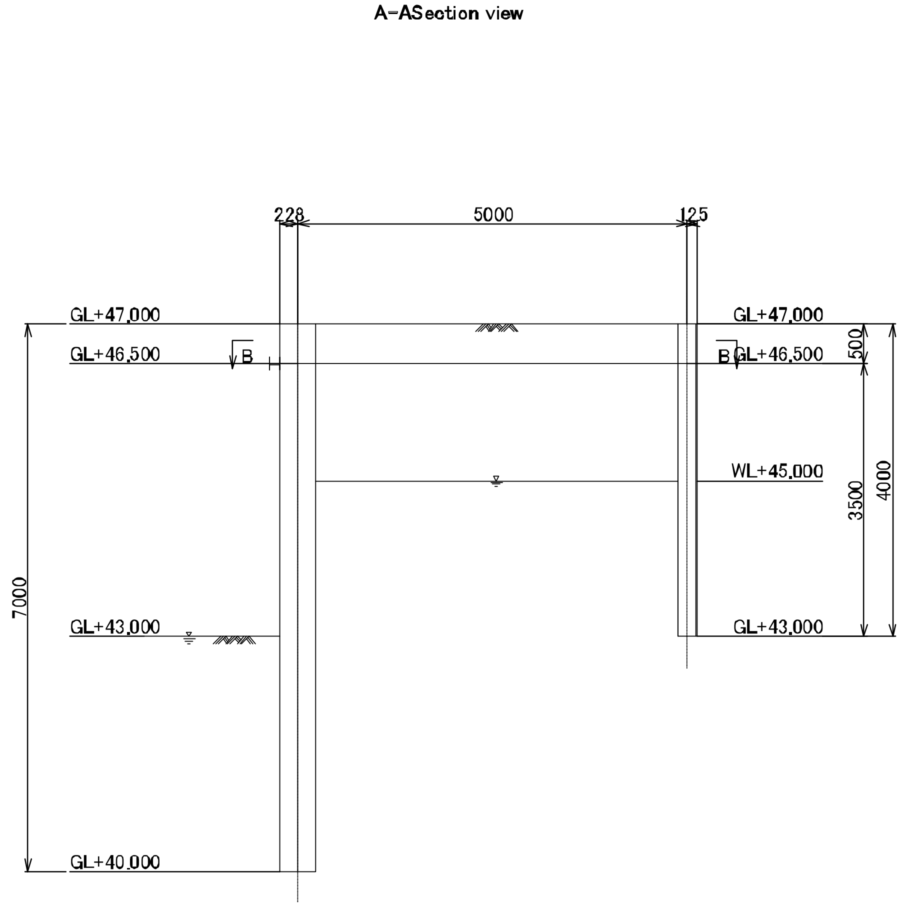
	top of wall G.L. m	ground level G.L. m
Right wall	47.000	47.000

top of raker pile :G.L. 47.000(m)

raker pile installation check range : 20.000(m)

Side view

* left-right direction



1.3 method

checking item

bearing capacity check	check Do
excavation bottom stability check	check Not do
surcharge by slope influence check	check Not do
bracing design	check Do
material	SS400
influence on surrounding ground check	check Do
FEM prediction method	check
Length round up value	0.5m

descrption of conventional method

water pressure distribution	triangle
calculation method for earth pressure to evaluate section	For Embedment length
Horizontal modulus of subgrade reaction for raker pile calculation	Internal calculation
Horizontal modulus of subgrade reaction for retaining wall stiffness check	Internal calculation
consider rock layer	not do

FORUM

elasto-plastic method concept

wall section change : not do

elastic portion rate : do

steady state check : not do

allowable displacement check : not do

analysis method : Analysis method 1

calculaion pitch : 0.25(m)

using elasto-plastic latteral pressure, embedment stability check when excavation: Consider S.F. of equi. len.

shape spring input method considered

H-subgrade reaction force calculation, shape dependent conversion width of load BH 10.000(m)

top of wall support condition Free

top of wall support condition Free

bracing combination condition(single wall analysis) rotation constrained No

for elasto-plastic method, latteral pressure

all Standard common

soil thickness above underground structure pressure: soil unit weight under ground water(Gamma -Gamma$_w$)

excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation

correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* 右壁

. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	1.000	Sandy	20.0	18.0	9.0	25.00	10.0	0.0	56000
2		Sandy	22.0	18.0	9.0	25.00	10.0	0.0	61600
3	1.000	Sandy	25.0	18.0	9.0	25.00	10.0	0.0	70000
4		Sandy	34.0	18.0	9.0	30.00	10.0	0.0	95200
5	1.000	Sandy	26.0	18.0	9.0	25.00	10.0	0.0	72800
6		Sandy	37.0	18.0	9.0	30.00	10.0	0.0	103600
7	1.000	Sandy	31.0	18.0	9.0	30.00	10.0	0.0	86800
8	1.000	Sandy	23.0	18.0	9.0	25.00	10.0	0.0	64400
9		Sandy	66.0	18.0	9.0	30.00	10.0	0.0	184800
10	1.000	Sandy	40.0	18.0	9.0	30.00	10.0	0.0	112000
11		Sandy	62.0	18.0	9.0	30.00	10.0	0.0	173600

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	1.000	Sandy	20.0	18.0	9.0	25.00	10.0	0.0	56000
2	1.000		22.0	18.0	9.0	25.00	10.0	0.0	61600
3	1.000	Sandy	25.0	18.0	9.0	25.00	10.0	0.0	70000
4	1.000		34.0	18.0	9.0	30.00	10.0	0.0	95200
5	1.000	Sandy	26.0	18.0	9.0	25.00	10.0	0.0	72800
6	1.000		37.0	18.0	9.0	30.00	10.0	0.0	103600
7	1.000	Sandy	31.0	18.0	9.0	30.00	10.0	0.0	86800
8	1.000	Sandy	23.0	18.0	9.0	25.00	10.0	0.0	64400
9	1.000		66.0	18.0	9.0	30.00	10.0	0.0	184800
10	1.000	Sandy	40.0	18.0	9.0	30.00	10.0	0.0	112000
11	1.000		62.0	18.0	9.0	30.00	10.0	0.0	173600

1.5 member

wall(steel sheet pile)

material

steel sheet pile material SY295

allowable bending stress 270(N/mm^2)

allowable shear stress 150(N/mm^2)

Young's modulus 2.00* 10^5(N/mm^2)

steel sheet pile effective rate Alpha

for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45

for moment of inertia(displacement calculation, member force) 0.45

section modulus (stress) 0.60

use

	use name	vertical load kN/m
右壁	PU28+1	0.00

raker pile(H steel pile)

material

material :SS400

allowable bending stress :210(N/mm^2)

allowable shear stress :120(N/mm^2)

Young's modulus :2.00* 10^5(N/mm^2)

use

use name :H−250×250× 9×14

vertical load :0.00(kN/unit)

tie rod

material

material :High tension steel 690

allowable tensile stress :264(N/mm^2)

Young's modulus :2.00* 10^5(N/mm^2)

use

use diameter :28.0(mm)

using number :1

tie rod inclination :none

applied screw

name :M16

effective cross sectional area :157.0(mm^2)

E.P. method

H length L m	bracing spring tension charac.	bracing pre load consid	bracing pre loaded kN/memb.	cstrc losnes mm	H sprg dirct inp Yes/No	H sprg const kN/m/m
5.000	Yes	Not do	0.01	0	No	----------

waling material

material

material :SS400

allowable bending stress Sig.a :interior calculation

design concept

waling type :U-type

checking equation :TL/10

use

use name : ┌150×75×6.5×10

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	0.00

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Primary exc.	45.500	45.000	none
2	Final Exc.	1	Final Exc.	43.000	43.000	Yes

* right wall

No	WT G.L.	surcharge kN/m²		virt sprt pt G.L. m
	natrlgrnd	natrlgrnd	exv	
1	45.000	10.00	0.00	int calc
2	45.000	10.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
Right wall	Percussion method	2.0	5	Use cohesive

Note:Construction method.

Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 influence on surrounding ground check

common setting

check objective wall :right wall

check case :final exc.

check depth

check point No	distance from wall (m)
1	5.000

allowable displacement qt

allowable Horizontal displacement qt:[0.020](m)

allowable Vertical displacement qt:[0.020](m) allowable inclination angle : [0.001](rad)

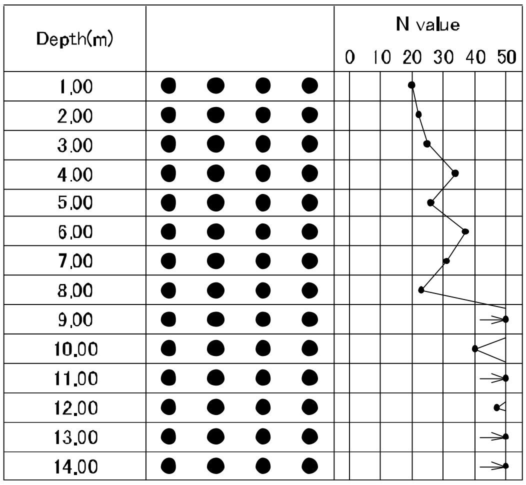
judgement on adjacent distance

judgement method : derived from deflection(sand ground)

properties for judgement : Phi=[30.00]deg.

1.10 boring log

* right wall



1.11 Design strength

1.11.1 Set value for design

(1)Simplified method

[Standard: Temporary structure construction guideline(H11)]

considered Do 0.3Gam h criteria for active earth pressure clay to calculate embedment length

considered.Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth

self-standing required embedment estimate coefficient : 2.50/Beta

min. embedment criteria : Based on design strength

soldier pile

Take 1.00 times of pile width when Beta is calculated.

bracing reaction force

when excavation: Downward shared method

when removal: Temp. Works Guid.Metro. express.H19

tie rod reaction force: Overhang beam divide method

raker pile

take 1.00 times of pile width for straight pile Beta calculation

coefficient is 2.50/Beta to estimate required embedment length

initiation point of passive slip surface is 1.00/Beta

(2)Earth pressure for section calculation

[Standard: Temp. Works Guid.,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18), Land impro. wall(H5)]

sand 2.000

clay

constituency of clay judgement N value Nc 5.000

soft clay N<=Nc 6.000

stiff clay N> Nc 4.000

(3)Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline,Metro.express.H19]

sandy soil	N<=10	1.000
	10< N<=30	2.000
	30< N	2.000
cohesive soil	N<=4	1.000
	4< N<=8	1.000
	8< N	1.000
treatment other than passive earth pressure	= pssv eth prss	
side resistance of passive earth pressure	consider: Do	

(4)Minimum Embedment depth

[Continuous wall]

self-standing 3.00(m)

when excavation with strut 3.00(m)

[Soldier pile]

self-standing 1.50(m)

when excavation with strut 1.50(m)

(5)Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20

conventional method

wall self-standing allowable displacement

wall self-standing allowable displacement is 3.0% of excavation depth

allowable displacement when checking stiffness 0.300(m)

raker pile allowable displacement 0.300(m)

elasto-plastic

required elastic region ratio 50.0(%)

(6)Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7)Bearing capacity coefficient

[Standard: Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method	1.0	1.0
vibration method	1.0	0.9
prss in	1.0	1.0
pre-boring method(sand filling)	0.0	0.5
pre-boring method(percussion,vibration, prss tip embedment)	1.0 0.0	1.0 0.5

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method,vibration method kN/m^2	100	150

drill and prss casting method	kN/m^2	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximum skin friction upper limit kN/m^2	200	150

(8)Analysis the effect to surrounding soil

simply prediction method; maximum settlement prediction diagram table

turning point No	I:hard line		II:middle,soft line	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.33	0.00	2.00
(2)	0.35	0.40	0.70	0.80
(3)	3.00	0.00	3.00	0.00

I : embedment tip ground strength = hard line

II: embedment tip ground strength = middle,soft line

x-ax: relative stiffness zeta(10^6kN m^2/m)

y-ax: surrounding ground max settlement /excavation depth (%)

max settlement predicition table

turning point No	I:30.0m under		II:30.0m over	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.85	0.00	3.50
(2)	0.50	0.25	0.95	0.58
(3)	3.00	0.00	3.00	0.00

I : presumed line for excavation width under 30m

II: presumed line for excavation width over 30m

x-ax: equivalent stiffness xi(10^6kN m^2/m)

y-ax: maximum settlement location surrounding ground /excavation depth

II Calculation results

1 Simplified method

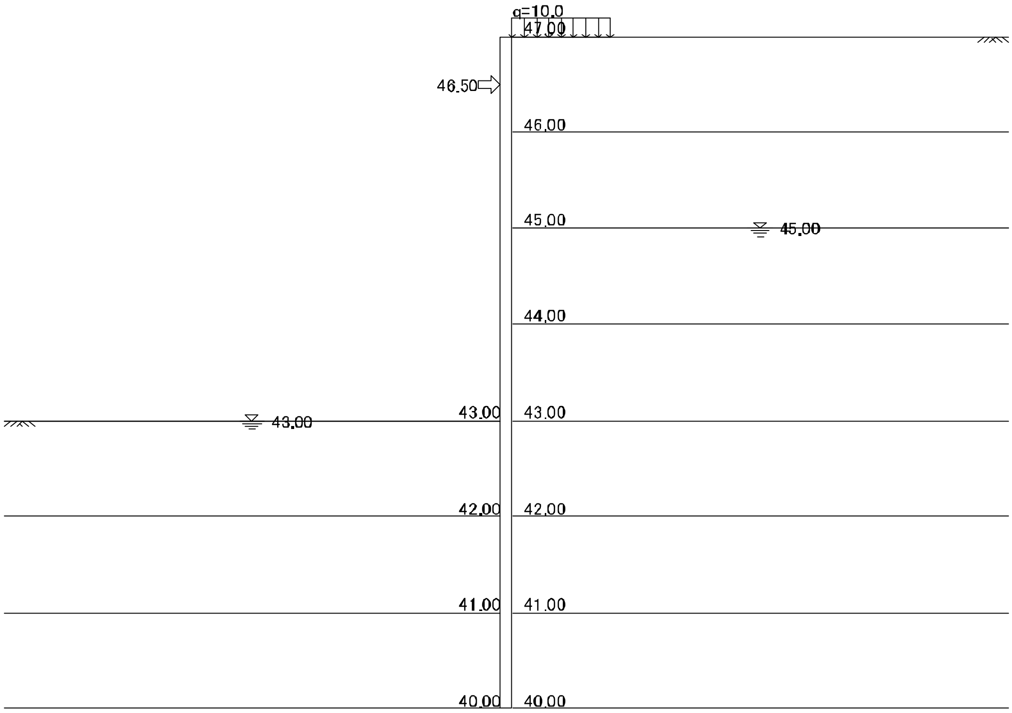
1.1 right wall design

1.1.1 final excavation

(1) check condition

state : Final excavated time

case name: final exc.



1) check condition

natural ground surface	G.L.(m)	47.000
excavation	G.L.(m)	43.000
lowest strut	G.L.(m)	46.500
water table at natural ground	G.L.(m)	45.000
water table at excavation	G.L.(m)	43.000
surcharge at natural ground q	kN/m^2	10.00
surcharge at excavation q	kN/m^2	0.00

2) ground condition

* natural ground

No	elevation		ground type	soil N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m^3)	sbmg wt (kN/m^3)		

1	47.000	46.000	Sandy	20.0	18.0	9.0	25.0	12.5
2	46.000	45.000	Sandy	22.0	18.0	9.0	25.0	12.5
3	45.000	44.000	Sandy	25.0	18.0	9.0	25.0	12.5
4	44.000	43.000	Sandy	34.0	18.0	9.0	30.0	15.0
5	43.000	42.000	Sandy	26.0	18.0	9.0	25.0	12.5
6	42.000	41.000	Sandy	37.0	18.0	9.0	30.0	15.0
7	41.000	40.000	Sandy	31.0	18.0	9.0	30.0	15.0
8	40.000	39.000	Sandy	23.0	18.0	9.0	25.0	12.5
9	39.000	38.000	Sandy	66.0	18.0	9.0	30.0	15.0
10	38.000	37.000	Sandy	40.0	18.0	9.0	30.0	15.0
11	37.000	36.000	Sandy	62.0	18.0	9.0	30.0	15.0
12	36.000	35.000	Sandy	47.0	18.0	9.0	30.0	15.0
13	35.000	34.000	Sandy	77.0	18.0	9.0	30.0	15.0
14	34.000	33.000	Sandy	84.0	18.0	9.0	30.0	15.0

No	cohesion			unc cmpr strg qu (kN/m²)	dfrm modul Alp. Eo (kN/m²)
	Co (kN/m²)	inc k (kN/m³)	base G.L.(m)		
1	10.0	0.0	47.000	20.0	56000
2	10.0	0.0	46.000	20.0	61600
3	10.0	0.0	45.000	20.0	70000
4	10.0	0.0	44.000	20.0	95200
5	10.0	0.0	43.000	20.0	72800
6	10.0	0.0	42.000	20.0	103600
7	10.0	0.0	41.000	20.0	86800
8	10.0	0.0	40.000	20.0	64400
9	10.0	0.0	39.000	20.0	184800
10	10.0	0.0	38.000	20.0	112000
11	10.0	0.0	37.000	20.0	173600

* excavation side

No	elevation		ground type	ave N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m³)	sbmg wt (kN/m³)		
1	43.000	42.000	Sandy	26.0	18.0	9.0	25.0	12.5
2	42.000		Sandy	37.0	18.0	9.0	30.0	15.0
3	41.000	41.000	Sandy	31.0	18.0	9.0	30.0	15.0
4	40.000		Sandy	23.0	18.0	9.0	25.0	12.5
5	39.000	40.000	Sandy	66.0	18.0	9.0	30.0	15.0
6	38.000		Sandy	40.0	18.0	9.0	30.0	15.0
7	37.000	39.000	Sandy	62.0	18.0	9.0	30.0	15.0
8	36.000	38.000	Sandy	47.0	18.0	9.0	30.0	15.0

No	cohesion			unc cmpr strg qu (kN/m²)	dfrm modul Alp. Eo (kN/m²)
	Co (kN/m²)	inc k (kN/m³)	base G.L.(m)		
1	10.0	0.0	43.000	20.0	72800
2	10.0	0.0	42.000	20.0	103600
3	10.0	0.0	41.000	20.0	86800
4	10.0	0.0	40.000	20.0	64400
5	10.0	0.0	39.000	20.0	184800
6	10.0	0.0	38.000	20.0	112000
7	10.0	0.0	37.000	20.0	173600
8	10.0	0.0	36.000	20.0	131600
9	10.0	0.0	35.000	20.0	215600
10	10.0	0.0	34.000	20.0	235200

(2) embedment length calculation

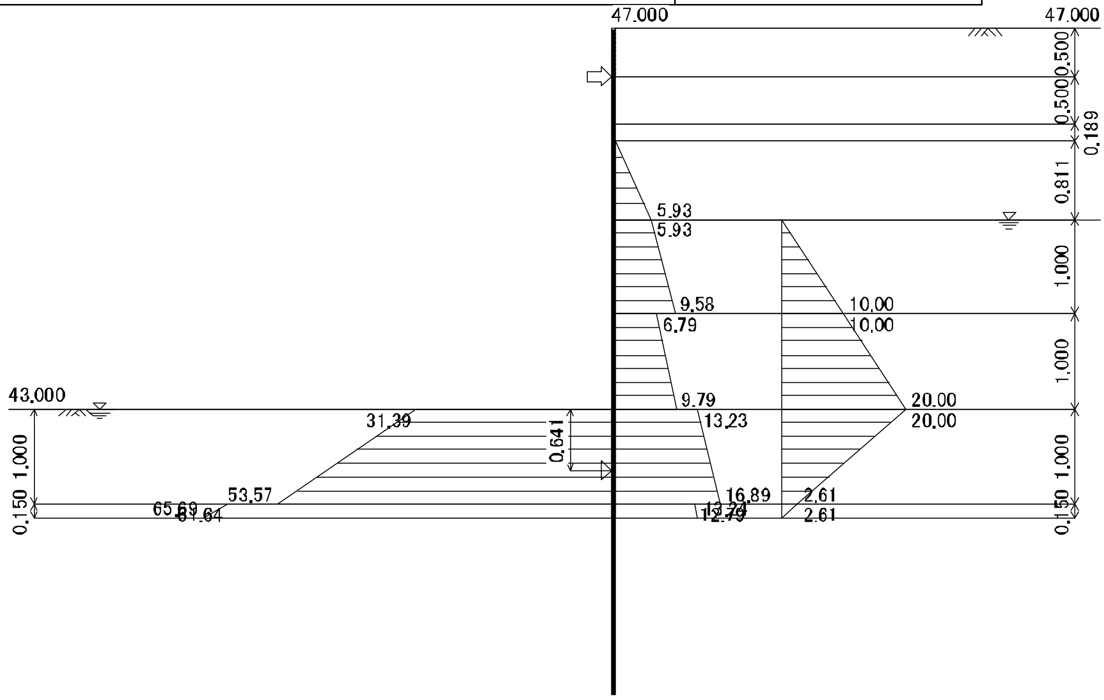
1) result summery

case name: final excavation

analysis method : embedment length is calculated from moment balance at lowest strut

excavation depth	(G.L. 43.000) m

req embd L	safety factor F balance depth Z(m) required embedment length D(m)	1.200 1.150(G.L. 41.850)m 1.380(G.L. 41.620)m
	virtual support point depth Y(m)	0.641(G.L. 42.359)m
minimum embedment length (m)		3.000(G.L. 40.000)m
final embd L	final embedment length L (m)	3.000(G.L. 40.000)m
	judge	OK
final all length		7.000m



* sum of external forces at the balanced depth (G.L. 41.850)m

item	moment		horizontal force	
Active side Compre. side	Ma+Mw(kN.m/m) Mp(kN.m/m)	214.68 215.47	Pa(kN/m) Pp(kN/m)	66.96 52.03
ratio(Mp/(Ma+ Mw))			1.0	
virtual support point depth (Y) m			0.641	

Mp is a moment at lowest strut, so assumed bearing depth Y is modified by the next equation.

virtual support point depth (Y) = Mp/Pp- (lowest strut place - excavation base).

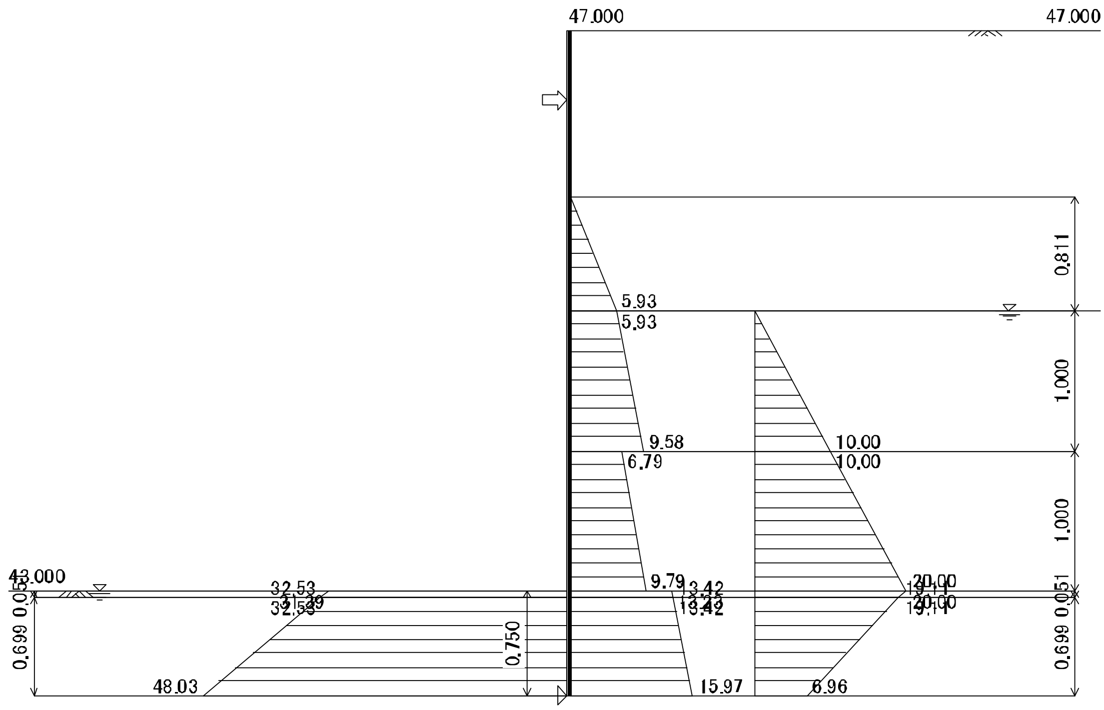
(3)calculation of member force

1)result summery

case name: final excavation

analysis method : check as a simple beam with a span between strut and virtual support point.

earth pressure is taken the earth pressure for embedment length calculation.



* single span supported at lowest strut and virtual support point

virtual support point is corrected 0.641(m) to 0.750(m) from embedment length calculation.

lowest strut depth		m	(G.L. 46.500)m
virtual support point depth		m	(G.L. 42.250)m
simple beam span		m	4.250
max bending moment	moment Mmax	kN.m/m	28.70
	depth(from strut)	m	2.481(G.L. 44.019)m
shear force	shear force Smax	kN/m	23.70
	depth(from strut)	m	3.551(G.L. 42.949)m
reaction	upper reaction force RA	kN/m	14.80
	lower reaction force RB	kN/m	23.70
*max displacement	displacement Del.max	m	0.0008
	depth(from strut)	m	2.125(G.L. 44.375)m

*reference value

3) retaining wall stiffness check

nevertheless wall stress has allowance, not to deform retaining wall within a certain level, checking enough stiffness assured. so displacement must be satisfied the following equation.

Del. = Del.1+ Del.2<=Del.a

where,

Del. : total retaining wall displacement

Del.1: maximum displacement calculated as a simple beam

$$Del.1 = \frac{5 * w * L^4}{384 * EIAlp.}$$

Del.2: influence displacement at elastic support

Del.2' = R/K

Del.2 = Del.2' /2

Del.a: allowable displacement

calculating model is SS beam at top strut and an elastic support of half of embeded depth, load is taken earth pressure for section check and water pressure throughout a span. if a ld has trapezoidal dstr, convert to an conversion uniform dstr ld with the same intensity.

rigid support level (top strut)		G.L.(m)	46.500
virtual support point depth	Y	m	0.750
1/2 of virtual support point depth		G.L.(m)	42.625
simple beam span	L	m	3.875
intensity applied on a simple beam	P	kN/m	49.94
equivalent uniform distribution load	w= P/L	kN/m²	12.888
Del.1	Young's modulus E	* 10^8kN/m²	2.000
	moment of inertia of area I	m⁴/m	0.00068380
	effective rate(displacement) Alp.	-----	0.450
	deformation of center in span Del.1	m	0.0006
Del.2	modulus of subgrade reaction kH	kN/m³	17492
	wall width B	m	1.000
	side area of spring block pile A= B* Y	m²	0.7500
	spring constant K= kH* A	kN/m²	13119
	reaction force R= w* L/2	kN/m	24.97
	elastic support displacement Del.2' = R/K	m	0.0019
	support displacement influence Del.2 = Del.2'/2	m	0.0010
total wall displacement Del. = Del.1+ Del.2		m	0.0016
position (a half of span)		G.L.(m)	44.563
allowable displacement	Del.a	m	0.300
Judge		-----	OK

* total intensity applied on a simple beam(P)

No	depth GL(m)	thk h (m)	action load p kN/m²	load P kN/m
1	46.500 46.000	0.500	0.00 0.00	0.00
2	46.000 45.811	0.189	0.00 0.00	0.00
3	45.811 45.000	0.811	0.00 5.93	2.40
4	45.000 44.000	1.000	5.93 19.58	12.75
5	44.000 43.000	1.000	16.79 29.79	23.29
6	43.000 42.949	0.051	33.23 32.53	1.68
7	42.949 42.625	0.324	32.53 28.08	9.82
Sig				49.94

* Horizontal modulus of subgrade reaction

Horizontal modulus of subgrade reaction is an average value to virtual support point, using the equation

$$kH = Eta\,kHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta= 1

kHo: H-modulus of subgrade reaction equivalent to that of a 30cm stiffness round plate.

$$kHo = \frac{1}{0.3}\ Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH* h (kN/m²)
1	43.000	42.250	0.750	72800	242667	17492	13119
Sig			0.750				13119

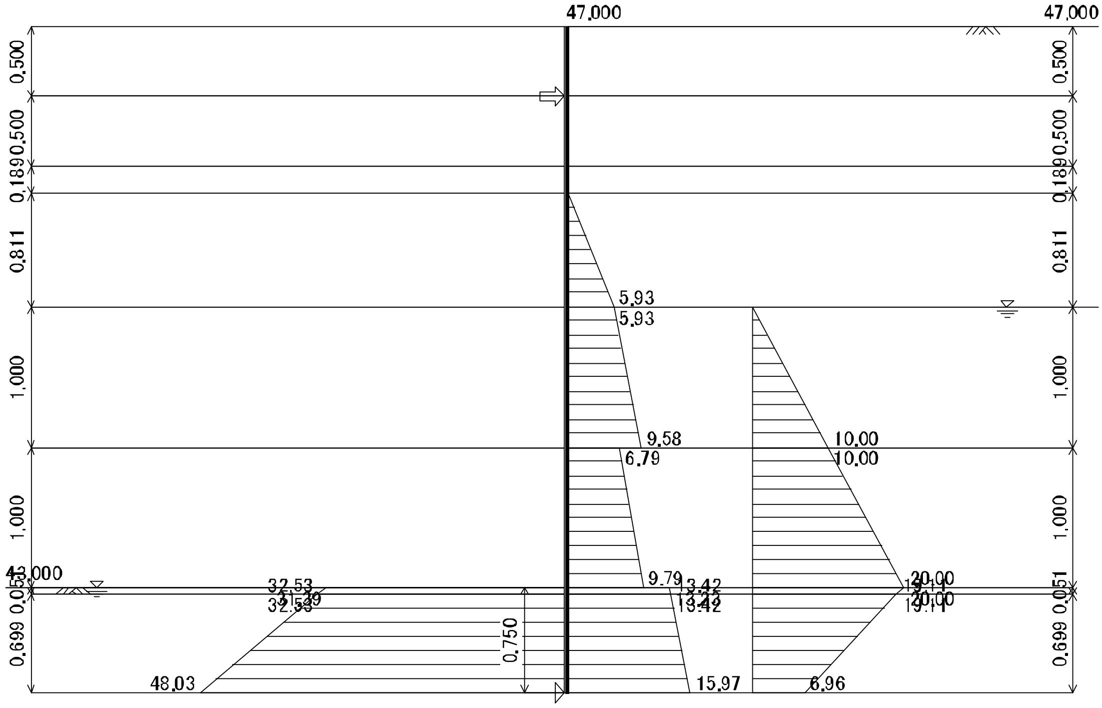
ave kH= Sig.(kH* h) /Sig.h= 17492(kN/m³)

BH: conversion width of load 10.0(m)

(4)calculation of bracing reaction force

1)result summery

analysis method : Overhang strut method



No	depth G.L. (m)		support G.L. (m)	reaction force kN/m	bracing reaction force kN/m
1	46.500	up span	--------	--------------	14.80
		low span	42.250	14.80	

timbering reaction= timbering No.(n)up spansprt rct+ reaction of lower support

up span bt focusing bracing and just above. Support at bracing above tmb No(n).

up span bt focusing bracing and just below. Support at bracing below tmb No(n).

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+1

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm³/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm²/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	28.70	0.00	23.70

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	15.9	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau : shear force stress (N/mm^2)

Taua: allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	1.0	150.0	OK

2 Elasto-plastic method

2.1 right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+1

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm^3/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm^2/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	28.26	0.00	20.82

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	15.7	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	0.9	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1) Primary excavation time

1) analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m²/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	47.000		--------	0.00	----------	--------	-0.16	--------
2	46.750		0.00		----------	--------	-0.14	--------
3	46.500		0.00	0.00	----------	--------	-0.13	--------
4	46.250		0.00		----------	--------	-0.12	--------
5	46.000		0.00	0.00	----------	--------	-0.11	--------
6	45.750		1.14	0.00	----------	--------	-0.10	--------
7	45.500	Ela.zone	2.28		4.75	1850	-0.09	0.2
8	45.250	Ela.zone	1.50	0.00	11.62	3700	-0.08	0.3
9	45.000	Ela.zone	0.73		14.25	3953	-0.07	0.3
10	44.750	Ela.zone	0.39	1.14	15.70	4205	-0.06	0.2
11	44.500	Ela.zone	0.05		9.45	2382	-0.05	0.1
12	44.467	Ela.zone	0.00	2.28	8.68	2102	-0.05	0.1
13	44.250	Ela.zone	0.00	1.50	17.04	3926	-0.04	0.2
14	44.000	Ela.zone	0.00		22.46	4962	-0.03	0.2
15	43.750	Ela.zone	0.00	0.73	27.11	5719	-0.02	0.1
16	43.500	Ela.zone	0.00		28.90	5719	-0.02	0.1
17	43.250	Ela.zone	0.00	0.39	30.69	5719	-0.01	0.1
18	43.000	Ela.zone	0.00	0.05	28.42	5046	-0.01	0.0
19	42.750	Ela.zone	0.00		25.75	4373	0.00	0.0
20	42.500	Ela.zone	0.00	0.00	27.01	4373	0.00	0.0
21	42.250	Ela.zone	0.00		28.27	4373	0.00	0.0
22	42.000	Ela.zone	0.00	0.00	34.65	5298	0.00	0.0
23	41.750	Ela.zone	0.00		41.43	6223	0.00	0.0
24	41.500	Ela.zone	0.00	0.00	43.22	6223	0.01	0.0
25	41.250	Ela.zone	0.00	0.00	45.01	6223	0.01	0.0
26	41.000	Ela.zone	0.00		46.80	5719	0.01	0.0
27	40.750	Ela.zone	0.00	0.00	48.59	5214	0.01	0.0
28	40.500	Ela.zone	0.00		50.38	5214	0.01	0.0
29	40.250	Ela.zone	0.00	0.00	52.17	5214	0.01	-0.1
30	40.000	Ela.zone	0.00	0.00	26.76	2607	0.01	0.0

note1: effective passive lateral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive lateral pressure in elastic range is no loading in analysis.

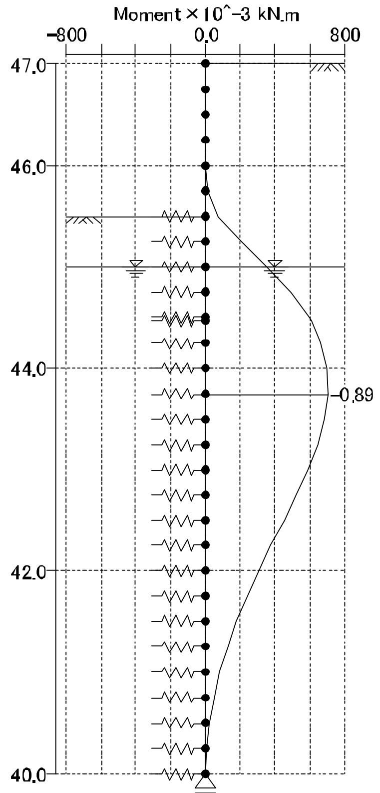
2) Primary excavation analysis result (member force, displacement)

Mmax = 0.0kN.m/m (working pos G.L. 46.00m) Mmin = -0.9kN.m/m (working pos G.L. 43.75m)

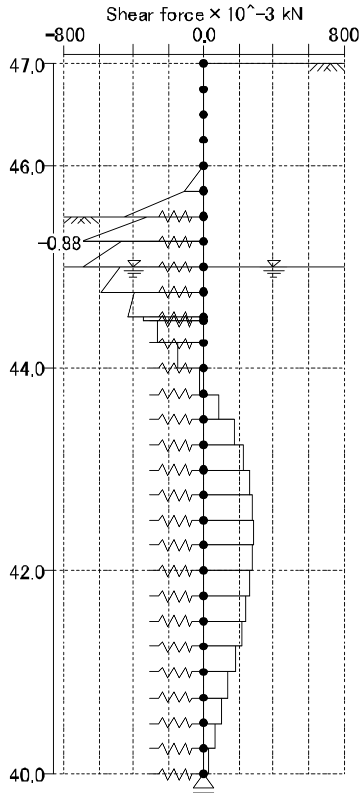
Smax = 0.4kN/m (working pos G.L. 42.50m) Smin = -0.9kN/m (working pos G.L. 45.25m)

Del.max= 0.01mm (working pos G.L. 40.00m Del.min= -0.16mm (working pos G.L. 47.00m)

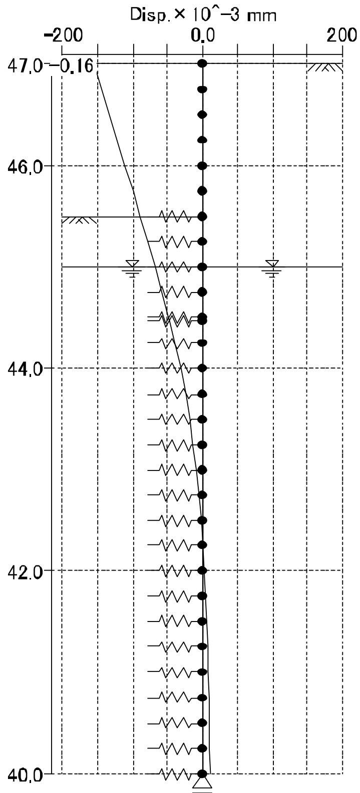
node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	47.000	----------	0.0	----------	0.0	-0.16	----------
2	46.750	0.0	0.0	0.0	0.0	-0.14	----------
3	46.500	0.0	0.0	0.0	0.0	-0.13	----------
4	46.250	0.0	0.0	0.0	0.0	-0.12	----------
5	46.000	0.0	0.0	0.0	0.0	-0.11	----------
6	45.750	0.0	0.0	-0.1	-0.1	-0.10	----------
7	45.500	-0.1	-0.1	-0.6	-0.4	-0.09	----------
8	45.250	-0.3	-0.3	-0.9	-0.6	-0.08	----------
9	45.000	-0.4	-0.4	-0.9	-0.6	-0.07	----------
10	44.750	-0.6	-0.6	-0.7	-0.5	-0.06	----------
11	44.500	-0.7	-0.7	-0.6	-0.4	-0.05	----------
12	44.467	-0.8	-0.8	-0.4	-0.3	-0.05	----------
13	44.250	-0.8	-0.8	-0.3	-0.2	-0.04	----------
14	44.000	-0.9	-0.9	-0.2	0.0	-0.03	----------
15	43.750	-0.9	-0.9	0.0	0.1	-0.02	----------
16	43.500	-0.9	-0.9	0.1	0.2	-0.02	----------
17	43.250	-0.8	-0.8	0.2	0.3	-0.01	----------
18	43.000	-0.7	-0.7	0.3	0.3	-0.01	----------
19	42.750	-0.7	-0.7	0.3	0.3	0.00	----------
20	42.500	-0.6	-0.6	0.3	0.4	0.00	----------
21	42.250	-0.5	-0.5	0.4	0.4	0.00	----------
22	42.000	-0.4	-0.4	0.4	0.3	0.00	----------
23	41.750	-0.3	-0.3	0.3	0.3	0.00	----------
24	41.500	-0.2	-0.2	0.3	0.3	0.01	----------
25	41.250	-0.2	-0.2	0.3	0.2	0.01	----------
26	41.000	-0.1	-0.1	0.2	0.2	0.01	----------
27	40.750	-0.1	-0.1	0.2	0.1	0.01	----------
28	40.500	0.0	0.0	0.1	0.1	0.01	----------
29	40.250	0.0	0.0	0.1	0.0	0.01	----------
30	40.000	0.0	----------	0.0	----------	0.01	----------



Moment graph



Shear force diagram



Displacement diagram

* pre-displacement and loading equivalent to pre-displacement

when strut is effective after next step, a load for pre-displacement is applied.

node No	displacement Del.x mm	release Del.L mm	preceding displacement Del.o mm	bracing spring Ks kN/m	preceding displacement load kN/m
3	-0.13	0.00	-0.13	13683.4	-1.82

where,

Del.x: wall displacement at strut level(->)+)

Del.L: construction release

Del.o: pre-disp(->)+) Del.o=Del.x-Del.L

(2) Comletion time

1) analysis results (latteral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	47.000		--------	0.00	----------	--------	-0.89	--------
2	46.750		0.00	0.00	----------	--------	-1.05	--------
3	46.500	Strut	0.00	0.00	-1.82	13683	-1.21	14.8
4	46.250		0.00	0.00	----------	--------	-1.38	--------
5	46.000		0.00	0.00	----------	--------	-1.53	--------
6	45.750		1.48	1.48	----------	--------	-1.68	--------
7	45.500		2.96	2.96	----------	--------	-1.82	--------
8	45.250		4.45	4.45	----------	--------	-1.95	--------
9	45.000		5.93	5.93	----------	--------	-2.06	--------
10	44.750		8.61	8.61	----------	--------	-2.14	--------
11	44.500		11.30	11.30	----------	--------	-2.20	--------
12	44.467		11.66	11.66	----------	--------	-2.21	--------
13	44.250		13.99	13.99	----------	--------	-2.23	--------
14	44.000		16.67	13.95	----------	--------	-2.24	--------
15	43.750		16.49	16.49	----------	--------	-2.22	--------
16	43.500		19.04	19.04	----------	--------	-2.17	--------
17	43.250		21.58	21.58	----------	--------	-2.09	--------
18	43.000	Ela.zone	24.12	27.42	4.55	2187	-1.99	4.3
19	42.750	Ela.zone	25.83	25.83	10.05	4373	-1.86	8.2
20	42.500	Ela.zone	24.24	24.24	11.30	4373	-1.73	7.5
21	42.250	Ela.zone	22.64	22.64	12.56	4373	-1.58	6.9
22	42.000	Ela.zone	21.05	17.79	15.61	5298	-1.42	7.5
23	41.750	Ela.zone	16.20	16.20	19.05	6223	-1.25	7.8
24	41.500	Ela.zone	14.62	14.62	20.84	6223	-1.08	6.7
25	41.250	Ela.zone	13.04	13.04	22.63	6223	-0.92	5.7
26	41.000	Ela.zone	11.45	11.45	24.42	5719	-0.75	4.3
27	40.750	Ela.zone	9.87	9.87	26.21	5214	-0.58	3.0
28	40.500	Ela.zone	8.29	8.29	28.00	5214	-0.41	2.2
29	40.250	Ela.zone	6.70	6.70	29.79	5214	-0.25	1.3
30	40.000	Ela.zone	5.12	--------	15.57	2607	-0.08	0.2

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

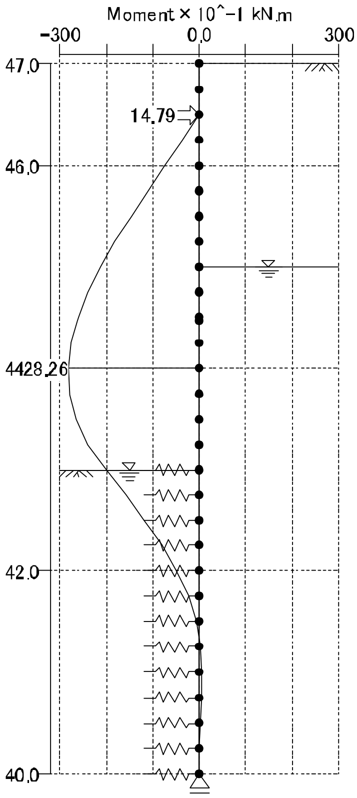
2) Completion time analysis result (member force, displacement)

Mmax = 28.3kN.m/m (working pos G.L. 44.00m) Mmin = -0.6kN.m/m (working pos G.L. 41.00m)

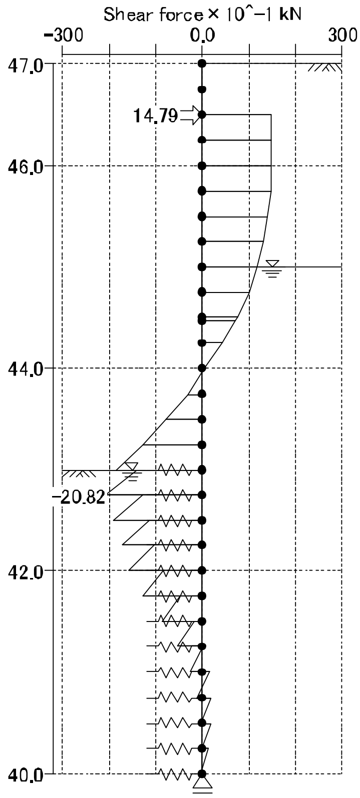
Smax = 14.8kN/m (working pos G.L. 46.50m) Smin = -20.8kN/m (working pos G.L. 42.75m)

Del.max=-------- mm (working pos G.L.--------m) Del.min= -2.24mm (working pos G.L. 44.00m)

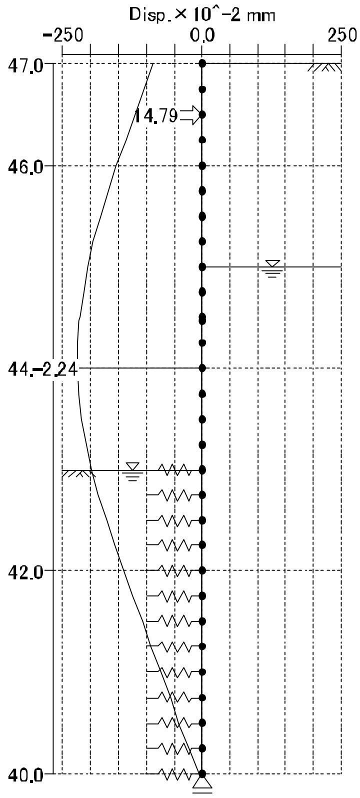
node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	47.000	----------	0.0	----------	0.0	-0.89	----------
2	46.750	0.0	0.0	0.0	0.0	-1.05	----------
3	46.500	0.0	0.0	0.0	14.8	-1.21	14.8
4	46.250	3.7	3.7	14.8	14.8	-1.38	----------
5	46.000	7.4	7.4	14.8	14.8	-1.53	----------
6	45.750	11.1	11.1	14.6	14.6	-1.68	----------
7	45.500	14.7	14.7	14.0	14.0	-1.82	----------
8	45.250	18.1	18.1	13.1	13.1	-1.95	----------
9	45.000	21.2	21.2	11.8	11.8	-2.06	----------
10	44.750	23.9	23.9	10.0	10.0	-2.14	----------
11	44.500	26.1	26.1	7.5	7.5	-2.20	----------
12	44.467	26.4	26.4	7.1	7.1	-2.21	----------
13	44.250	27.6	27.6	4.4	4.4	-2.23	----------
14	44.000	28.3	28.3	0.5	0.5	-2.24	----------
15	43.750	27.9	27.9	-3.3	-3.3	-2.22	----------
16	43.500	26.6	26.6	-7.7	-7.7	-2.17	----------
17	43.250	24.0	24.0	-12.8	-12.8	-2.09	----------
18	43.000	20.1	20.1	-18.5	-14.2	-1.99	----------
19	42.750	15.7	15.7	-20.8	-12.7	-1.86	----------
20	42.500	11.8	11.8	-18.9	-11.4	-1.73	----------
21	42.250	8.2	8.2	-17.2	-10.4	-1.58	----------
22	42.000	4.9	4.9	-15.8	-8.3	-1.42	----------
23	41.750	2.3	2.3	-12.6	-4.8	-1.25	----------
24	41.500	0.6	0.6	-8.6	-1.9	-1.08	----------
25	41.250	-0.3	-0.3	-5.3	0.4	-0.92	----------
26	41.000	-0.6	-0.6	-2.7	1.6	-0.75	----------
27	40.750	-0.5	-0.5	-1.1	2.0	-0.58	----------
28	40.500	-0.3	-0.3	-0.3	1.8	-0.41	----------
29	40.250	-0.1	-0.1	0.0	1.3	-0.25	----------
30	40.000	0.0	----------	-0.2	----------	-0.08	----------



Moment graph



Shear force diagram



Displacement diagram

3 Bearing capacity

3.1 Bearing capacity

3.1.1 check condition

(1) check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	40.000
exv bs ps	G.L.(m)	43.000
embd L L	m	3.000

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	706.82	353.41	0.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	23.0	34.0	28.5	5700.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N-val Ni	Li* Ni
1	42.000	41.000	1.000	37.0	37.00
2	41.000	40.000	1.000	31.0	31.00
Sig			2.000		68.00

3) circumference friction force(Sig.Li* fi)

* sand : fi= 2BetaNs(note; Ns<=50
* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)
* coefficient of skin friction with construction method: Beta= 1.0
* Nvalue <=2 fi= 0.0 in weak soil
* all friction resistance Sig.Li* fi= 578.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m^2)	skin friction Li* fi (kN/m)
1	1.000	26.0	-----	52.00	52.00
2	1.000	37.0	-----	74.00	74.00
3	1.000	31.0	-----	62.00	62.00
Sig	3.000				188.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m^2)	skin friction Li* fi (kN/m)
1	1.000	20.0	-----	40.00	40.00
2	1.000	22.0	-----	44.00	44.00
3	1.000	25.0	-----	50.00	50.00
4	1.000	34.0	-----	68.00	68.00
5	1.000	26.0	-----	52.00	52.00
6	1.000	37.0	-----	74.00	74.00
7	1.000	31.0	-----	62.00	62.00
Sig	7.000				390.00

4 Bracing, Raker pile calculation

4.1 tie rod design

(1) applied member

using tie rod diameter : tie rod diameterPhi 28.0(mm)* using # n=1

using material : high tension steel690

allowable tensile stress : Sig.a = 264(N/mm²)

tie rod installation spacing : L = 1.800(m)

screw part(listed, effective cross sectional area) : M16(A = 157.0mm²)

(2) tie rod calculation of member force

tie rod tension is calculated with tie rod reaction and spacing using the following equation.

T = Ra* L = 16.62* 1.800 = 29.92(kN/unit)

where,

T : tie rod tension(kN/unit)

Ra: tie rod reaction force(kN/m)

La: tie rod installation interval (m)

(3) tie rod stress calc

tie rod stress should be satisfied the following equation.

$$Sig. = \frac{T * 10^3}{n * A} \le Sig.a$$

where,

Sig. : tie rod stress.(N/mm²)

Sig.a: allowable tensile stress(N/mm²)

n : using number

A : using cross sectional area (mm²)

$$Sig. = \frac{29.92 * 10^3}{1 * 157.0} = 190.55\ (N/mm^2) \le Sig.a = 264(N/mm^2)...\quad OK$$

4.2 Design of raker pile

4.2.1 Dimensions of a pile

Dimensions of a pile are as follows.

(1) using material

Type : H steel pile(B = 250mm)

Use : H−250×250× 9×14

Dimensions	Unit	Value
Cross sectional area A	cm²/m	91.43
Moment of inertia I	cm⁴/m	10700
Section modulus Z	cm³/m	860

(2) material

Using material : SS400

Young's modulus : $E = 2.000 * 10^8 (kN/m^2)$

4.2.2 Calculate installation layout

(1) calculate necessary installation distance

Rake pile is placed on actv failure plane starting from virtual support point and pssv failure plane starting from 1.00/Beta of depth below tie rod intersect above the location of tie rod.

In this, actv and pssv failure planes intersect at tie rod depth is called a req inst distance.

1) active failure plane

Act. fail. plane on back side starting from a sup. pointed of a rt wl (GL-12.250m) is described.

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	actv failure agl zetaa(Deg.) = 45+Phi/2	failure line width Ldi(m) = hi* cotzetaa
5	43.000	42.250	0.750	25.00	57.50	0.478
4	44.000	43.000	1.000	30.00	60.00	0.577
3	45.000	44.000	1.000	25.00	57.50	0.637
2	46.000	45.000	1.000	25.00	57.50	0.637
1	46.500	46.000	0.500	25.00	57.50	0.319
Si.			4.250			2.648

2) passive failure plane

Passive failure on back side starting from the position 1.00/Beta below rake pile tie rod is.

$$\text{Starting position of raker pile} = \text{tie rod position of raker pile} - \frac{1.00}{\text{Beta}}$$

$$= \text{G.L.}46.500 - \frac{1.00}{0.773414} = \text{G.L.}45.207(\text{m})$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	pssv failure agl zetap(Deg.) = 45-Phi/2	failure line width Ldi(m) = hi* cotzetap
2	46.000	45.207	0.793	25.00	32.50	1.245
1	46.500	46.000	0.500	25.00	32.50	0.785
Si.			1.293			2.030

3) required installation distance

Required installation distance Ldmin is given as following equation.

Ldmin = Sig.hi* cotzetaa + Sig.hi* cotzetap =2.648 +2.030 =4.678(m)

(2) installation position of raker pile

From above, raker pile is installed Ld =4.678(m) on backside.

Ld =5.000(m) =>Ldmin =4.678(m)... It is safe.

(3) calculate a characteristic value Beta to determine required installation position.

Beta at raker pile instl at distance from req instl distance Ldmin = 4.678(m) from rt wl is given.

1) calculate characteristic value Beta

Characteristic value Beta is calculated using the following equation.

$$\text{Beta} = \sqrt[4]{\frac{kH^* B}{4EIAlp.}} = \sqrt[4]{\frac{122654.9^*\ 250.0^*\ 10^{-3}}{4^*\ 2.000^*\ 10^{8*}\ 10700^*\ 10^{-8*}\ 1.000}} = 0.773414(m^{-1})$$

where,

Horizontal subgrade reaction coefficient kH = 122654.9(kN/m^3)

width of raker pile B = 250.0* 10^{-3}(m)

B is flange WB in case of H steel, or [1.00] times of pile diameter in case of st pipe pile.

Young's modulus E = 2.000* 10^8(kN/m^2)

Moment of inertia of area I = 10700* 10^{-8}(m^4)

effective rate(for embedment calculation) Alp. = 1.000

2) calculation of horizontal subgrade reaction coefficient

H-subgrade reaction coefficient is an average value within 1/Beta= 46.500(m) from G.L.1.293(m) using the following equation.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta : coefficient regarding to wall type (1.00 in case of raker pile)

kHo: H-subgrade reaction coefficient equi to plate bear test result by stiffness round plate of 30cm diameter

$$kHo = \left(\frac{1}{0.3}\right)Alp.Eo$$

where,

Eo: ground modulus of deformation(kN/m^2)

Alp.:coefficient to calculate subgrade reaction coefficent

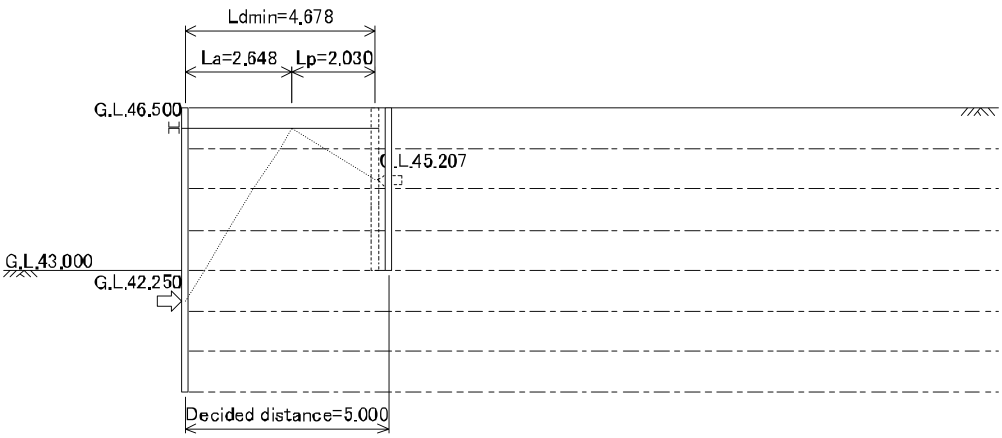
BH conversion width of load is calculated using the following equation.

$$BH = \sqrt{\frac{D}{Beta}} = \sqrt{\frac{250 * 10^{-3}}{0.773414}} = 0.5685(m)$$

where, D is flange WB in case of H steel pile, or a pile diameter D of steel pipe pile.

$$\text{Average kH within the range of } \frac{1}{Beta} = \frac{Sig.kH * h}{Sig.h} = \frac{158589}{1.293} = 122654.9 \text{ (kN/m}^3\text{)}$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	Alp.Eo kN/m²	kHo kN/m³	kH kN/m³	kH*h kN/m²
1	46.500	46.000	0.500	56000	186667	115567	57784
2	46.000	45.207	0.793	61600	205333	127124	100805
Si.			1.293				158589



4.2.3 calculate embedment length

(1)length of raker pile

Pile L to include embd L req from the calc as an infinite pile on elastic grnd as described below.

$$D = \text{Safety coefficient}\frac{}{Beta} = \frac{2.50}{0.773414} = 3.232(m) <= \text{real embedment length}=3.500(m)... \quad OK$$

raker pile head EL		(G.L. 47.000)m
rake pile tie rod position EL		(G.L. 46.500)m
raker pile design ground level		(G.L. 46.500)m
required embedment length	safety coeff	2.50
	chra Beta(m^{-1})	0.773414
	D= safety coeff/Beta	3.232(G.L. 43.268)m
final embedment length	real length (m)	3.500(G.L. 43.000)m
	judgement	OK
final total length		4.000m

(2)calculate Beta at raker pile installed position

It follows the result of Beta=0.773414(m^{-1}) obtained in calculating a necessary distance.

4.2.4 calculation of member force

(1) calculation of member force

1) maximum bending moment

$$Mmax = 0.3224\frac{H}{Beta} = 0.3224*\frac{29.92}{0.773414} = 12.47$$

where,

H: horizontal force acting on a raker pile

tension frc per single tie rod is given as H = Ra* L* secTheta (Theta: tie rod inc agl).

2) location of maximum bending moment induced (lower than design ground level)

$$Lm = \frac{Pi}{4Beta} = \frac{Pi}{4*\ 0.773414} = 1.015$$

Summery of member force calculation is shown in the table below.

characteristic value	Beta	m^{-1}	0.773414
induced force	horizontal force H	kN/M	29.92
	height (from design GL) h	m	0.000
maximum bending moment	moment Mmax	kN.m/M	12.47
	location (from design GL)	m	1.015 (G.L. 45.485) m
shear force	shear force Smax	kN/M	29.92
	location (from design GL)	m	0.000 (G.L. 46.500) m

(2) calculation of Beta

It is the same Beta as the result of calculating embedment length.

(3) calculation of displacement

Displacement at the location of tie rod must be satisfied the following equation.

$$Del. = \frac{H}{2EIAlp.Beta^3} <= Del.a$$

where,

characteristic value Beta		m^{-1}	0.773414
Young's modulus E		$* 10^{8}$ kN/m^2	2.000
moment of inertia I		$* 10^{-8}$ m^4/M	10700
eff ratio (for moment of inertia) Alp.		-----	1.000
Horizontal force H		kN/M	29.92
height (from design GL) h		m (G.L. m)	0.000 (G.L. 46.500) m
allowable displacement Del.a		m	0.300

$$Del. = \frac{H}{2EIAlp.Beta^3} = \frac{29.92}{2*\ 2.000*\ 10^{8}*\ 10700*\ 10^{-8}*\ 1.000*\ 0.773414^{3}}$$

Del. = 0.002 (m) <= Del.a = 0.300 (m) ... OK

4.2.5 stresses of raker pile

(1) using section

type : H-steel pile

use : H-250×250×9×14

using material : SS400

dimensions	unit	value
section height H	(mm)	250
web thickness t1	(mm)	9
flange thickness t2	(mm)	14
section modulus Z	$* 10^{3}$ (mm^3)	860
crs sectional area A	$* 10^{2}$ (mm^2)	91.43

(2) design member force

design member forces are shown in the following table.

moment M * 10^6(N.mm)	axial force N * 10^3(N)	shear force S * 10^3(N)
12.47	0.00	29.92

(3) bending stress

bending stress must satisfy the following equation.

$$Sig. = \frac{M}{Z} + \frac{N}{A} <= Sig.ba$$

where,

Sig. : bending stress(N/mm^2)

Sig.ba : allowable bending stress(N/mm^2)

L= 3.500* 10^3(mm) (L is a length from tie rod position to raker pile tip.)

b= 250 (mm) (b is flange width)

from 4.5< L/b<=30

$$Sig.ba=Sig.a-3.6\left(\frac{L}{b} - 4.5\right)=210-3.6\left(\frac{3.500*\ 10^3}{250} - 4.5\right)=175(N/mm^2)$$

z : using section modulus

A : using cross sectional area

$$Sig. = \frac{12.47*\ 10^6}{860.0*\ 10^3} + \frac{0.00*\ 10^3}{91.43*\ 10^2} =14.50\ (N/mm^2) <=Sig.ba=175(N/mm^2)...\quad OK$$

(4) shear stress

shear stress must satisfy the following equation.

$$Tau = \frac{S}{Aw} <= Taua$$

where,

Tau : shear stress(N/mm^2)

Taua : allowable shear stress(N/mm^2)

Aw : using web section area(mm^2) (hf-2* t2)* t1

$$Tau = \frac{29.92*\ 10^3}{1998} =14.97\ (N/mm^2) <=Taua=120(N/mm^2)...\quad OK$$

4.3 waling design

(1) applied member

use : [150×75×6.5×10

using material : SS400

allowable bending stress : Sig.a = 139.8(N/mm^2)

(2) moment calculation

moment working on waling is calculated using the following equation.

$$M = \frac{T*\ L}{10} = \frac{29.92*\ 1.800}{10} = 5.38(kN.m/m)$$

where,

M:BM(kN.m/m)

T:tie rod tension(kN/unit)

L:tie rod installation spacing (m)

(3) stress

waling stress should be satisfied the following equation.

$$Sig. = \frac{M*\ 10^6}{Z*\ 10^3} <=Sig.a$$

where,

Sig. : waling stress(N/mm^2)

Sig.a: allowable bending stress(N/mm^2)

4.5< L/b<=30, Sig.a=[140- 2.4(L/b- 4.5)]* 1.5 (N/mm^2)

$=[140-2.4(1.800/0.075-4.5)]*1.5=139.8(N/mm^2)$

M : BM (kN.m/m)

Z : sct modulus ($=115*2cm^3$) *two makes one set, double of registered steel sct modulus.

Sig. $= \dfrac{5.38*10^6}{230*10^3} = 23.41(N/mm^2) <= $ Sig. a= $139.8(N/mm^2)$ ... OK

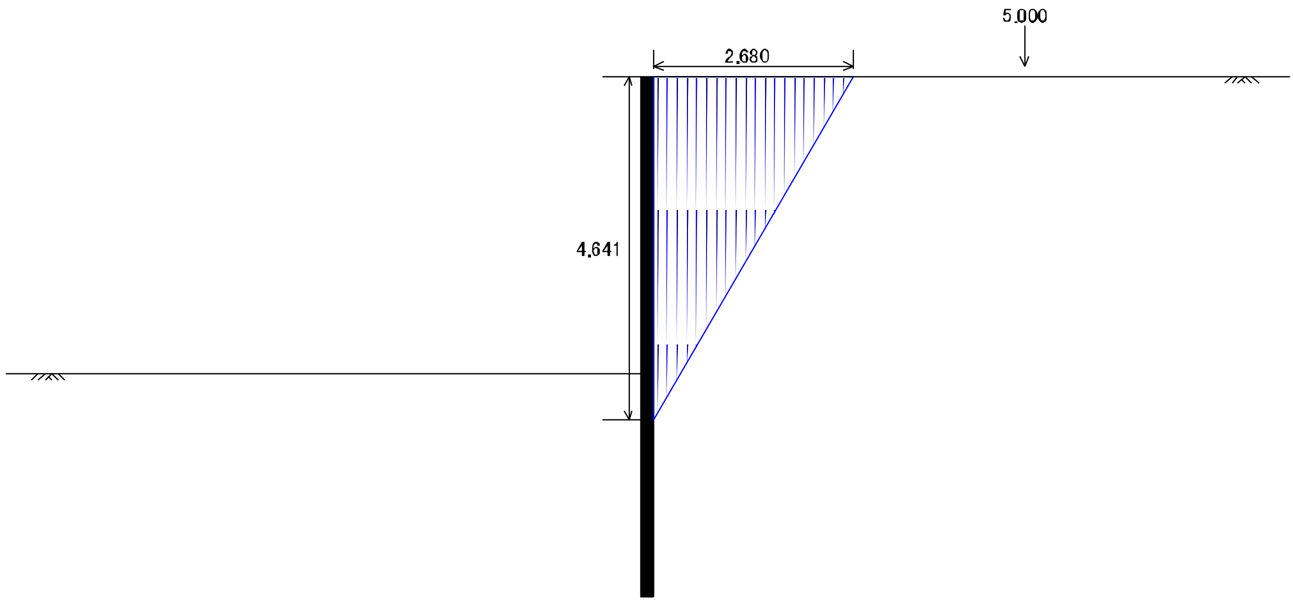
5 influence on surrounding ground

5.1 judgement on adjacent distance

(1)check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	47.000
excavation	G.L.(m)	43.000
virtual support point	G.L.(m)	42.359



(2)judgement on adjacent distance

1)influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{4.641}{\tan\left(45 + \frac{30.00}{2}\right)} = 2.680\ (m)$$

where,

Lxa: influence range on ground deformation by temporary works

dy : depth up to virtual support point of retaining wall

Phi: soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2)judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

Cover

(2) Ibrahimia Canal

(Upper left side)

I Design condition

1.1 fundamental data

file : Ibrahimia 2c1

title:

comment:

bracing type Raker pile tie rod type

wall type Steel sheet pile

type Normal

raker pile type H Beam pile(vertical)

applied standard- conventional method road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method: Wall inside-inside distance

plane shape type	Straight line
excavation width B (m) excavation length Le (m)	10.000 9.000

influence of water table	w/Do
base water table(before excavation) G.L.(m)	42.000

erection planning

final excavation depth G.L. 44.000(m)

excavation for installation strut 1.000(m)

tie rod setting point G.L. 48.500(m)

tie rod horizontal spacing 1.800(m)

1.2 shape

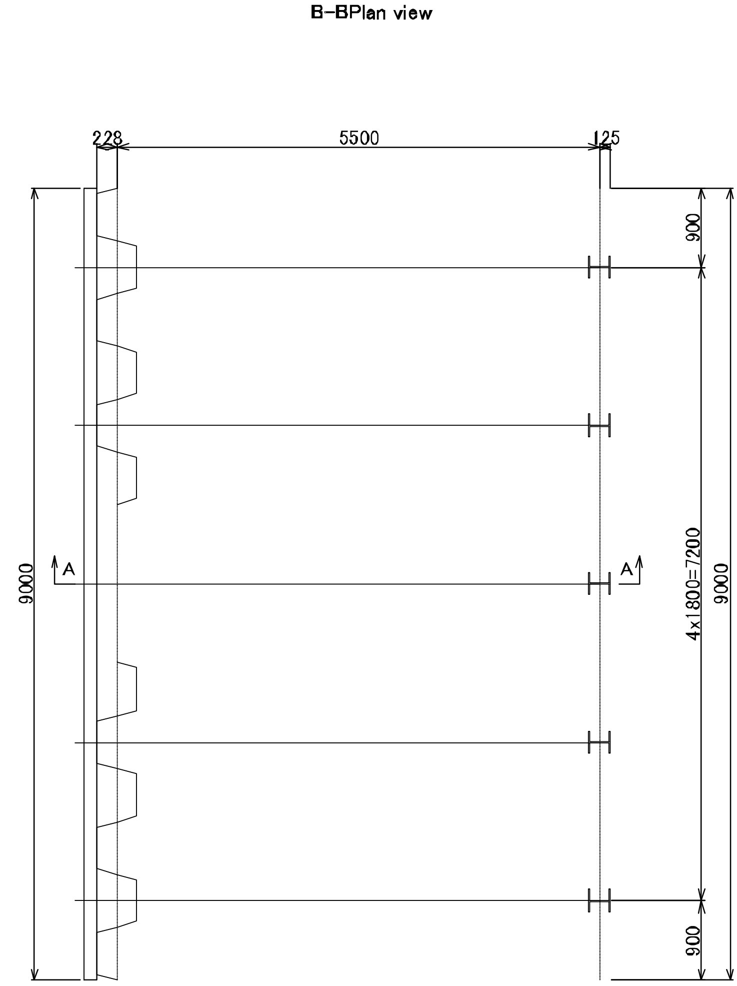
Design wall right wall

plane shape

	interval mm
wall to 1	900
1 to 2	1800
2 to 3	1800
3 to 4	1800
4 to 5	1800
5 to wall	900

tie rod and raker pile relationship: Direct connect

plan



side section shape

	top of wall G.L. m	ground level G.L. m
Right wall	50.000	49.000

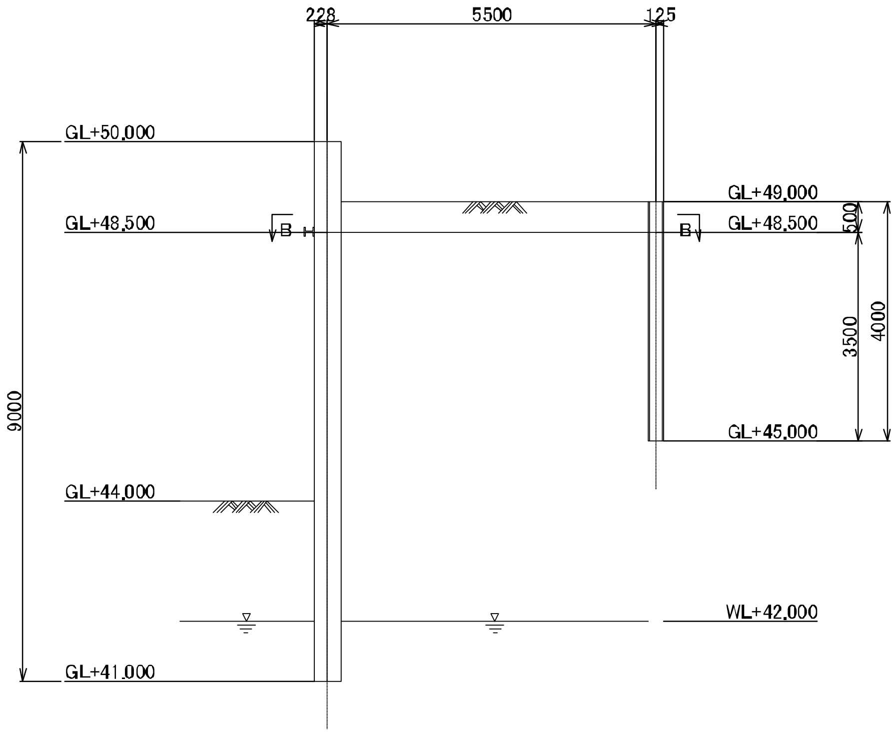
top of raker pile :G.L. 49.000(m)

raker pile installation check range : 20.000(m)

Side view

* left-right direction

A-ASection view



1.3 method

checking item

bearing capacity check	check Do
excavation bottom stability check	check Not do
surcharge by slope influence check	check Not do
bracing design	check Do
material	SS400
influence on surrounding ground check	check Do
simply prediction method	check
approximate prediction method	check
FEM prediction method	check
Length round up value	0.5m

descrption of conventional method

water pressure distribution	triangle
calculation method for earth pressure to evaluate section	For Embedment length
Horizontal modulus of subgrade reaction for raker pile calculation	Internal calculation

Horizontal modulus of subgrade reaction for retaining wall stiffness check Internal calculation
consider rock layer not do

elasto-plastic method concept
wall section change : not do

elastic portion rate : do
steady state check : not do
allowable displacement check : not do
analysis method : Analysis method 1
calculaion pitch : 0.50(m)
using elasto-plastic latteral pressure, embedment stability check when excavation: Consider S.F. of equi. len.
shape spring input method considered
H-subgrade reaction force calculation, shape dependant conversion width of load BH 10.000(m)
top of wall support condition Free
top of wall support condition Free
bracing combination condition(single wall analysis) rotation constrained No

for elasto-plastic method, latteral pressure
all Standard common
soil thickness above underground structure pressure: soil unit weight under ground water(Gamma -$Gamma_w$)
excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation
correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* right wall
. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	4.000	Sandy	27.0	18.0	9.0	25.00	10.0	0.0	75600
2	8.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200
3	7.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	4.000	Sandy	27.0	18.0	9.0	25.00	10.0	0.0	75600
2	8.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200
3	7.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

1.5 member

wall(steel sheet pile)
material
steel sheet pile material SY295
allowable bending stress 270(N/mm^2)
allowable shear stress 150(N/mm^2)
Young's modulus 2.00* 10^5(N/mm^2)
steel sheet pile effective rate Alpha
for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45
for moment of inertia(displacement calculation, member force) 0.45
section modulus (stress) 0.60

use

	use name	vertical load kN/m
Right wall	28PU+1	0.00

raker pile(H steel pile)

material

material :SS400

allowable bending stress :210(N/mm²)

allowable shear stress :120(N/mm²)

Young's modulus :$2.00*\ 10^5$(N/mm²)

use

use name :H−250×250× 9×14

vertical load :0.00(kN/unit)

tie rod

material

material :high tension steel690

allowable tensile stress :264(N/mm²)

Young's modulus :$2.00*\ 10^5$(N/mm²)

use

use diameter :28.0(mm)

using number :1

tie rod inclination :none

applied screw

name :M30

effective cross sectional area :561.0(mm²)

E.P. method

H length L m	bracing spring tension charac.	bracing pre load consid	bracing pre loaded kN/memb.	cstrc losnes mm	H-sprg dirct inp Yes/No	H-sprg const kN/m/m
5.500	Yes	Not do	0.01	0	No	----------

waling material

material

material :SS400

allowable bending stress Sig.a :interior calculation

design concept

waling type :U-type

checking equation :TL/10

use

use name : ∟150×75×9×12.5

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	0.00

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Primary exc.	47.500	42.000	none
2	Final Exc.	1	Completion time	44.000	42.000	Yes

* right wall

No	WT G.L.	surcharge kN/m^2		virt sprt pt G.L. m
	natrlgrnd	natrlgrnd	exv	
1	42.000	20.00	0.00	int calc
2	42.000	20.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11, Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
Right wall	Percussion method	2.0	5	Use cohesive

Note:Construction method.

Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 influence on surrounding ground check

common setting

check objective wall :right wall

check case :completion time

check depth

check point No	distance from wall (m)
1	5.000

allowable displacement qt

allowable Horizontal displacement qt:[0.020](m)

allowable Vertical displacement qt:[0.020](m)

allowable inclination angle :[0.001](rad)

judgement on adjacent distance

judgement method :derived from deflection(sand ground)

properties for judgement :Phi=[30.00]deg.

simple prediction method

maximum settlement prediction, draw a presumed line internally.

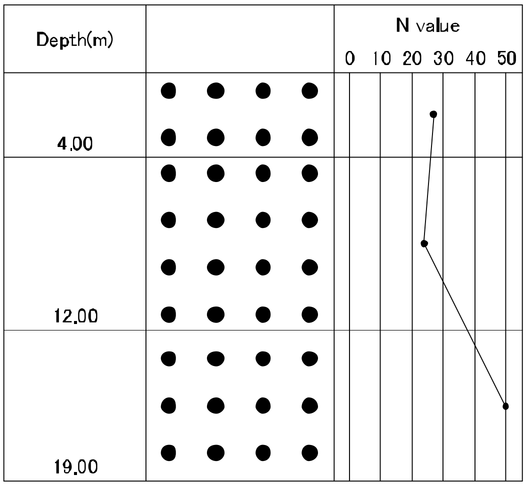
maximum settlement prediction, draw a presumed line internally.

approximate value prediction method

Set ground surface settlement area(As)
Assume As [1.00] times of retaining wall deformation area (Ad)
Set depth at zero displacement of retaining wall (H0)
define displacement zero horizontal displacement[0.10]mm under
ground settlement influence range (L0, L1) setting
ground settlement influence range (L0) is [1.00] times of (H0) depth at zero displacement of retaining wall in trapezoidal distribution, constant settlement (L1) is [1.00] times of excavation depth (H)

1.10 boring log

* right wall



1.11 Design strength

1.11.1 Set value for design

(1) Simplified method

[Standard: Temporary structure construction guideline(H11)]
considered Do 0.3Gam h criteria for active earth pressure clay to calculate embedment length
considered. Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth
self-standing required embedment estimate coefficient : 2.50/Beta
min embedment criteria : Based on design strength
soldier pile
Take 1.00 times of pile width when Beta is calculated.
eth prss ld W under exv btm and side result:Temporary structure construction guideline, Metro.express.H19
bracing reaction force
when excavation: Downward shared method
when removal: Temp. Works Guid.Metro. express.H19
tie rod reaction force: Overhang beam divide method
raker pile
take 1.00 times of pile width for straight pile Beta calculation
coefficient is 2.50/Beta to estimate required embedment length
initiation point of passive slip surface is 1.00/Beta

(2) Earth pressure for section calculation

[Standard: Temp. Works Guid., Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18), Land impro. wall(H5)]
sand 2.000

clay

constituency of clay judgement Nvalue Nx 5.000

soft clay N<=Nx 6.000

stiff clay N> Nx 4.000

(3) Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline, Metro. express. H19]

sandy soil	N<=10	1.000
	10< N<=30	2.000
	30< N	2.000
cohesive soil	N<=4	1.000
	4< N<=8	1.000
	8< N	1.000
treatment other than passive earth pressure		= pssv eth prss
side resistance of passive earth pressure		consider: Do

(4) Minimum Embedment depth

[Continuous wall]

self-standing 3.00(m)

when excavation with strut 3.00(m)

[Soldier pile]

self-standing 1.50(m)

when excavation with strut 1.50(m)

(5) Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20

conventional method

wall self-standing allowable displacement

wall self-standing allowable displacement is 3.0% of excavation depth

allowable displacement when checking stiffness 0.300(m)

raker pile allowable displacement 0.300(m)

elasto-plastic

required elastic region ratio 50.0(%)

(6) Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7) Bearing capacity coefficient

[Standard: Temp. Works Guid. H11, Metro. express. H19, Std. Dsgn. Spec. Vol. 2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method	1.0	1.0
vibration method	1.0	0.9
prss in	1.0	1.0
pre-boring method(sand filling)	0.0	0.5
pre-boring method(percussion, vibration, prss tip embedment)	1.0	1.0
	0.0	0.5

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method, vibration method kN/m²	100	150
drill and prss casting method kN/m²	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximumskin friction upper limit kN/m²	200	150

(1) (8) Analysis the effect to surrounding soil

simply prediction method; maximum settlement prediction diagram table

turning point No	I: hard line		II: middle, soft line	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.33	0.00	2.00
(2)	0.35	0.40	0.70	0.80
(3)	3.00	0.00	3.00	0.00

I : embedment tip ground strength = hard line

II: embedment tip ground strength = middle, soft line

x-ax: relative stiffness zeta(10^6kN m²/m)

y-ax: surrounding ground max settlement /excavation depth (%)

max settlement predicition table

turning point No	I: 30.0m under		II: 30.0m over	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.85	0.00	3.50
(2)	0.50	0.25	0.95	0.58
(3)	3.00	0.00	3.00	0.00

I : presumed line for excavation width under 30m

II: presumed line for excavation width over 30m

x-ax: equivalent stiffness xi(10^6kN m²/m)

y-ax: maximum settlement location surrounding ground /excavation depth

II Calculation results

1 Simplified method

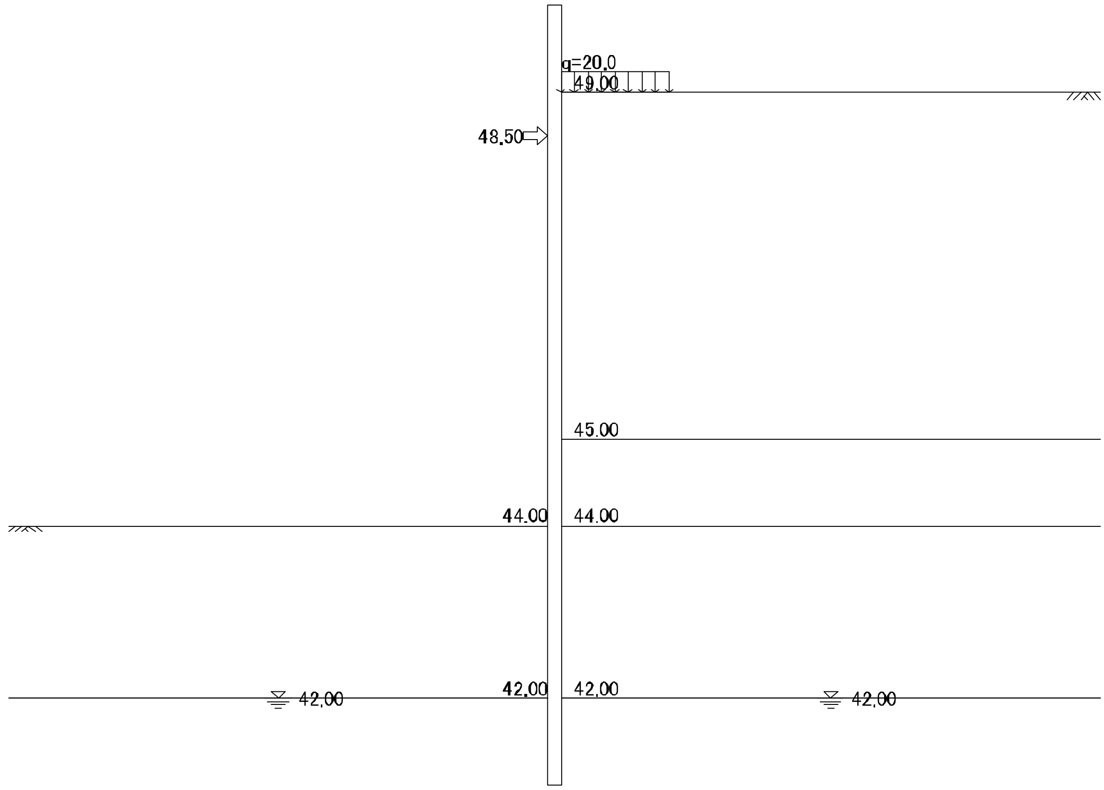
1.1 Right wall design

1.1.1 complesion time

(1) check condition

state : Final excavated time

case name: completion time



1) check condition

natural ground surface	G.L.(m)	49.000
excavation	G.L.(m)	44.000
lowest strut	G.L.(m)	48.500
water table at natural ground	G.L.(m)	42.000
water table at excavation	G.L.(m)	42.000
surcharge at natural ground q	kN/m^2	20.00
surcharge at excavation q	kN/m^2	0.00

2) ground condition

* natural ground

No	elevation		ground type	soil N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m^3)	sbmg wt (kN/m^3)		
1	49.000	45.000	Sandy	27.0	18.0	9.0	25.0	12.5
2	45.000	44.000	Sandy	24.0	18.0	9.0	25.0	12.5
3	44.000	42.000	Sandy	24.0	18.0	9.0	25.0	12.5
4	42.000	37.000	Sandy	24.0	18.0	9.0	25.0	12.5
5	37.000	30.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion Co (kN/m2)	inc k (kN/m3)	base G.L.(m)	unc cmpr strg qu (kN/m2)	dfrm modul Al p. Eo (kN/m2)
1	10.0	0.0	49.000	20.0	75600
2	10.0	0.0	45.000	20.0	67200
3	10.0	0.0	45.000	20.0	67200
4	10.0	0.0	45.000	20.0	67200
5	10.0	0.0	37.000	20.0	140000

* excavation side

No	elevation upper G.L.(m)	bottom G.L.(m)	ground type	ave N val	soil unit weight wet wt (kN/m3)	sbmg wt (kN/m3)	internal fric agl (deg.)	wall fric agl (deg.)
1	44.000	42.000	Sandy	24.0	18.0	9.0	25.0	12.5
2	42.000	37.000	Sandy	24.0	18.0	9.0	25.0	12.5
3	37.000	30.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion Co (kN/m2)	inc k (kN/m3)	base G.L.(m)	unc cmpr strg qu (kN/m2)	dfrm modul Al p. Eo (kN/m2)
1	10.0	0.0	45.000	20.0	67200
2	10.0	0.0	45.000	20.0	67200
3	10.0	0.0	37.000	20.0	140000

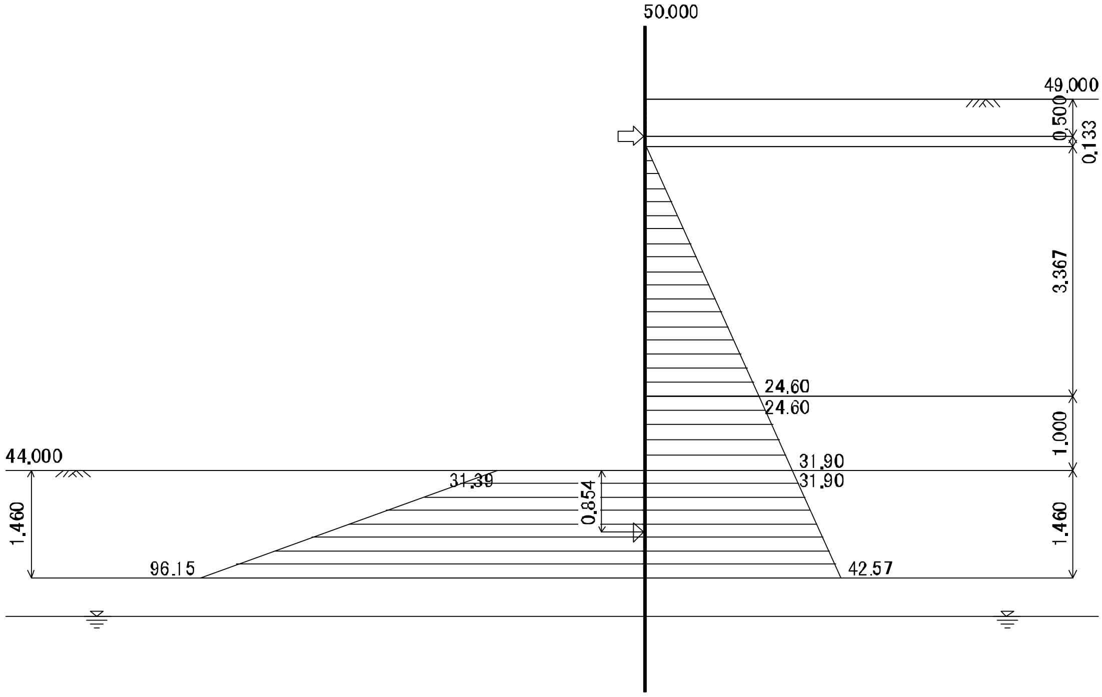
(2) embedment length calculation

1) result summery

case name: completion time

analysis method : embedment length is calculated from moment balance at lowest strut

excavation depth		(G.L. 44.000)m
req embd L	safety factor F	1.200
	balance depth Z(m)	1.460(G.L. 42.540)m
	required embedment length D(m)	1.752(G.L. 42.248)m
	virtual support point depth Y(m)	0.854(G.L. 43.146)m
minimum embedment length (m)		3.000(G.L. 41.000)m
final embd L	final embedment length L (m)	3.000(G.L. 41.000)m
	judge	OK
final all length		9.000m



* sum of external forces at the balanced depth (G.L. 42.540) m

item	moment		horizontal force	
Active side Compre. side	Ma+Mw(kN.m/ m) Mp(kN.m/m)	498.29 498.43	Pa(kN/m) Pp(kN/m)	124.03 93.10
ratio(Mp/(Ma+ Mw))			1.0	
virtual support point depth (Y) m			0.854	

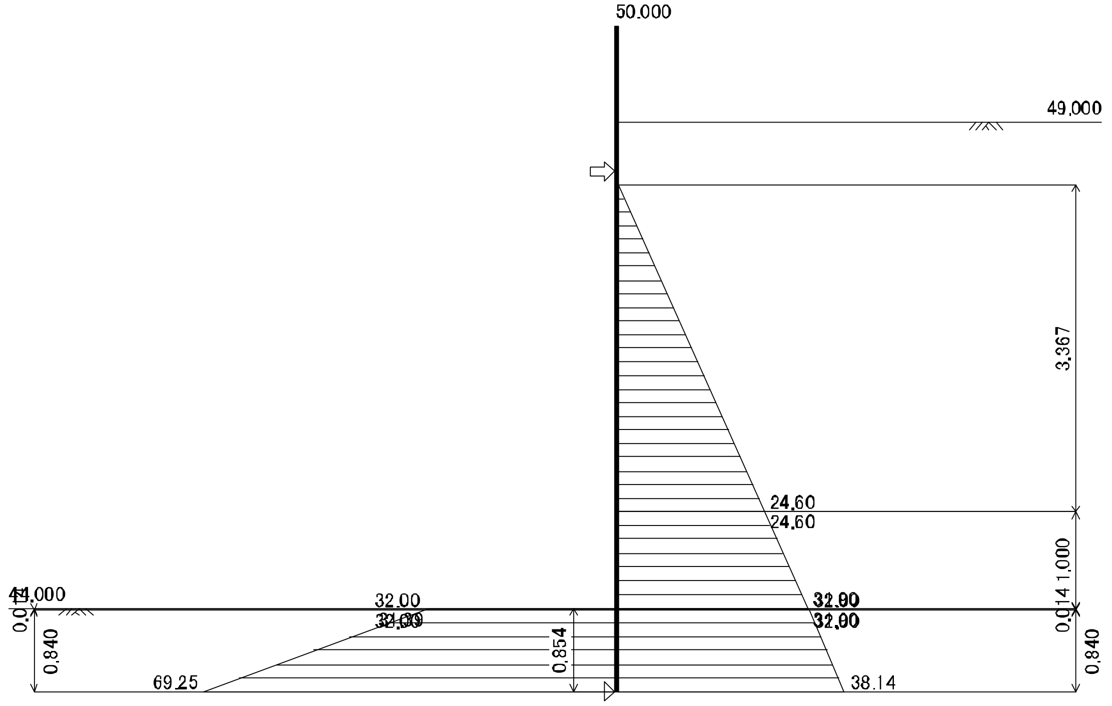
Mp is a moment at lowest strut, so assumed bearing depth Y is modified by the next equation.
virtual support point depth (Y) = Mp/Pp- (lowest strut place - excavation base).

(3) calculation of member force

1) result summery

case name: completion time

analysis method : check as a simple beam with a span between strut and virtual support point.
earth pressure is taken the earth pressure for embedment length calculation.



* single span supported at lowest strut and virtual support point

lowest strut depth		m	(G.L. 48.500) m
virtual support point depth		m	(G.L. 43.146) m
simple beam span		m	5.354
max bending moment	moment Mmax	kN.m/m	61.46
	depth(from strut)	m	3.001(G.L. 45.499) m
shear force	shear force Smax	kN/m	39.61
	depth(from strut)	m	4.514(G.L. 43.986) m
reaction	upper reaction force RA	kN/m	30.05
	lower reaction force RB	kN/m	39.61
*max displacement	displacement Del.max	m	0.0028
	depth(from strut)	m	2.677(G.L. 45.823) m

*reference value

3) retaining wall stiffness check

nevertheless wall stress has allowance, not to deform retaining wall within a certain level, checking enough stiffness assured. so displacement must be satisfied the following equation.

Del. = Del.1+ Del.2<=Del.a

where,

Del. : total retaining wall displacement

Del.1: maximum displacement calculated as a simple beam

$$\text{Del.1} = \frac{5^{*}\ w^{*}\ L^{4}}{384^{*}\ \text{EIAlp.}}$$

Del.2: influence displacement at elastic support

Del.2' = R/K

Del.2 = Del.2' /2

Del.a: allowable displacement

calculating model is SS beam at top strut and an elastic support of half of embeded depth, load is taken earth pressure for section check and water pressure throughout a span. if a ld has trapezoidal dstr, convert to an conversion uniform dstr ld with the same intensity.

rigid support level (top strut)		G.L.(m)	48.500
virtual support point depth	Y	m	0.854
1/2 of virtual support point depth		G.L.(m)	43.573
simple beam span	L	m	4.927
intensity applied on a simple beam	P	kN/m	83.95
Del.1	Young's modulus E	* 10^8 kN/m²	2.000
	moment of inertia of area I	m⁴/m	0.00068380
	effective rate(displacement) Alp.	-----	0.450
	deformation of center in span Del.1	m	0.0021
Del.2	modulus of subgrade reaction kH	kN/m³	16147
	wall width B	m	1.000
	side area of spring block pile A=B*Y	m²	0.8535
	spring constant K=kH*A	kN/m²	13782
	reaction force R=w*L/2	kN/m	41.97
	elastic support displacement Del.2' =R/K	m	0.0030
total wall displacement Del. = Del.1+Del.2		m	0.0036
position (a half of span)		G.L.(m)	46.037
allowable displacement	Del.a	m	0.300
Judge		-----	OK

* total intensity applied on a simple beam(P)

No	depth GL(m)	thk h (m)	action load p kN/m²	load P kN/m
1	48.500 48.367	0.133	0.00 0.00	0.00
2	48.367 45.000	3.367	0.00 24.60	41.41
3	45.000 44.000	1.000	24.60 31.90	28.25
4	44.000 43.986	0.014	31.90 32.00	0.45
5	43.986 43.573	0.413	32.00 35.02	13.84
Sig				83.95

* Horizontal modulus of subgrade reaction

Horizontal modulus of subgrade reaction is an average value to virtual support point, using the equation

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta=1

kHo: H-modulus of subgrade reaction equivalent to that of a 30cm stiffness round plate.

$$kHo = \frac{1}{0.3} Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH*h (kN/m²)
1	44.000	43.146	0.854	67200	224000	16147	13782
Sig			0.854				13782

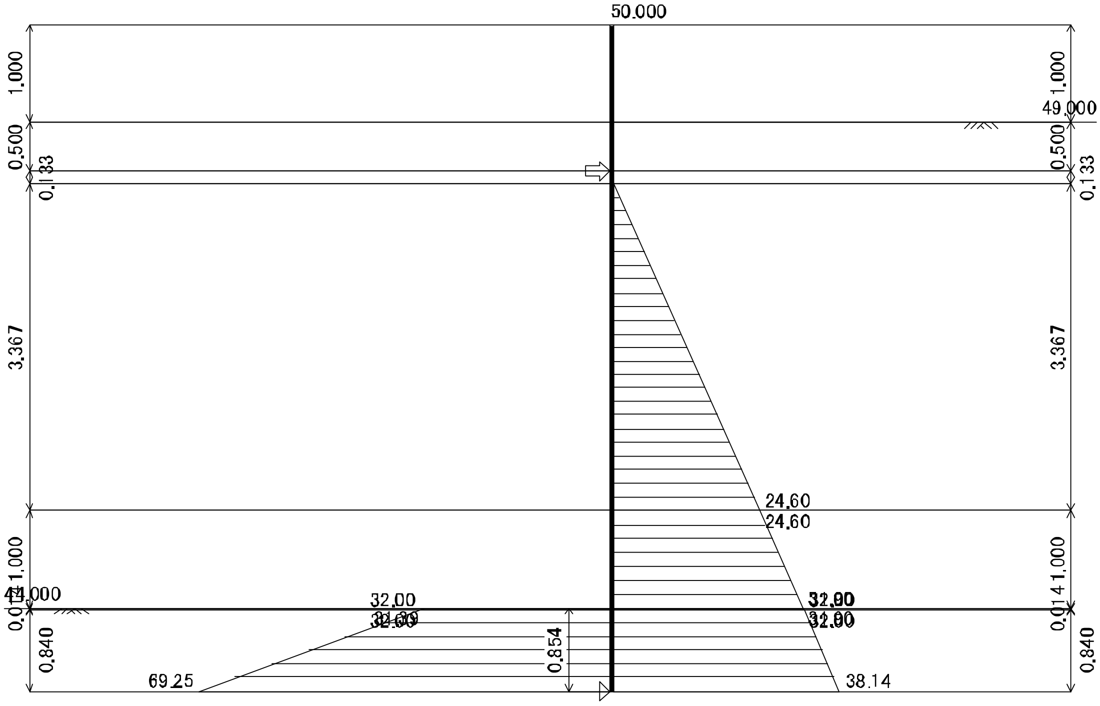
ave kH=Sig.(kH*h)/Sig.h= 16147(kN/m³)

BH: conversion width of load 10.0(m)

(4) calculation of bracing reaction force

1) result summery

analysis method : Overhang strut method



No	depth G.L. (m)		support G.L. (m)	reaction force kN/m	bracing reaction force kN/m
1	48.500	up span	--------	--------------	30.05
		low span	43.146	30.05	

timbering reaction= timbering No.(n)up spansprt rct+ reaction of lower support

up span bt focusing bracing and just above. Support at bracing above tmb No(n).

up span bt focusing bracing and just below. Support at bracing below tmb No(n).

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions		unit	value
section modulus	Z	$*10^3(mm^3/m)$	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	$*10^2(mm^2/m)$	226.00

(2) design member force

design member force is as following table.

state	moment M $*10^6$(N.mm/m)	axial force N $*10^3$(N/m)	shear force S $*10^3$(N/m)
Max.	61.46	0.00	39.61

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm²	allowable stress N/mm²	Judge
Max.	34.1	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} \leq Taua$$

where,

Tau : shear force stress (N/mm²)

Taua: allowable shear stress (N/mm²)

state	stress Tau N/mm²	allowable stress Taua N/mm²	Judge
Max.	1.8	150.0	OK

2 Elasto-plastic method

2.1 Right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm³/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm²/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	62.70	0.00	47.26

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm²)

Sig.sa: allowable bending stress(N/mm²)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm²	allowable stress N/mm²	Judge
Max.	34.8	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm²)

Taua:allowable shear stress (N/mm²)

state	stress Tau N/mm²	allowable stress Taua N/mm²	Judge
Max.	2.1	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1) Primary excavation

1) analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	50.000		--------	0.00	----------	--------	-1.36	--------
2	49.500		0.00	0.00	----------	--------	-1.20	--------
3	49.000		0.00	0.00	----------	--------	-1.05	--------
4	48.500		2.11	2.11	----------	--------	-0.89	--------
5	48.000		4.22	4.22	----------	--------	-0.74	--------
6	47.500	Ela.zone	6.33	6.33	10.20	4541	-0.58	2.6
7	47.000	Ela.zone	4.79	4.79	28.89	9083	-0.44	4.0
8	46.500	Ela.zone	3.25	3.25	40.20	9083	-0.31	2.8
9	46.000	Ela.zone	1.70	1.70	51.51	9083	-0.21	1.9
10	45.500	Ela.zone	0.16	0.16	33.25	5009	-0.12	0.6
11	45.448	Ela.zone	0.00	0.00	33.11	4541	-0.11	0.5
12	45.000	Ela.zone	0.00	0.00	70.58	8110	-0.06	0.5
13	44.500	Ela.zone	0.00	0.00	85.44	8073	-0.01	0.1
14	44.000	Ela.zone	0.00	0.00	96.75	8073	0.01	-0.1
15	43.500	Ela.zone	0.00	0.00	108.06	8073	0.03	-0.3
16	43.000	Ela.zone	0.00	0.00	119.37	8073	0.04	-0.3
17	42.500	Ela.zone	0.00	0.00	130.67	8073	0.04	-0.3
18	42.000	Ela.zone	0.00	0.00	141.20	8073	0.04	-0.3
19	41.500	Ela.zone	0.00	0.00	147.01	8073	0.04	-0.3
20	41.000	Ela.zone	0.00	--------	75.39	4037	0.04	-0.2

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

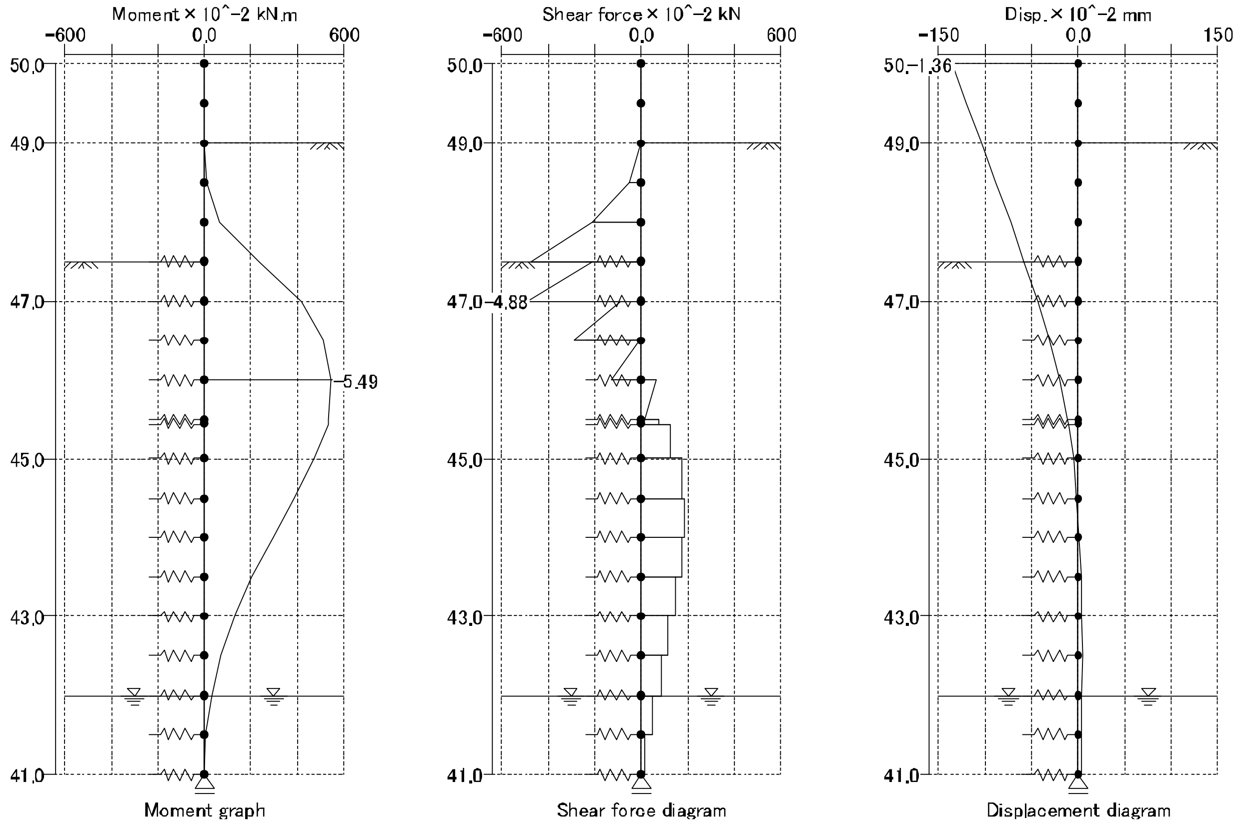
2) Primary excavation analysis result (member force, displacement)

Mmax = 0.0kN.m/m (working pos G.L. 49.00m) Mmin = -5.5kN.m/m (working pos G.L. 46.00m)

Smax = 1.9kN/m (working pos G.L. 44.50m) min = -4.9kN/m (working pos G.L. 47.00m)

Del.max= 0.04mm (working pos G.L. 42.50m) Del.min= -1.36mm (working pos G.L. 50.00m)

node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H rct kN/m
		upper	bottom	upper	bottom		
1	50.000	----------	0.0	----------	0.0	-1.36	----------
2	49.500	0.0	0.0	0.0	0.0	-1.20	----------
3	49.000	0.0	0.0	0.0	0.0	-1.05	----------
4	48.500	-0.1	-0.1	-0.5	-0.5	-0.89	----------
5	48.000	-0.7	-0.7	-2.1	-2.1	-0.74	----------
6	47.500	-2.4	-2.4	-4.8	-2.1	-0.58	----------
7	47.000	-4.2	-4.2	-4.9	-0.9	-0.44	----------
8	46.500	-5.1	-5.1	-2.9	0.0	-0.31	----------
9	46.000	-5.5	-5.5	-1.3	0.6	-0.21	----------
10	45.500	-5.3	-5.3	0.1	0.7	-0.12	----------
11	45.448	-5.3	-5.3	0.7	1.3	-0.11	----------
12	45.000	-4.7	-4.7	1.3	1.7	-0.06	----------
13	44.500	-3.9	-3.9	1.7	1.9	-0.01	----------
14	44.000	-2.9	-2.9	1.9	1.7	0.01	----------
15	43.500	-2.1	-2.1	1.7	1.5	0.03	----------
16	43.000	-1.3	-1.3	1.5	1.2	0.04	----------
17	42.500	-0.7	-0.7	1.2	0.8	0.04	----------
18	42.000	-0.3	-0.3	0.8	0.5	0.04	----------
19	41.500	-0.1	-0.1	0.5	0.2	0.04	----------
20	41.000	0.0	----------	0.2	----------	0.04	----------



* pre-displacement and loading equivalent to pre-displacement

when strut is effective after next step, a load for pre-displacement is applied.

node No	displacement Del.x mm	release Del.L mm	preceding displacement Del.o mm	bracing spring Ks kN/m	preceding displacement load kN/m
4	-0.89	0.00	-0.89	12439.4	-11.08

where,

Del.x: wall displacement at strut level(->)+)

Del.L: construction release

Del.o: pre-disp(->)+) Del.o=Del.x-Del.L

(2)完成時

1)analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m² top	bottom	effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
1	50.000		--------	0.00	----------	--------	-1.11	--------
2	49.500		0.00	0.00	----------	--------	-1.99	--------
3	49.000		0.00	0.00	----------	--------	-2.87	--------
4	48.500	Strut	3.07	3.07	-11.08	12439	-3.75	35.5
5	48.000		6.15	6.15	----------	--------	-4.62	--------
6	47.500		9.22	9.22	----------	--------	-5.42	--------
7	47.000		12.30	12.30	----------	--------	-6.09	--------
8	46.500		15.37	15.37	----------	--------	-6.58	--------
9	46.000		18.45	18.45	----------	--------	-6.84	--------
10	45.500		21.52	21.52	----------	--------	-6.86	--------
11	45.448		21.84	21.84	----------	--------	-6.85	--------
12	45.000		24.60	24.60	----------	--------	-6.63	--------
13	44.500		28.25	28.25	----------	--------	-6.16	--------
14	44.000	Pla.zone	31.90	31.90	10.20	4037	-5.49	0.0
15	43.500	Pla.zone	30.36	30.36	28.89	8073	-4.70	0.0
16	43.000	Ela.zone	28.82	28.82	40.20	8073	-3.85	31.1
17	42.500	Ela.zone	27.27	27.27	51.51	8073	-2.99	24.2
18	42.000	Ela.zone	25.73	25.73	62.03	8073	-2.15	17.4
19	41.500	Ela.zone	25.04	25.04	67.84	8073	-1.33	10.8
20	41.000	Ela.zone	24.36	--------	35.81	4037	-0.52	2.1

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

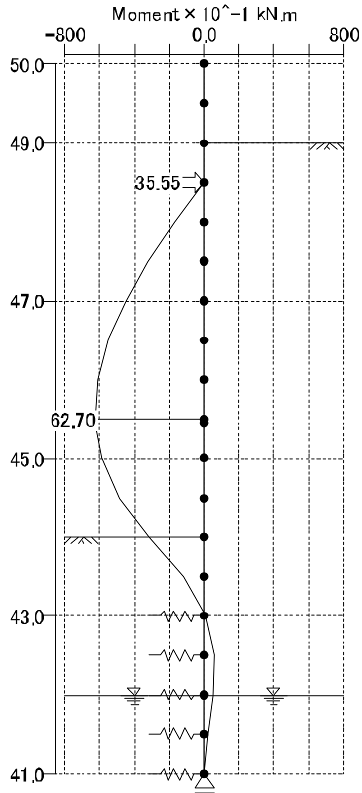
2)completion time analysis result (member force, displacement)

Mmax = 62.7kN m/m (working pos G.L. 45.50m) Mmin = -5.6kN m/m (working pos G.L. 42.50m)

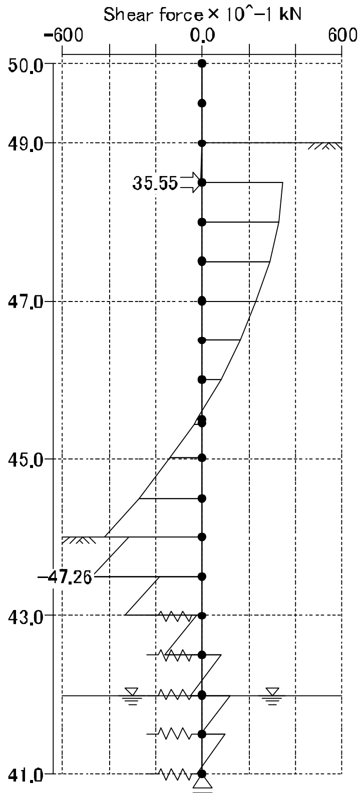
Smax = 34.8kN/m (working pos G.L. 48.50m) Smin = -47.3kN/m (working pos G.L. 43.50m)

Del.max=-------- mm (working pos G.L.--------m) Del.min= -6.86mm (working pos G.L. 45.50m)

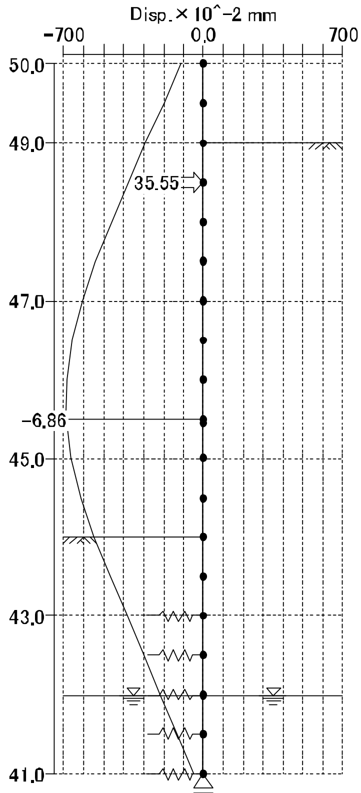
node No	G.L.	moment kN m/m upper	bottom	shear force kN/m upper	bottom	disp mm	brc H rct kN/m
1	50.000	----------	0.0	----------	0.0	-1.11	----------
2	49.500	0.0	0.0	0.0	0.0	-1.99	----------
3	49.000	0.0	0.0	0.0	0.0	-2.87	----------
4	48.500	-0.1	-0.1	-0.8	34.8	-3.75	35.5
5	48.000	16.7	16.7	32.5	32.5	-4.62	----------
6	47.500	32.1	32.1	28.6	28.6	-5.42	----------
7	47.000	45.1	45.1	23.2	23.2	-6.09	----------
8	46.500	55.1	55.1	16.3	16.3	-6.58	----------
9	46.000	61.2	61.2	7.9	7.9	-6.84	----------
10	45.500	62.7	62.7	-2.1	-2.1	-6.86	----------
11	45.448	62.6	62.6	-3.2	-3.2	-6.85	----------
12	45.000	58.8	58.8	-13.6	-13.6	-6.63	----------
13	44.500	48.8	48.8	-26.9	-26.9	-6.16	----------
14	44.000	31.7	31.7	-41.9	-31.7	-5.49	----------
15	43.500	11.9	11.9	-47.3	-18.4	-4.70	----------
16	43.000	-1.0	-1.0	-33.2	-2.1	-3.85	----------
17	42.500	-5.6	-5.6	-16.1	8.0	-2.99	----------
18	42.000	-4.9	-4.9	-5.2	12.2	-2.15	----------
19	41.500	-2.0	-2.0	-0.5	10.3	-1.33	----------
20	41.000	0.0	----------	-2.1	----------	-0.52	----------



Moment graph



Shear force diagram



Displacement diagram

3 Bearing capacity

3.1 Bearing capacity

3.1.1 check condition

(1) check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	41.000
exv bs ps	G.L.(m)	44.000
embd L L	m	3.000

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	660.48	330.24	0.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	24.0	24.0	24.0	4800.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N-val Ni	Li* Ni
1	43.000	42.000	1.000	24.0	24.00
2	42.000	41.000	1.000	24.0	24.00
Sig			2.000		48.00

3) circumference friction force(Sig.Li* fi)

* sand : fi= 2BetaNs(note; Ns<=50
* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)
* coefficient of skin friction with construction method: Beta= 1.0
* Nvalue <=2 fi= 0.0 in weak soil
* all friction resistance Sig.Li* fi= 552.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li*fi (kN/m)
1	2.000	24.0	-----	48.00	96.00
2	1.000	24.0	-----	48.00	48.00
Sig	3.000				144.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li*fi (kN/m)
1	4.000	27.0	-----	54.00	216.00
2	1.000	24.0	-----	48.00	48.00
3	2.000	24.0	-----	48.00	96.00
4	1.000	24.0	-----	48.00	48.00
Sig	8.000				408.00

4 Bracing, Raker pile calculation

4.1 tie rod design

(1)applied member

using tie rod diameter :tie rod diameterPhi 28.0(mm)* using # n=1

using material :high tension steel690

allowable tensile stress :Sig.a = 264(N/mm²)

tie rod installation spacing :L = 1.800(m)

screw part(listed, effective cross sectional area) :M30(A = 561.0mm²)

(2)tie rod calculation of member force

tie rod tension is calculated with tie rod reaction and spacing using the following equation.

T = Ra* L = 45.60* 1.800 = 82.08(kN/unit)

where,

T :tie rod tension(kN/unit)

Ra:tie rod reaction force(kN/m)

La:tie rod installation interval (m)

(3)tie rod stress calc

tie rod stress should be satisfied the following equation.

$$Sig. = \frac{T^* 10^3}{n^* A} <= Sig.a$$

where,

Sig. :tie rod stress.(N/mm²)

Sig.a:allowable tensile stress(N/mm²)

n :using number

A :using cross sectional area (mm²)

$$Sig. = \frac{82.08^* 10^3}{1^* 561.0} = 146.31 \text{ (N/mm}^2\text{)} <= Sig.a = 264 \text{(N/mm}^2\text{)} ... \quad OK$$

4.2 Design of raker pile

4.2.1 Dimensions of a pile

Dimensions of a pile are as follows.

(1)using material

Type :H steel pile(B = 250mm)

Use :H−250×250× 9×14

Dimensions	Unit	Value
Cross sectional area A	cm²/m	91.43
Moment of inertia I	cm⁴/m	10700
Section modulus Z	cm³/m	860

(2)material

Using material :SS400

Young's modulus :E = 2.000* 10^8(kN/m²)

4.2.2 Calculate installation layout

(1)calculate necessary installation distance

Rake pile is placed on actv failure plane starting from virtual support point and pssv failure plane starting from 1.00/Beta of depth below tie rod intersect above the location of tie rod.

In this, actv and pssv failure planes intersect at tie rod depth is called a req inst distance.

1)active failure plane

Act. fail. plane on back side starting from a sup. pointed of a rt wl (GL-13.146m) is described.

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	actv failure agl zetaa(Deg.) = 45+Phi/2	failure line width Ldi(m) = hi* cotzetaa
2	45.000	43.146	1.854	25.00	57.50	1.181
1	48.500	45.000	3.500	25.00	57.50	2.230
Si.			5.354			3.411

2) passive failure plane

Passive failure on back side starting from the position 1.00/Beta below rake pile tie rod is.

$$\text{Starting position of raker pile} = \text{tie rod position of raker pile} - \frac{1.00}{Beta}$$

$$= G.L.48.500 - \frac{1.00}{0.826473} = G.L.47.290(m)$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	pssv failure agl zetap(Deg.) = 45-Phi/2	failure line width Ldi(m) = hi* cotzetap
1	48.500	47.290	1.210	25.00	32.50	1.899
Si.			1.210			1.899

3) required installation distance

Required installation distance Ldmin is given as following equation.

Ldmin = Sig.hi* cotzetaa + Sig.hi* cotzetap =3.411 +1.899 =5.310(m)

(2) installation position of raker pile

From above, raker pile is installed Ld =5.310(m) on backside.

Ld =5.500(m) =>Ldmin =5.310(m)... It is safe.

(3) calculate a characteristic value Beta to determine required installation position.

Beta at raker pile instl at distance from req instl distance Ldmin = 5.310(m) from rt wl is given.

1) calculate characteristic value Beta

Characteristic value Beta is calculated using the following equation.

$$Beta = \sqrt[4]{\frac{kH^* B}{4EI Alp.}} = \sqrt[4]{\frac{159946.5^* 250.0^* 10^{-3}}{4^* 2.000^* 10^{8*} 10700^* 10^{-8*} 1.000}} = 0.826473(m^{-1})$$

where,

Horizontal subgrade reaction coefficient kH = 159946.5(kN/m^3)

width of raker pile B = 250.0* 10^{-3}(m)

B is flange WB in case of H steel, or [1.00] times of pile diameter in case of st pipe pile.

Young's modulus E = 2.000* 10^8(kN/m^2)

Moment of inertia of area I = 10700* 10^{-8}(m^4)

effective rate(for embedment calculation) Alp. = 1.000

2) calculation of horizontal subgrade reaction coefficient

H-subgrade reaction coefficient is an average value within 1/Beta= 48.500(m) from G.L. 1.210(m) using the following equation.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta : coefficient regarding to wall type (1.00 in case of raker pile)

kHo: H-subgrade reaction coefficient equi to plate bear test result by stiffness round plate of 30cm diameter

$$kHo = \left(\frac{1}{0.3}\right) Alp.Eo$$

where,

Eo: ground modulus of deformation(kN/m^2)

Alp.: coefficient to calculate subgrade reaction coefficent

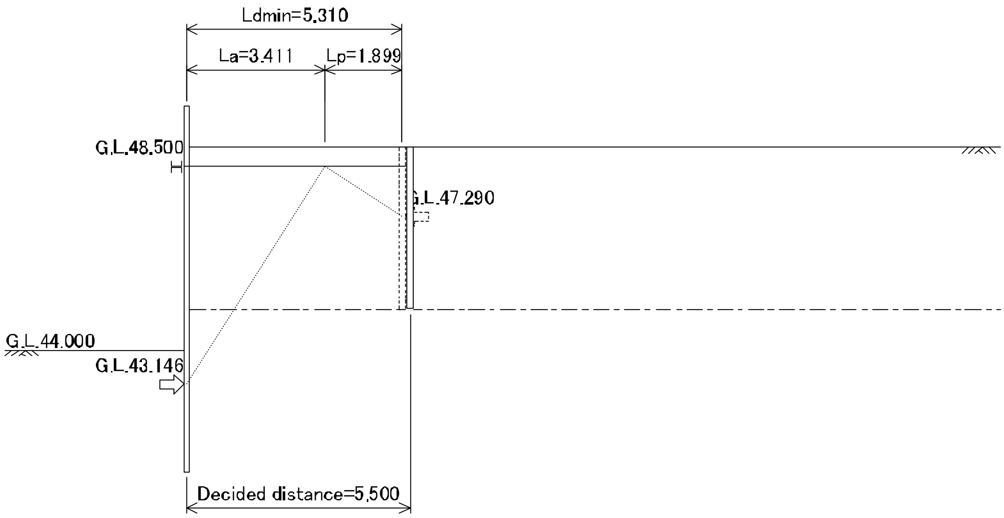
BH conversion width of load is calculated using the following equation.

$$BH = \sqrt{\frac{D}{Beta}} = \sqrt{\frac{250 * 10^{-3}}{0.826473}} = 0.5500(m)$$

where, D is flange WB in case of H steel pile, or a pile diameter D of steel pipe pile.

$$\text{Average kH within the range of } \frac{1}{Beta} = \frac{Sig.kH * h}{Sig.h} = \frac{193529}{1.210} = 159946.5 \ (kN/m^3)$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	Alp.Eo kN/m^2	kHo kN/m^3	kH kN/m^3	kH* h kN/m^2
1	48.500	47.290	1.210	75600	252000	159946	193529
Si.			1.210				193529



4.2.3 calculate embedment length

(1)length of raker pile

Pile L to include embd L req from the calc as an infinite pile on elastic grnd as described below.

$$D = \text{Safety coefficient} \frac{}{Beta} = \frac{2.50}{0.826473} = 3.025(m) <= \text{real embedment length}=3.500(m)... \quad OK$$

raker pile head EL rake pile tie rod position EL raker pile design ground level		(G.L. 49.000)m (G.L. 48.500)m (G.L. 48.500)m
required embedment length	safety coeff chra Beta(m^{-1}) D= safety coeff/Beta	2.50 0.826473 3.025(G.L. 45.475)m
final embedment length	real length (m)	3.500(G.L. 45.000)m
	judgement	OK
final total length		4.000m

(2)calculate Beta at raker pile installed position

It follows the result of Beta=0.826473(m^{-1}) obtained in calculating a necessary distance.

4.2.4 calculation of member force

(1) calculation of member force

1) maximum bending moment

$$Mmax = 0.3224\frac{H}{Beta} = 0.3224*\frac{82.08}{0.826473} = 32.02$$

where,

H: horizontal force acting on a raker pile

tension frc per single tie rod is given as H = Ra* L* secTheta (Theta: tie rod inc agl).

2) location of maximum bending moment induced (lower than design ground level)

$$Lm = \frac{Pi}{4Beta} = \frac{Pi}{4*\ 0.826473} = 0.950$$

Summery of member force calculation is shown in the table below.

characteristic value	Beta	m^{-1}	0.826473
induced force	horizontal force H	kN/M	82.08
	height(from design GL) h	m	0.000
maximum bending moment	moment Mmax	kN.m/M	32.02
	location(from design GL)	m	0.950(G.L. 47.550)m
shear force	shear force Smax	kN/M	82.08
	location(from design GL)	m	0.000(G.L. 48.500)m

(2) calculation of Beta

It is the same Beta as the result of calculating embedment length.

(3) calculation of displacement

Displacement at the location of tie rod must be satisfied the following equation.

$$Del. = \frac{H}{2EIAlp.Beta^3} <= Del.a$$

where,

characteristic value	Beta	m^{-1}	0.826473
Young's modulus	E	$*10^8$ kN/m^2	2.000
moment of inertia	I	$*10^{-8}$m^4/M	10700
eff ratio (for moment of inertia)	Alp.	-----	1.000
Horizontal force	H	kN/M	82.08
height (from design GL)	h	m(G.L.m)	0.000(G.L. 48.500)m
allowable displacement	Del.a	m	0.300

$$Del. = \frac{H}{2EIAlp.Beta^3} = \frac{82.08}{2*\ 2.000*\ 10^{8}*\ 10700*\ 10^{-8}*\ 1.000*\ 0.826473^3}$$

Del. =0.003(m) <=Del.a=0.300(m)... OK

4.2.5 stresses of raker pile

(1) using section

type : H-steel pile

use : H-250×250× 9×14

using material : SS400

dimensions	unit	value
section height H	(mm)	250
web thickness t1	(mm)	9
flange thickness t2	(mm)	14
section modulus Z	$*10^3$(mm^3)	860
crs sectional area A	$*10^2$(mm^2)	91.43

(2) design member force

design member forces are shown in the following table.

moment M $*10^6$(N.mm)	axial force N $*10^3$(N)	shear force S $*10^3$(N)
32.02	0.00	82.08

(3) bending stress

bending stress must satisfy the following equation.

$$\text{Sig.} = \frac{M}{Z} + \frac{N}{A} <= \text{Sig.ba}$$

where,

Sig. : bending stress(N/mm²)

Sig.ba : allowable bending stress(N/mm²)

L= 3.500* 10^3(mm) (L is a length from tie rod position to raker pile tip.)

b= 250 (mm) (b is flange width)

from 4.5< L/b<=30

$$\text{Sig.ba} = \text{Sig.a} - 3.6\left(\frac{L}{b} - 4.5\right) = 210 - 3.6\left(\frac{3.500 * 10^3}{250} - 4.5\right) = 175(\text{N/mm}^2)$$

z : using section modulus

A : using cross sectional area

$$\text{Sig.} = \frac{32.02 * 10^6}{860.0 * 10^3} + \frac{0.00 * 10^3}{91.43 * 10^2} = 37.23\ (\text{N/mm}^2) <= \text{Sig.ba} = 175(\text{N/mm}^2)\ ... \quad \text{OK}$$

(4) shear stress

shear stress must satisfy the following equation.

$$\text{Tau} = \frac{S}{Aw} <= \text{Taua}$$

where,

Tau : shear stress(N/mm²)

Taua : allowable shear stress(N/mm²)

Aw : using web section area(mm²) (hf - 2* t2)* t1

$$\text{Tau} = \frac{82.08 * 10^3}{1998} = 41.08\ (\text{N/mm}^2) <= \text{Taua} = 120(\text{N/mm}^2)\ ... \quad \text{OK}$$

4.3 waling design

(1) applied member

use : ˉ150×75×9×12.5

using material : SS400

allowable bending stress : Sig.a = 139.8(N/mm²)

(2) moment calculation

moment working on waling is calculated using the following equation.

$$M = \frac{T * L}{10} = \frac{82.08 * 1.800}{10} = 14.77(\text{kN.m/m})$$

where,

M:BM (kN.m/m)

T: tie rod tension(kN/unit)

L: tie rod installation spacing (m)

(3) stress

waling stress should be satisfied the following equation.

$$\text{Sig.} = \frac{M * 10^6}{Z * 10^3} <= \text{Sig.a}$$

where,

Sig. : waling stress(N/mm²)

Sig.a: allowable bending stress(N/mm²)

4.5< L/b<=30, Sig.a=[140- 2.4(L/b- 4.5)]* 1.5 (N/mm²)

=[140- 2.4(1.800/0.075- 4.5)]* 1.5=139.8(N/mm²)

M : BM (kN.m/m)

Z : sct modulus (= 140* 2cm³) *two makes one set, double of registered steel sct modulus.

$$Sig. = \frac{14.77*10^6}{280*10^3} = 52.77(N/mm^2) <= Sig.a = 139.8(N/mm^2)... \quad OK$$

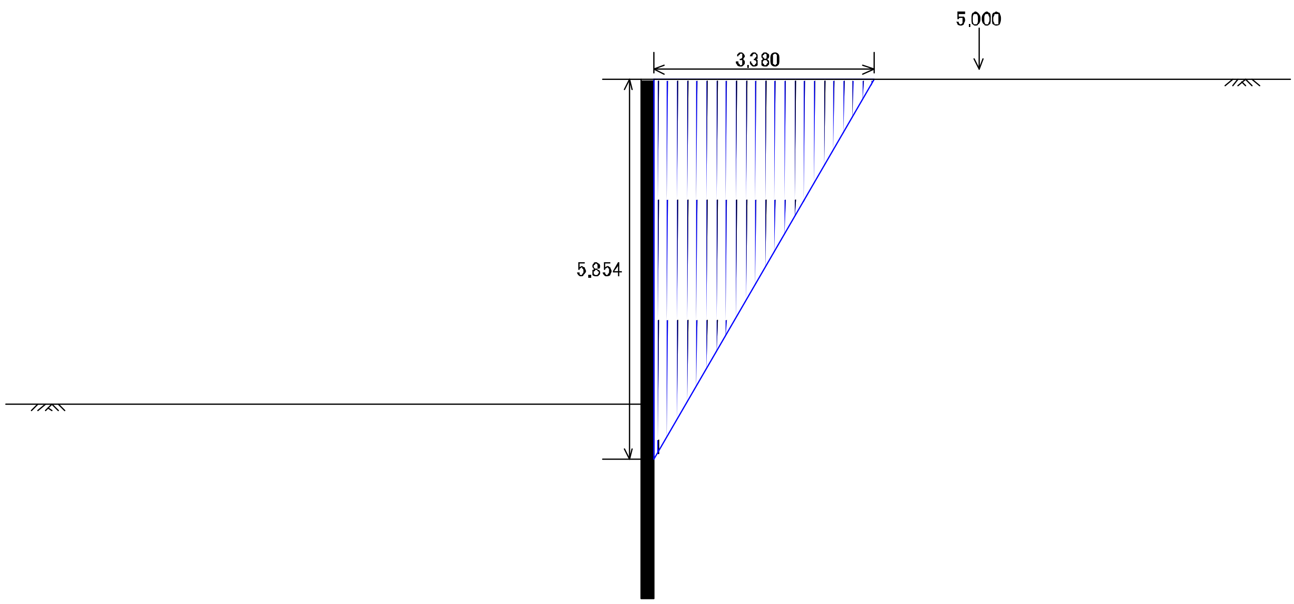
5 influence on surrounding ground

5.1 judgement on adjacent distance

(1)check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	49.000
excavation	G.L.(m)	44.000
virtual support point	G.L.(m)	43.146



(2)judgement on adjacent distance

1)influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{5.854}{\tan\left(45 + \frac{30.00}{2}\right)} = 3.380\ (m)$$

where,

Lxa: influence range on ground deformation by temporary works

dy : depth up to virtual support point of retaining wall

Phi: soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2)judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

Cover

(3) Ibrahimia Canal

(Lower Left Side)

I Design condition

1.1 fundamental data

file : Ibrahimia 3d1

title:

comment:

bracing type Raker pile tie rod type

wall type Steel sheet pile

type Normal

raker pile type H Beam pile(vertical)

applied standard- conventional method road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method: Wall inside-inside distance

plane shape type	Straight line
excavation width B (m) excavation length Le (m)	20.000 9.000

influence of water table	w/Do
base water table(before excavation) G.L.(m)	39.000

erection planning

final excavation depth G.L. 37.500(m)

excavation for installation strut 1.000(m)

tie rod setting point G.L. 43.000(m)

tie rod horizontal spacing 1.800(m)

1.2 shape

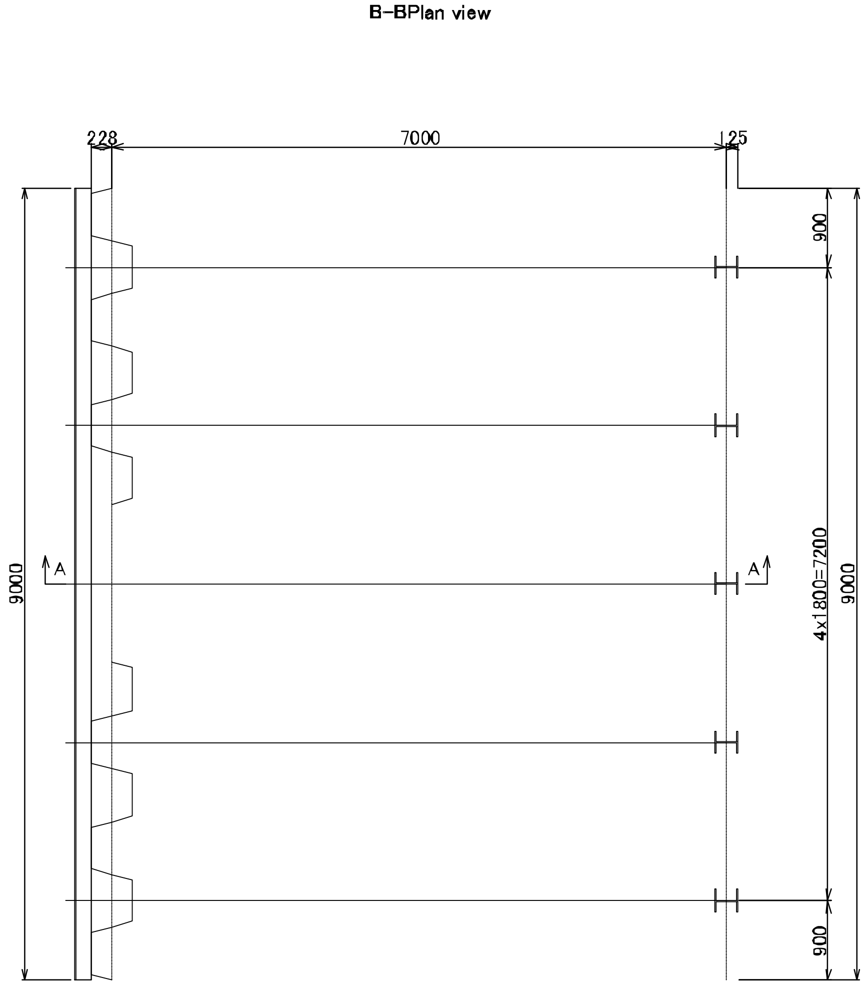
Design wall right wall

plane shape

	interval mm
wall to 1	900
1 to 2	1800
2 to 3	1800
3 to 4	1800
4 to 5	1800
5 to wall	900

tie rod and raker pile relationship: Direct connect

plan



side section shape

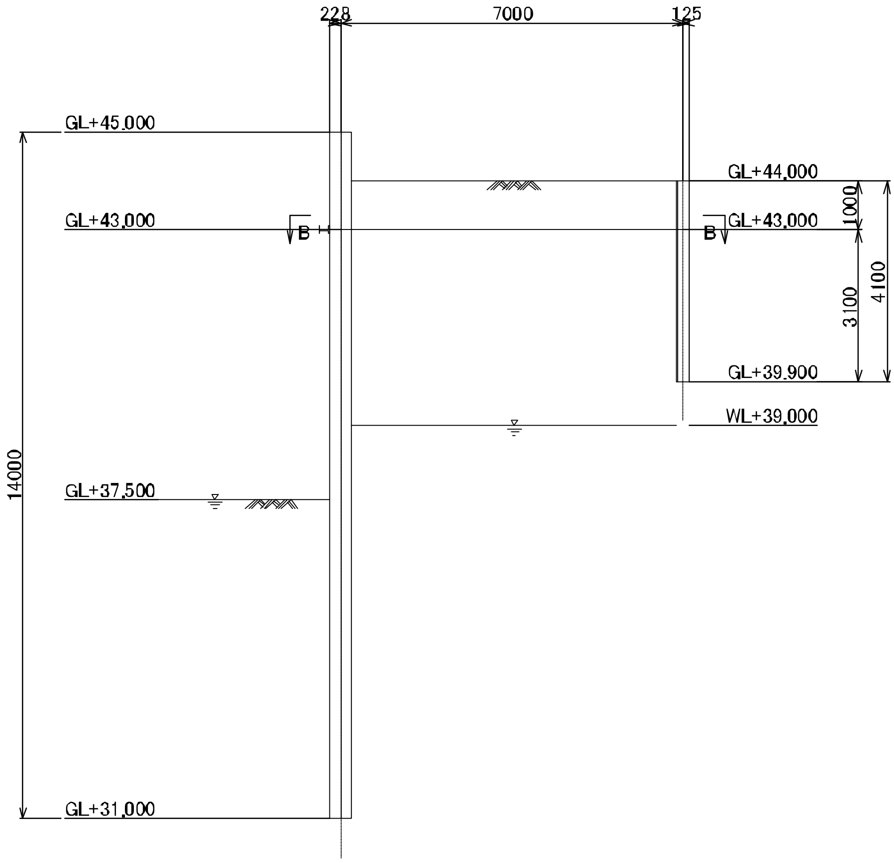
	top of wall G.L. m	ground level G.L. m
Right wall	45.000	44.000

top of raker pile :G.L. 44.000(m)

raker pile installation check range : 20.000(m)

Side view
* left-right direction

A-ASection view



1.3 method

checking item

bearing capacity check check Do

excavation bottom stability check check Not do

surcharge by slope influence check check Not do

bracing design check Do

material SS400

influence on surrounding ground check check Not do

Length round up value 0.5m

descrption of conventional method

water pressure distribution triangle

calculation method for earth pressure to evaluate section For Embedment length

Horizontal modulus of subgrade reaction for raker pile calculation Internal calculation

Horizontal modulus of subgrade reaction for retaining wall stiffness check Internal calculation

consider rock layer not do

elasto-plastic method concept

wall section change : not do

elastic portion rate : do

steady state check : not do

allowable displacement check : not do

analysis method : Analysis method 1

calculaion pitch : 0.50(m)

using elasto-plastic latteral pressure, embedment stability check when excavation: Consider S.F. of equi. len.

shape spring input method considered

H-subgrade reaction force calculation, shape dependant conversion width of load BH 10.000(m)

top of wall support condition Free

top of wall support condition Free

bracing combination condition(single wall analysis) rotation constrained No

for elasto-plastic method, latteral pressure

all Standard common

soil thickness above underground structure pressure: soil unit weight under ground water(Gamma -$Gamma_w$)

excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation

correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* right wall

. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	4.000	Sandy	27.0	18.0	9.0	25.00	10.0	0.0	75600
2	8.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200
3	7.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	4.000	Sandy	27.0	18.0	9.0	25.00	10.0	0.0	75600
2	8.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200
3	7.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

1.5 member

wall(steel sheet pile)

material

steel sheet pile material SY295

allowable bending stress 270(N/mm^2)

allowable shear stress 150(N/mm^2)

Young's modulus 2.00* 10^5(N/mm^2)

steel sheet pile effective rate Alpha

for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45

for moment of inertia(displacement calculation, member force) 0.45

section modulus (stress) 0.60

use

	use name	vertical load kN/m
右壁	28PU+1	0.00

raker pile(H steel pile)

material

material :SS400

allowable bending stress :210(N/mm²)

allowable shear stress :120(N/mm²)

Young's modulus :2.00* 10^5(N/mm²)

use

use name :H−250×250× 9×14

vertical load :0.00(kN/unit)

tie rod

material

material :high tension steel690

allowable tensile stress :264(N/mm²)

Young's modulus :2.00* 10^5(N/mm²)

use

use diameter :28.0(mm)

using number :2

tie rod inclination :none

applied screw

name :M33

effective cross sectional area :694.0(mm²)

E.P. method

H length L m	bracing spring tension charac.	bracing pre load consid	bracing pre loaded kN/memb.	cstrc losnes mm	H sprg dirct inp Yes/No	H sprg const kN/m/m
6.000	Yes	Not do	0.01	0	No	----------

waling material

material

material :SS400

allowable bending stress Sig.a :interior calculation

design concept

waling type :U-type

checking equation :TL/10

use

use name : [200×80×7.5×11

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	0.00

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Primary excavation	42.000	39.000	none
2	Final Exc.	1	Completion time	37.500	37.500	Yes

* 右壁

No	WT G.L.	surcharge kN/m²		virt sprt pt G.L. m
	natrlgrnd	natrlgrnd	exv	
1	39.000	10.00	0.00	int calc
2	39.000	10.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
Right wall	Percussion method	2.0	5	Use cohesive

Note:Construction method.

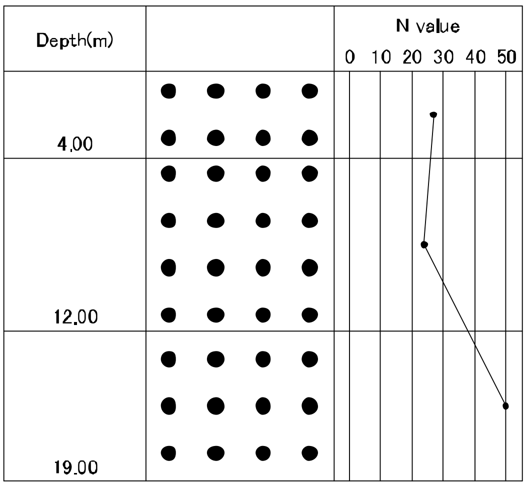
Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 boring log

* right wall



1.10 Design strength

1.10.1 Set value for design

(1)Simplified method

[Standard: Temporary structure construction guideline(H11)]

considered Do 0.3Gamh criteria for active earth pressure clay to calculate embedment length

considered.Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth

self-standing required embedment estimate coefficient : 2.50/Beta

min embedment criteria : Based on design strength

soldier pile
Take 1.00 times of pile width when Beta is calculated.
eth prss ld W under exv btm and side result:Temporary structure construction guideline,Metro.express.H19
bracing reaction force
when excavation: Downward shared method
when removal: Temp. Works Guid.Metro. express.H19
tie rod reaction force: Overhang beam divide method
raker pile
take 1.00 times of pile width for straight pile Beta calculation
coefficient is 2.50/Beta to estimate required embedment length
initiation point of passive slip surface is 1.00/Beta

(2) Earth pressure for section calculation

[Standard: Temp. Works Guid., Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18), Land impro. wall(H5)]
sand 2.000
clay
constituency of clay judgement Nvalue Nx 5.000
soft clay N<=Nx 6.000
stiff clay N> Nx 4.000

(3) Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline,Metro.express.H19]

sandy soil	N<=10	1.000
	10< N<=30	2.000
	30< N	2.000
cohesive soil	N<=4	1.000
	4< N<=8	1.000
	8< N	1.000
treatment other than passive earth pressure		= pssv eth prss
side resistance of passive earth pressure		consider:Do

(4) Minimum Embedment depth

[Continuous wall]
self-standing 3.00(m)
when excavation with strut 3.00(m)
[Soldier pile]
self-standing 1.50(m)
when excavation with strut 1.50(m)

(5) Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20
conventional method
wall self-standing allowable displacement
wall self-standing allowable displacement is 3.0% of excavation depth
allowable displacement when checking stiffness 0.300(m)
raker pile allowable displacement 0.300(m)
elasto-plastic
required elastic region ratio 50.0(%)

(6) Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7) Bearing capacity coefficient

[Standard: Temp. Works Guid.H11, Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method	1.0	1.0
vibration method	1.0	0.9
prss in	1.0	1.0
pre-boring method(sand filling)	0.0	0.5
pre-boring method(percussion, vibration, prss tip embedment)	1.0 0.0	1.0 0.5

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method, vibration method kN/m^2	100	150
drill and prss casting method kN/m^2	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximum skin friction upper limit kN/m^2	200	150

II Calculation results

1 Simplified method

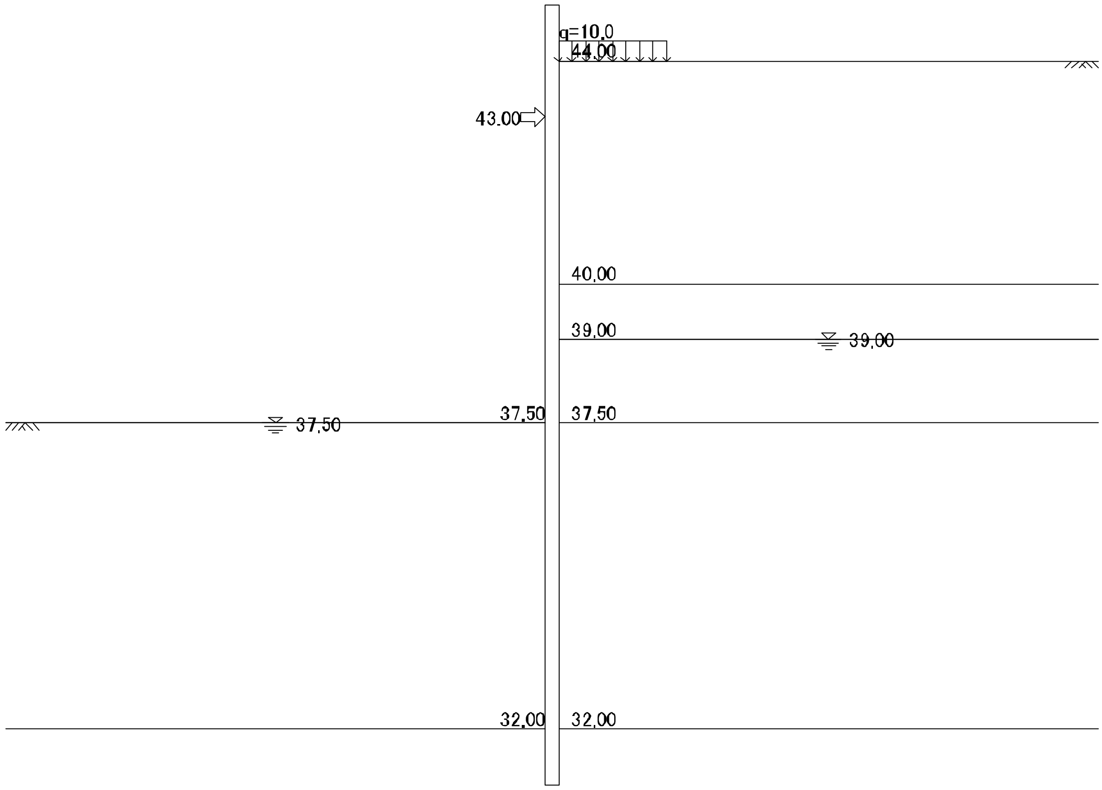
1.1 Right wall design

1.1.1 completion time

(1) check condition

state : Final excavated time

case name: Completion time



1) check condition

natural ground surface	G.L.(m)	44.000
excavation	G.L.(m)	37.500
lowest strut	G.L.(m)	43.000
water table at natural ground	G.L.(m)	39.000
water table at excavation	G.L.(m)	37.500
surcharge at natural ground q	kN/m^2	10.00
surcharge at excavation q	kN/m^2	0.00

2) ground condition

* natural ground

No	elevation		ground type	soil N val	soil unit weight		internal fric agl	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m^3)	sbmg wt (kN/m^3)		
1	44.000	40.000	Sandy	27.0	18.0	9.0	25.0	12.5
2	40.000	39.000	Sandy	24.0	18.0	9.0	25.0	12.5
3	39.000	37.500	Sandy	24.0	18.0	9.0	25.0	12.5
4	37.500	32.000	Sandy	24.0	18.0	9.0	25.0	12.5
5	32.000	25.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m2)	dfrm modul Alp.Eo (kN/m2)
	Co (kN/m2)	inc k (kN/m3)	base G.L.(m)		
1	10.0	0.0	44.000	20.0	75600
2	10.0	0.0	40.000	20.0	67200
3	10.0	0.0	40.000	20.0	67200
4	10.0	0.0	40.000	20.0	67200
5	10.0	0.0	32.000	20.0	140000

* excavation side

No	elevation		ground type	ave N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m3)	sbmg wt (kN/m3)		
1	37.500	32.000	Sandy	24.0	18.0	9.0	25.0	12.5
2	32.000	25.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m2)	dfrm modul Alp.Eo (kN/m2)
	Co (kN/m2)	inc k (kN/m3)	base G.L.(m)		
1	10.0	0.0	40.000	20.0	67200
2	10.0	0.0	32.000	20.0	140000

(1)

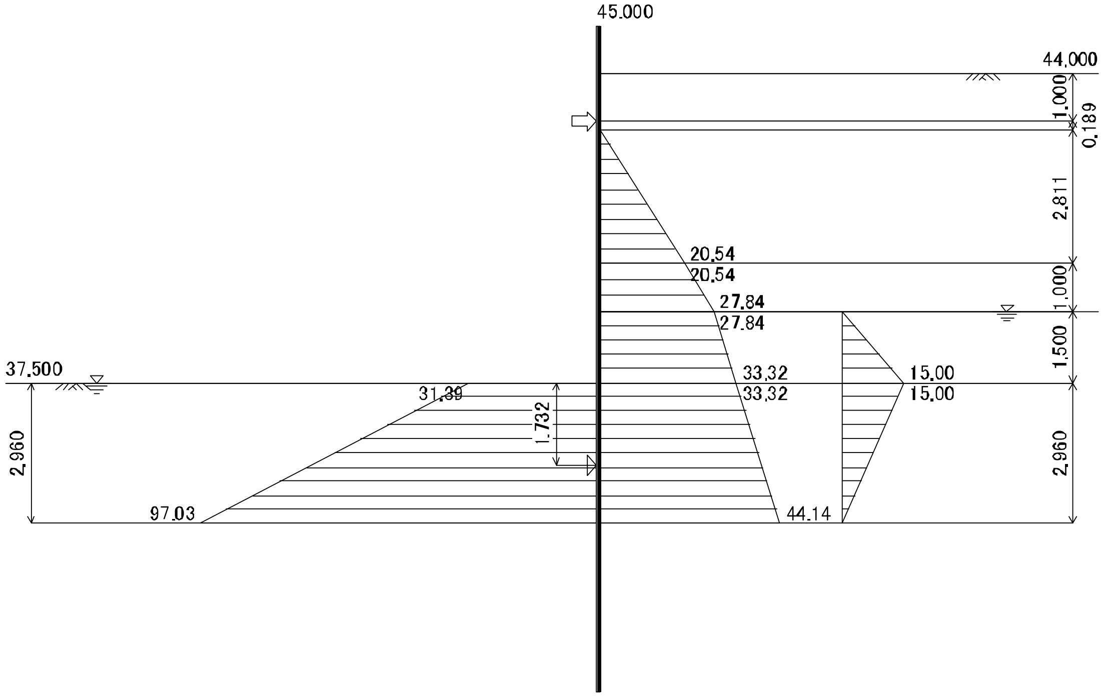
(2) embedment length calculation

1) result summery

case name: Completion time

analysis method : embedment length is calculated from moment balance at lowest strut

excavation depth		(G.L. 37.500) m
req embd L	safety factor F	1.200
	balance depth Z(m)	2.960(G.L. 34.540) m
	required embedment length D(m)	3.552(G.L. 33.948) m
	virtual support point depth Y(m)	1.732(G.L. 35.768) m
minimum embedment length (m)		3.000(G.L. 34.500) m
final embd L	final embedment length L (m)	6.500(G.L. 31.000) m
	judge	OK
final all length		14.000m



* sum of external forces at the balanced depth (G.L. 34.540)m

item	moment		horizontal force	
Active side Compre. side	Ma+Mw(kN.m/ m) Mp(kN.m/m)	1372.11 1374.62	Pa(kN/m) Pp(kN/m)	247.03 190.07
ratio(Mp/(Ma+ Mw))			1.0	
virtual support point depth (Y) m			1.732	

Mp is a moment at lowest strut, so assumed bearing depth Y is modified by the next equation.
virtual support point depth (Y) = Mp/Pp- (lowest strut place - excavation base).

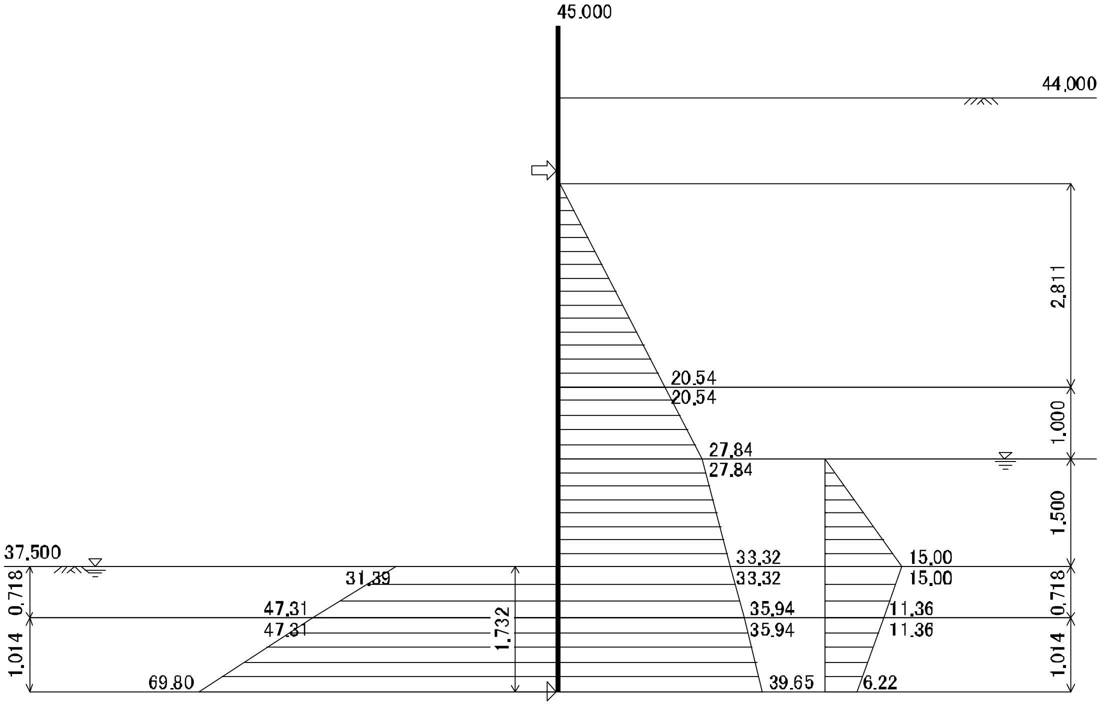
(3)calculation of member force

1)result summery

case name: compketion time

analysis method : check as a simple beam with a span between strut and virtual support point.

earth pressure is taken the earth pressure for embedment length calculation.



* single span supported at lowest strut and virtual support point

lowest strut depth		m	(G.L. 43.000)m
virtual support point depth		m	(G.L. 35.768)m
simple beam span		m	7.232
max bending moment	moment Mmax	kN.m/m	146.04
	depth(from strut)	m	4.011(G.L. 38.989)m
shear force	shear force Smax	kN/m	62.90
	depth(from strut)	m	6.218(G.L. 36.782)m
reaction	upper reaction force RA	kN/m	53.36
	lower reaction force RB	kN/m	62.90
*max displacement	displacement Del.max	m	0.0124
	depth(from strut)	m	3.616(G.L. 39.384)m

*reference value

3) retaining wall stiffness check

nevertheless wall stress has allowance, not to deform retaining wall within a certain level, checking enough stiffness assured. so displacement must be satisfied the following equation.

Del. = Del.1+ Del.2<=Del.a

where,

Del. : total retaining wall displacement

Del.1: maximum displacement calculated as a simple beam

$$Del.1 = \frac{5*w*L^4}{384*EIAlp.}$$

Del.2: influence displacement at elastic support

Del.2' = R/K

Del.2 = Del.2' /2

Del.a: allowable displacement

calculating model is SS beam at top strut and an elastic support of half of embeded depth, load is taken earth pressure for section check and water pressure throughout a span.
if a ld has trapezoidal dstr, convert to an conversion uniform dstr ld with the same intensity.

rigid support level (top strut)		G.L.(m)	43.000
virtual support point depth	Y	m	1.732
1/2 of virtual support point depth		G.L.(m)	36.634
simple beam span	L	m	6.366
intensity applied on a simple beam	P	kN/m	151.50
[illegible]			[illegible]
Del.1 Young's modulus	E	* 10^8 kN/m²	2.000
Del.1 moment of inertia of area	I	m⁴/m	0.00068380
Del.1 effective rate(displacement)	Alp.	-----	0.450
Del.1 deformation of center in span	Del.1	m	0.0083
Del.2 modulus of subgrade reaction	kH	kN/m³	16147
Del.2 wall width	B	m	1.000
Del.2 side area of spring block pile	A= B* Y	m²	1.7321
Del.2 spring constant	K= kH* A	kN/m²	27969
Del.2 reaction force	R= w* L/2	kN/m	75.75
Del.2 elastic support displacement	Del.2' = R/K	m	0.0027
total wall displacement	Del. = Del.1+ Del.2	m	0.0096
position (a half of span)		G.L.(m)	39.817
allowable displacement	Del.a	m	0.300
Judge		-----	OK

* total intensity applied on a simple beam(P)

No	depth GL(m)	thk h (m)	action load p kN/m²	load P kN/m
1	43.000 42.811	0.189	0.00 0.00	0.00
2	42.811 40.000	2.811	0.00 20.54	28.87
3	40.000 39.000	1.000	20.54 27.84	24.19
4	39.000 37.500	1.500	27.84 48.32	57.13
5	37.500 36.782	0.718	48.32 47.31	34.33
6	36.782 36.634	0.148	47.31 47.10	6.99
Sig				151.50

* Horizontal modulus of subgrade reaction

Horizontal modulus of subgrade reaction is an average value to virtual support point, using the equation

$$kH = Eta\,kHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta= 1

kHo: H modulus of subgrade reaction equivalent to that of a 30cm stiffness round plate.

$$kHo = \frac{1}{0.3}\ Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH* h (kN/m²)
1	37.500	35.768	1.732	67200	224000	16147	27969
Sig			1.732				27969

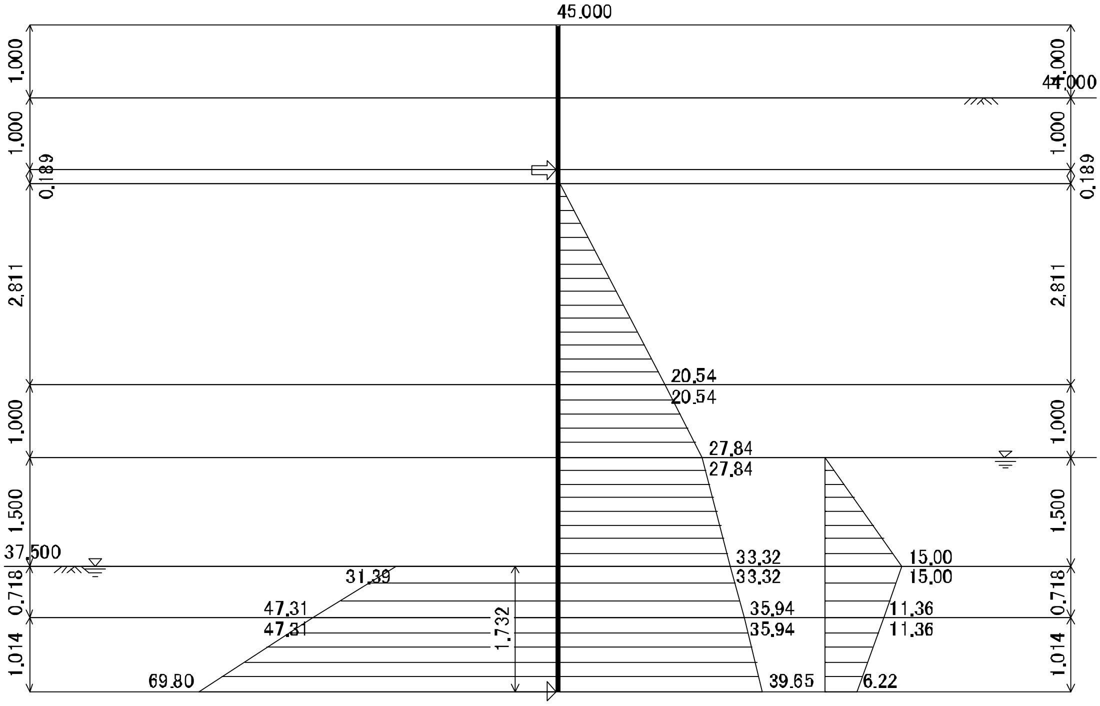
ave kH= Sig.(kH* h) /Sig.h= 16147(kN/m³)

BH: conversion width of load 10.0(m)

(4) calculation of bracing reaction force

1) result summery

analysis method : Overhang strut method



No	depth G.L. (m)		support G.L. (m)	reaction force kN/m	bracing reaction force kN/m
1	43.000	up span	--------	-------------	53.36
		low span	35.768	53.36	

timbering reaction= timbering No.(n)up spansprt rct+ reaction of lower support

up span bt focusing bracing and just above. Support at bracing above tmb No(n).

up span bt focusing bracing and just below. Support at bracing below tmb No(n).

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm^3/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm^2/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	146.04	0.00	62.90

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	81.1	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	2.8	150.0	OK

2 Elasto-plastic method

2.1 Right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm^3/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm^2/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	123.77	0.00	76.35

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} \leq Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	68.8	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} \leq Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	3.4	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1) Primary excavation

1) analysis results (latteral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m² top	bottom	effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m²/m	disp Del. mm	elst rct R kN/m
1	45.000		--------	0.00	----------	--------	-1.87	--------
2	44.500		0.00	0.00	----------	--------	-1.67	--------
3	44.000		0.00	0.00	----------	--------	-1.47	--------
4	43.500		1.48	1.48	----------	--------	-1.26	--------
5	43.000		2.96	2.96	----------	--------	-1.06	--------
6	42.500		4.45	4.45	----------	--------	-0.86	--------
7	42.000	El a. zone	5.93	5.93	10.20	4541	-0.67	3.0
8	41.500	El a. zone	4.38	4.38	28.89	9083	-0.49	4.5
9	41.000	El a. zone	2.84	2.84	40.20	9083	-0.34	3.1
10	40.500	El a. zone	1.30	1.30	46.98	8357	-0.21	1.8
11	40.080	El a. zone	0.00	0.00	29.54	4541	-0.13	0.6
12	40.000	El a. zone	0.00	0.00	37.81	4763	-0.12	0.6
13	39.500	El a. zone	0.00	0.00	74.13	8073	-0.05	0.4
14	39.000	El a. zone	0.00	0.00	84.65	8073	0.00	0.0
15	38.500	El a. zone	0.00	0.00	90.46	8073	0.03	-0.2
16	38.000	El a. zone	0.00	0.00	95.49	8073	0.04	-0.3
17	37.500	El a. zone	0.00	0.00	100.52	8073	0.05	-0.4
18	37.000	El a. zone	0.00	0.00	105.54	8073	0.05	-0.4
19	36.500	El a. zone	0.00	0.00	110.57	8073	0.04	-0.3
20	36.000	El a. zone	0.00	0.00	115.60	8073	0.03	-0.3
21	35.500	El a. zone	0.00	0.00	120.62	8073	0.02	-0.2
22	35.000	El a. zone	0.00	0.00	125.65	8073	0.02	-0.1
23	34.500	El a. zone	0.00	0.00	130.67	8073	0.01	-0.1
24	34.000	El a. zone	0.00	0.00	135.70	8073	0.01	-0.1
25	33.500	El a. zone	0.00	0.00	140.73	8073	0.00	0.0
26	33.000	El a. zone	0.00	0.00	145.75	8073	0.00	0.0
27	32.500	El a. zone	0.00	0.00	150.78	8073	0.00	0.0
28	32.000	El a. zone	0.00	0.00	155.81	12447	0.00	0.0
29	31.500	El a. zone	0.00	0.00	160.83	16820	0.00	0.1
30	31.000	El a. zone	0.00	--------	82.30	8410	0.00	0.0

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

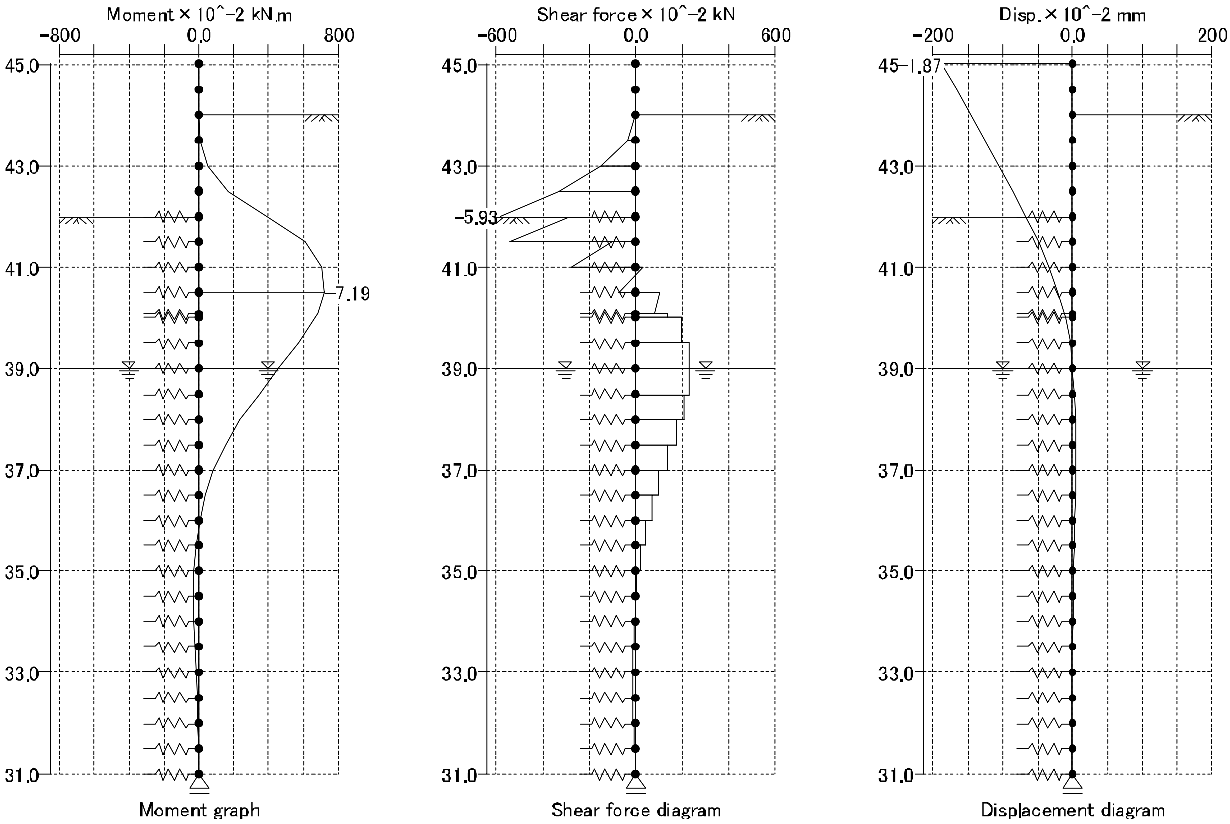
2)primary excavation analysis result (member force, displacement)

Mmax = 0.3kN.m/m (working pos G.L. 34.50m) Mmin = -7.2kN.m/m (working pos G.L. 40.50m)

Smax = 2.3kN/m (working pos G.L. 39.50m) Smin = -5.9kN/m (working pos G.L. 42.00m)

Del.max= 0.05mm (working pos G.L. 37.50m) Del.min= -1.87mm (working pos G.L. 45.00m)

node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	45.000	----------	0.0	----------	0.0	-1.87	----------
2	44.500	0.0	0.0	0.0	0.0	-1.67	----------
3	44.000	0.0	0.0	0.0	0.0	-1.47	----------
4	43.500	-0.1	-0.1	-0.4	-0.4	-1.26	----------
5	43.000	-0.5	-0.5	-1.5	-1.5	-1.06	----------
6	42.500	-1.7	-1.7	-3.3	-3.3	-0.86	----------
7	42.000	-4.0	-4.0	-5.9	-2.9	-0.67	----------
8	41.500	-6.1	-6.1	-5.5	-1.0	-0.49	----------
9	41.000	-7.0	-7.0	-2.8	0.3	-0.34	----------
10	40.500	-7.2	-7.2	-0.7	1.1	-0.21	----------
11	40.080	-6.8	-6.8	0.8	1.4	-0.13	----------
12	40.000	-6.7	-6.7	1.4	1.9	-0.12	----------
13	39.500	-5.7	-5.7	1.9	2.3	-0.05	----------
14	39.000	-4.6	-4.6	2.3	2.3	0.00	----------
15	38.500	-3.4	-3.4	2.3	2.1	0.03	----------
16	38.000	-2.4	-2.4	2.1	1.7	0.04	----------
17	37.500	-1.5	-1.5	1.7	1.3	0.05	----------
18	37.000	-0.9	-0.9	1.3	1.0	0.05	----------
19	36.500	-0.4	-0.4	1.0	0.7	0.04	----------
20	36.000	0.0	0.0	0.7	0.4	0.03	----------
21	35.500	0.2	0.2	0.4	0.2	0.02	----------
22	35.000	0.3	0.3	0.2	0.1	0.02	----------
23	34.500	0.3	0.3	0.1	0.0	0.01	----------
24	34.000	0.3	0.3	0.0	-0.1	0.01	----------
25	33.500	0.2	0.2	-0.1	-0.1	0.00	----------
26	33.000	0.2	0.2	-0.1	-0.1	0.00	----------
27	32.500	0.1	0.1	-0.1	-0.1	0.00	----------
28	32.000	0.1	0.1	-0.1	-0.1	0.00	----------
29	31.500	0.0	0.0	-0.1	0.0	0.00	----------
30	31.000	0.0	----------	0.0	----------	0.00	----------



* pre-displacement and loading equivalent to pre-displacement

when strut is effective after next step, a load for pre-displacement is applied.

node No	displacement Del.x mm	release Del.L mm	preceding displacement Del.o mm	bracing spring Ks kN/m	preceding displacement load kN/m
5	-1.06	0.00	-1.06	22805.6	-24.24

where,

Del.x: wall displacement at strut level(->)+)

Del.L: construction release

Del.o: pre-disp(->)+) Del.o=Del.x-Del.L

(2) Completion time

1) analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m² top	bottom	effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
1	45.000		--------	0.00	----------	--------	6.58	--------
2	44.500		0.00	0.00	----------	--------	4.04	--------
3	44.000		0.00	0.00	----------	--------	1.50	--------
4	43.500		2.57	2.57	----------	--------	-1.05	--------
5	43.000	Strut	5.13	5.13	-24.24	22806	-3.59	57.7
6	42.500		7.70	7.70	----------	--------	-6.12	--------
7	42.000		10.27	10.27	----------	--------	-8.54	--------
8	41.500		12.84	12.84	----------	--------	-10.76	--------
9	41.000		15.40	15.40	----------	--------	-12.68	--------
10	40.500		17.97	17.97	----------	--------	-14.23	--------
11	40.080		20.13	20.13	----------	--------	-15.20	--------
12	40.000		20.54	20.54	----------	--------	-15.35	--------
13	39.500		24.19	24.19	----------	--------	-15.98	--------
14	39.000		27.84	27.84	----------	--------	-16.12	--------
15	38.500		33.95	33.95	----------	--------	-15.75	--------
16	38.000		40.06	40.06	----------	--------	-14.92	--------
17	37.500	Pla.zone	46.16	46.16	9.42	4037	-13.69	0.0
18	37.000	Pla.zone	44.44	44.44	22.61	8073	-12.16	0.0
19	36.500	Pla.zone	42.72	42.72	27.63	8073	-10.46	0.0
20	36.000	Pla.zone	41.00	41.00	32.66	8073	-8.71	0.0
21	35.500	Pla.zone	39.28	39.28	37.69	8073	-7.05	0.0
22	35.000	Pla.zone	37.56	37.56	42.71	8073	-5.55	0.0
23	34.500	Ela.zone	35.84	35.84	47.74	8073	-4.27	34.5
24	34.000	Ela.zone	34.12	34.12	52.77	8073	-3.23	26.0
25	33.500	Ela.zone	32.40	32.40	57.79	8073	-2.40	19.3
26	33.000	Ela.zone	30.68	30.68	62.82	8073	-1.74	14.0
27	32.500	Ela.zone	28.96	28.96	67.84	8073	-1.20	9.7
28	32.000	Ela.zone	27.24	27.24	72.87	12447	-0.75	9.3
29	31.500	Ela.zone	25.52	25.52	77.90	16820	-0.33	5.5
30	31.000	Ela.zone	23.80	--------	40.83	8410	0.07	-0.6

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

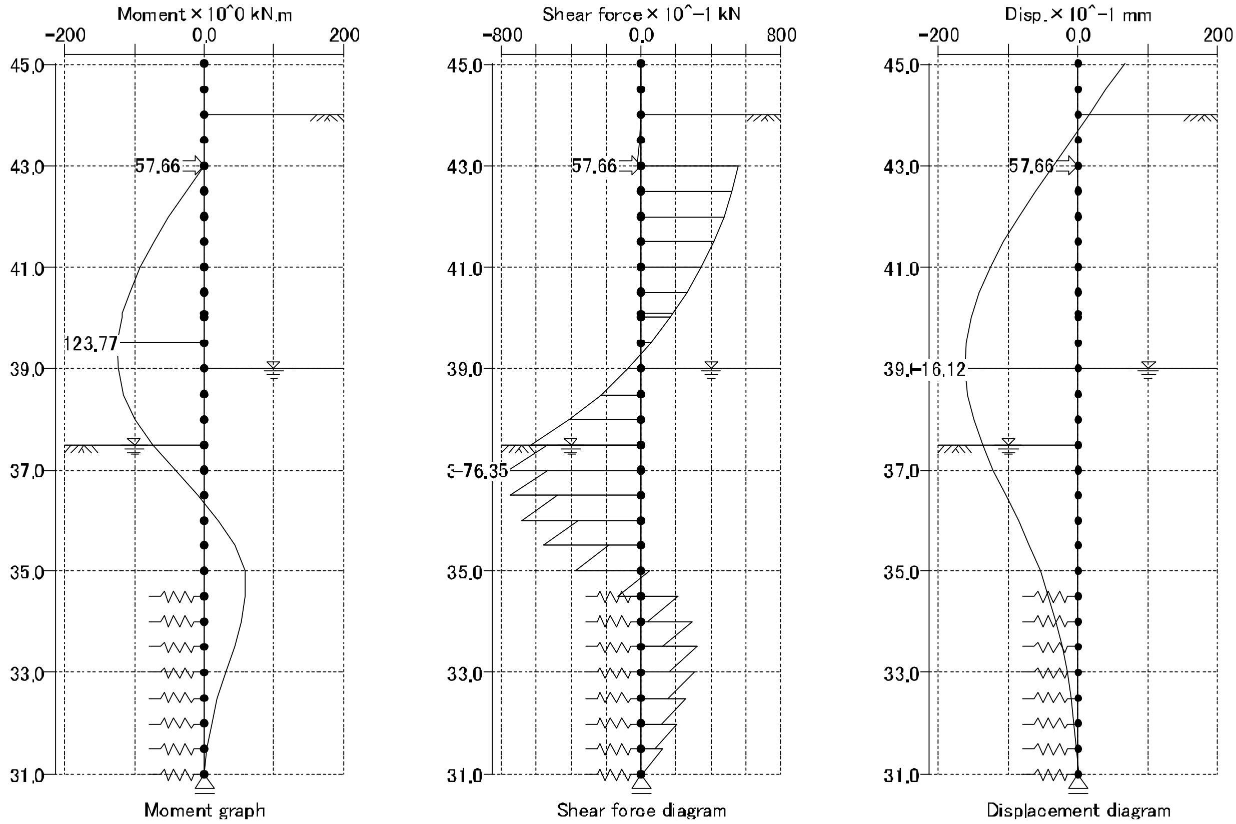
2)completiontime analysis result (member force, displacement)

Mmax = 123.8kN.m/m (working pos G.L. 39.50m) Mmin = -59.9kN.m/m (working pos G.L. 34.50m)

Smax = 55.1kN/m (working pos G.L. 43.00m) Smin = -76.4kN/m (working pos G.L. 37.00m)

Del.max= 6.58mm (working pos G.L. 45.00m) Del.min= -16.12mm (working pos G.L. 39.00m)

node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	45.000	----------	0.0	----------	0.0	6.58	----------
2	44.500	0.0	0.0	0.0	0.0	4.04	----------
3	44.000	0.0	0.0	0.0	0.0	1.50	----------
4	43.500	-0.1	-0.1	-0.6	-0.6	-1.05	----------
5	43.000	-0.9	-0.9	-2.6	55.1	-3.59	57.7
6	42.500	25.9	25.9	51.9	51.9	-6.12	----------
7	42.000	50.8	50.8	47.4	47.4	-8.54	----------
8	41.500	73.1	73.1	41.6	41.6	-10.76	----------
9	41.000	92.2	92.2	34.5	34.5	-12.68	----------
10	40.500	107.4	107.4	26.2	26.2	-14.23	----------
11	40.080	116.8	116.8	18.2	18.2	-15.20	----------
12	40.000	118.2	118.2	16.6	16.6	-15.35	----------
13	39.500	123.8	123.8	5.4	5.4	-15.98	----------
14	39.000	123.3	123.3	-7.6	-7.6	-16.12	----------
15	38.500	115.7	115.7	-23.1	-23.1	-15.75	----------
16	38.000	99.7	99.7	-41.6	-41.6	-14.92	----------
17	37.500	73.7	73.7	-63.1	-53.7	-13.69	----------
18	37.000	41.1	41.1	-76.4	-53.7	-12.16	----------
19	36.500	8.8	8.8	-75.5	-47.9	-10.46	----------
20	36.000	-20.5	-20.5	-68.8	-36.2	-8.71	----------
21	35.500	-43.6	-43.6	-56.2	-18.6	-7.05	----------
22	35.000	-57.7	-57.7	-37.8	4.9	-5.55	----------
23	34.500	-59.9	-59.9	-13.4	21.1	-4.27	----------
24	34.000	-53.8	-53.8	3.6	29.6	-3.23	----------
25	33.500	-43.1	-43.1	13.0	32.3	-2.40	----------
26	33.000	-31.0	-31.0	16.5	30.6	-1.74	----------
27	32.500	-19.4	-19.4	15.7	25.4	-1.20	----------
28	32.000	-10.3	-10.3	11.3	20.6	-0.75	----------
29	31.500	-3.4	-3.4	7.4	12.9	-0.33	----------
30	31.000	0.0	----------	0.6	----------	0.07	----------


Moment × 10^0 kN.m
-200
0.0
200
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
57.66
123.77
Moment graph
Shear force × 10^-1 kN
-800
0.0
800
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
57.66
-76.35
Shear force diagram
Disp. × 10^-1 mm
-200
0.0
200
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
57.66
-16.12
Displacement diagram

3 Bearing capacity

3.1 Bearing capacity

3.1.1 check condition

(1) check method : Temp. Works Guid.H11, Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	31.000
exv bs ps	G.L.(m)	37.500
embd L L	m	6.500

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	1244.80	622.40	0.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	50.0	37.0	40.0	8000.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N-val Ni	Li * Ni
1	33.000	32.000	1.000	24.0	24.00
2	32.000	31.000	1.000	50.0	50.00
Sig			2.000		74.00

3) circumference friction force(Sig.Li * fi)

* sand : fi= 2BetaNs(note; Ns<=50
* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)
* coefficient of skin friction with construction method: Beta= 1.0
* Nvalue <=2 fi= 0.0 in weak soil
* all friction resistance Sig.Li * fi= 1064.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li* fi (kN/m)
1	5.500	24.0	-----	48.00	264.00
2	1.000	50.0	-----	100.00	100.00
Sig	6.500				364.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li* fi (kN/m)
1	4.000	27.0	-----	54.00	216.00
2	1.000	24.0	-----	48.00	48.00
3	1.500	24.0	-----	48.00	72.00
4	5.500	24.0	-----	48.00	264.00
5	1.000	50.0	-----	100.00	100.00
Sig	13.000				700.00

4 Bracing, Raker pile calculation

4.1 tie rod design

(1) applied member

using tie rod diameter :tie rod diameterPhi 28.0(mm)* using # n=2

using material :high tension steel690

allowable tensile stress :Sig.a = 264(N/mm^2)

tie rod installation spacing :L = 1.800(m)

screw part(listed, effective cross sectional area) :M33(A = 694.0mm^2)

(2) tie rod calculation of member force

tie rod tension is calculated with tie rod reaction and spacing using the following equation.

T = Ra* L = 54.07* 1.800 = 97.33(kN/unit)

where,

T :tie rod tension(kN/unit)

Ra:tie rod reaction force(kN/m)

La:tie rod installation interval (m)

(3) tie rod stress calc

tie rod stress should be satisfied the following equation.

$$Sig. = \frac{T* 10^3}{n* A} <= Sig.a$$

where,

Sig. :tie rod stress.(N/mm^2)

Sig.a:allowable tensile stress(N/mm^2)

n :using number

A :using cross sectional area (mm^2)

$$Sig. = \frac{97.33* 10^3}{2* 694.0} = 70.12\ (N/mm^2) <= Sig.a = 264(N/mm^2)...\quad OK$$

4.2 Design of raker pile

4.2.1 Dimensions of a pile

Dimensions of a pile are as follows.

(1) using material

Type :H steel pile(B = 250mm)

Use :H−250×250× 9×14

Dimensions	Unit	Value
Cross sectional area A	cm^2/m	91.43
Moment of inertia I	cm^4/m	10700
Section modulus Z	cm^3/m	860

(2) material

Using material :SS400

Young's modulus :E = 2.000* 10^8(kN/m^2)

4.2.2 Calculate installation layout

(1) calculate necessary installation distance

Rake pile is placed on actv failure plane starting from virtual support point and pssv failure plane starting from 1.00/Beta of depth below tie rod intersect above the location of tie rod.

In this, actv and pssv failure planes intersect at tie rod depth is called a req inst distance.

1) active failure plane

Act. fail. plane on back side starting from a sup. pointed of a rt wl (GL35.768m) is described.

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	actv failure agl zetaa(Deg.) = 45+Phi/2	failure line width Ldi(m) = hi* cotzetaa
2	40.000	35.768	4.232	25.00	57.50	2.696
1	43.000	40.000	3.000	25.00	57.50	1.911
Si.			7.232			4.607

2) passive failure plane

Passive failure on back side starting from the position 1.00/Beta below rake pile tie rod is.

$$\text{Starting position of raker pile} = \text{tie rod position of raker pile} - \frac{1.00}{\text{Beta}}$$

$$= \text{G.L.}43.000 - \frac{1.00}{0.826473} = \text{G.L.}41.790(\text{m})$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	pssv failure agl zetap(Deg.) = 45-Phi/2	failure line width Ldi(m) = hi* cotzetap
1	43.000	41.790	1.210	25.00	32.50	1.899
Si.			1.210			1.899

3) required installation distance

Required installation distance Ldmin is given as following equation.

Ldmin = Sig.hi* cotzetaa + Sig.hi* cotzetap =4.607 +1.899 =6.506(m)

(2) installation position of raker pile

From above, raker pile is installed Ld =6.506(m) on backside.

Ld =7.000(m) =>Ldmin =6.506(m)... It is safe.

(3) calculate a characteristic value Beta to determine required installation position.

Beta at raker pile instl at distance from req instl distance Ldmin = 6.506(m) from rt wl is given.

1) calculate characteristic value Beta

Characteristic value Beta is calculated using the following equation.

$$\text{Beta} = \sqrt[4]{\frac{kH^* B}{4EI Alp.}} = \sqrt[4]{\frac{159946.5^* 250.0^* 10^{-3}}{4^* 2.000^* 10^{8*} 10700^* 10^{-8*} 1.000}} = 0.826473(m^{-1})$$

where,

Horizontal subgrade reaction coefficient kH = 159946.5(kN/m^3)

width of raker pile B = 250.0* 10^{-3}(m)

B is flange WB in case of H steel, or [1.00] times of pile diameter in case of st pipe pile.

Young's modulus E = 2.000* 10^8(kN/m^2)

Moment of inertia of area I = 10700* 10^{-8}(m^4)

effective rate(for embedment calculation) Alp. = 1.000

2) calculation of horizontal subgrade reaction coefficient

H-subgrade reaction coefficient is an average value within 1/Beta= 43.000(m) from G.L. 1.210(m) using the following equation.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta : coefficient regarding to wall type (1.00 in case of raker pile)

kHo: H-subgrade reaction coefficient equi to plate bear test result by stiffness round plate of 30cm diameter

$$kHo = \left(\frac{1}{0.3}\right) Alp.Eo$$

where,

Eo: ground modulus of deformation(kN/m^2)

Alp.: coefficient to calculate subgrade reaction coefficent

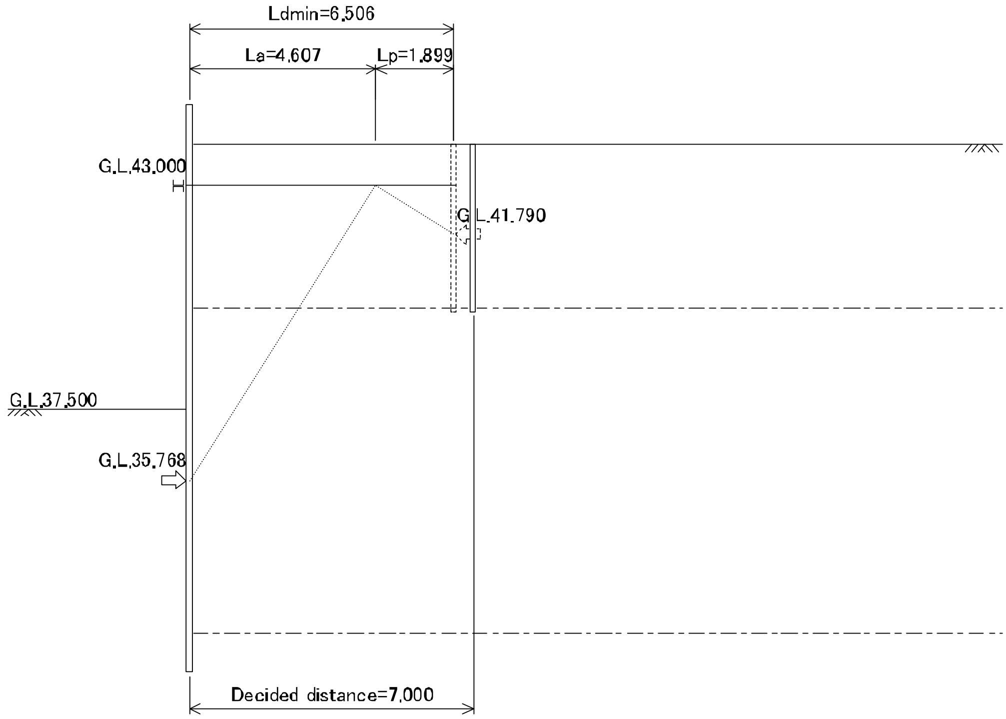
BH conversion width of load is calculated using the following equation.

$$BH = \sqrt{\frac{D}{\text{Beta}}} = \sqrt{\frac{250^* 10^{-3}}{0.826473}} = 0.5500(m)$$

where, D is flange WB in case of H steel pile, or a pile diameter D of steel pipe pile.

$$\text{Average kH within the range of } \frac{1}{\text{Beta}} = \frac{\text{Sig.kH* h}}{\text{Sig.h}} = \frac{193529}{1.210} = 159946.5\ (\text{kN/m}^3)$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	Alp.Eo kN/m^2	kHo kN/m^3	kH kN/m^3	kH* h kN/m^2
1	43.000	41.790	1.210	75600	252000	159946	193529
Si.			1.210				193529



4.2.3 calculate embedment length

(1)length of raker pile

Pile L to include embd L req from the calc as an infinite pile on elastic grnd as described below.

$$D = \text{Safety coefficient} \frac{}{\text{Beta}} = \frac{2.50}{0.826473} = 3.025(\text{m}) \Leftarrow \text{real embedment length}=3.100(\text{m})... \quad \text{OK}$$

raker pile head EL rake pile tie rod position EL raker pile design ground level		(G.L. 44.000)m (G.L. 43.000)m (G.L. 43.000)m
required embedment length	safety coeff chra Beta(m^{-1}) D= safety coeff/Beta	2.50 0.826473 3.025(G.L. 39.975)m
final embedment length	real length (m)	3.100(G.L. 39.900)m
	judgement	OK
final total length		4.100m

(2)calculate Beta at raker pile installed position

It follows the result of Beta=0.826473(m^{-1}) obtained in calculating a necessary distance.

4.2.4 calculation of member force

(1) calculation of member force

1) maximum bending moment

$$Mmax = 0.3224\frac{H}{Beta} = 0.3224*\frac{97.33}{0.826473} = 37.97$$

where,

H: horizontal force acting on a raker pile

tension frc per single tie rod is given as H = Ra* L* secTheta (Theta: tie rod inc agl).

2) location of maximum bending moment induced (lower than design ground level)

$$Lm = \frac{Pi}{4Beta} = \frac{Pi}{4*\ 0.826473} = 0.950$$

Summery of member force calculation is shown in the table below.

characteristic value	Beta	m^{-1}	0.826473
induced force	horizontal force H height (from design GL) h	kN/M m	97.33 0.000
maximum bending moment	moment Mmax location (from design GL)	kN.m/M m	37.97 0.950 (G.L. 42.050) m
shear force	shear force Smax location (from design GL)	kN/M m	97.33 0.000 (G.L. 43.000) m

(2) calculation of Beta

It is the same Beta as the result of calculating embedment length.

(3) calculation of displacement

Displacement at the location of tie rod must be satisfied the following equation.

$$Del. = \frac{H}{2EI\,Alp.\,Beta^3} <= Del.a$$

where,

characteristic value Beta		m^{-1}	0.826473
Young's modulus	E	$*10^8$ kN/m²	2.000
moment of inertia	I	$*10^{-8}$ m⁴/M	10700
eff ratio (for moment of inertia)	Alp.	-----	1.000
Horizontal force	H	kN/M	97.33
height (from design GL)	h	m (G.L. m)	0.000 (G.L. 43.000) m
allowable displacement	Del.a	m	0.300

$$Del. = \frac{H}{2EI\,Alp.\,Beta^3} = \frac{97.33}{2*\ 2.000*\ 10^8*\ 10700*\ 10^{-8}*\ 1.000*\ 0.826473^3}$$

Del. = 0.004 (m) <= Del.a = 0.300 (m) ... OK

4.2.5 stresses of raker pile

(1) using section

type : H-steel pile

use : H-250×250×9×14

using material : SS400

dimensions	unit	value
section height H	(mm)	250
web thickness t1	(mm)	9
flange thickness t2	(mm)	14
section modulus Z	$*10^3$ (mm³)	860
crs sectional area A	$*10^2$ (mm²)	91.43

(2) design member force

design member forces are shown in the following table.

moment M $*10^6$ (N.mm)	axial force N $*10^3$ (N)	shear force S $*10^3$ (N)
37.97	0.00	97.33

(3) bending stress

bending stress must satisfy the following equation.

$$Sig. = \frac{M}{Z} + \frac{N}{A} <= Sig.ba$$

where,

Sig. : bending stress(N/mm²)

Sig.ba : allowable bending stress(N/mm²)

L= 3.100* 10³(mm) (L is a length from tie rod position to raker pile tip.)

b= 250 (mm) (b is flange width)

from 4.5< L/b<=30

$$Sig.ba=Sig.a-3.6\left(\frac{L}{b}-4.5\right)=210-3.6\left(\frac{3.100*10^3}{250}-4.5\right)=181(N/mm^2)$$

z : using section modulus

A : using cross sectional area

$$Sig. = \frac{37.97*10^6}{860.0*10^3} + \frac{0.00*10^3}{91.43*10^2} = 44.15\ (N/mm^2) <= Sig.ba=181(N/mm^2)\ldots \quad OK$$

(4) shear stress

shear stress must satisfy the following equation.

$$Tau = \frac{S}{Aw} <= Taua$$

where,

Tau : shear stress(N/mm²)

Taua : allowable shear stress(N/mm²)

Aw : using web section area(mm²) (hf-2* t2)* t1

$$Tau = \frac{97.33*10^3}{1998} = 48.71\ (N/mm^2) <= Taua=120(N/mm^2)\ldots \quad OK$$

4.3 waling design

(1) applied member

use : ⌐200×80×7.5×11

using material : SS400

allowable bending stress : Sig.a = 145.2(N/mm²)

(2) moment calculation

moment working on waling is calculated using the following equation.

$$M = \frac{T*L}{10} = \frac{97.33*1.800}{10} = 17.52(kN.m/m)$$

where,

M:BM(kN.m/m)

T:tie rod tension(kN/unit)

L:tie rod installation spacing (m)

(3) stress

waling stress should be satisfied the following equation.

$$Sig. = \frac{M*10^6}{Z*10^3} <= Sig.a$$

where,

Sig. : waling stress(N/mm²)

Sig.a: allowable bending stress(N/mm²)

4.5< L/b<=30, Sig.a=[140- 2.4(L/b- 4.5)]* 1.5 (N/mm²)

=[140- 2.4(1.800/0.080- 4.5)]* 1.5=145.2(N/mm²)

M : BM(kN.m/m)

Z : sct modulus (= 195* 2cm³) *two makes one set, double of registered steel sct modulus.

$$Sig. = \frac{17.52 * 10^6}{390 * 10^3} = 44.92(N/mm^2) <= Sig.a = 145.2(N/mm^2) ... \quad OK$$

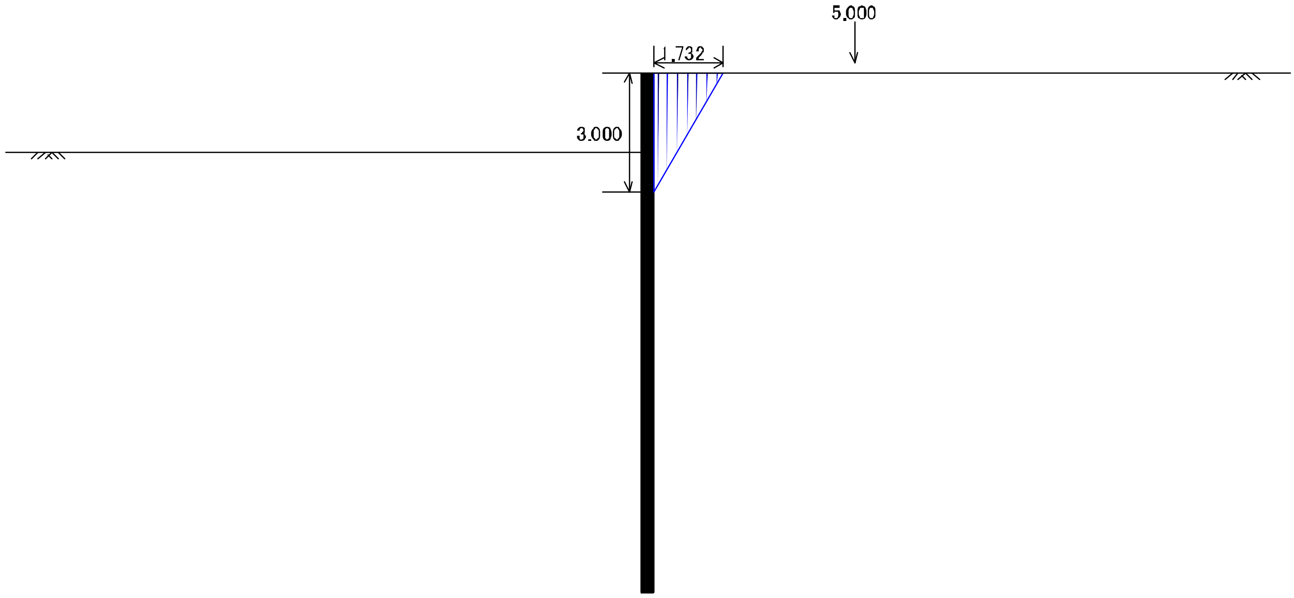
5 influence on surrounding ground

5.1 judgement on adjacent distance

(1) check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	44.000
excavation	G.L.(m)	42.000
virtual support point	G.L.(m)	41.000



(2) judgement on adjacent distance

1) influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{3.000}{\tan\left(45 + \frac{30.00}{2}\right)} = 1.732 \ (m)$$

where,

Lxa: influence range on ground deformation by temporary works

dy : depth up to virtual support point of retaining wall

Phi : soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2) judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

Cover
(4) Ibrahimia Canal
(Right side)

I Design condition

1.1 fundamental data

file : Ibrahimia R2

title:

comment:

bracing type Self-standing type

wall type Steel sheet pile

type Normal

applied standard- conventional method road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method: Wall inside-inside distance

plane shape type	Straight line
excavation width B (m)	10.000
excavation length Le (m)	9.000

influence of water table	w/Do
base water table(before excavation) G.L.(m)	44.000

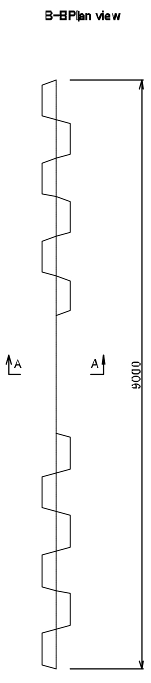
erection planning

Exca.depth G.L. 44.000(m)

1.2 shape

Design wall right wall

plan

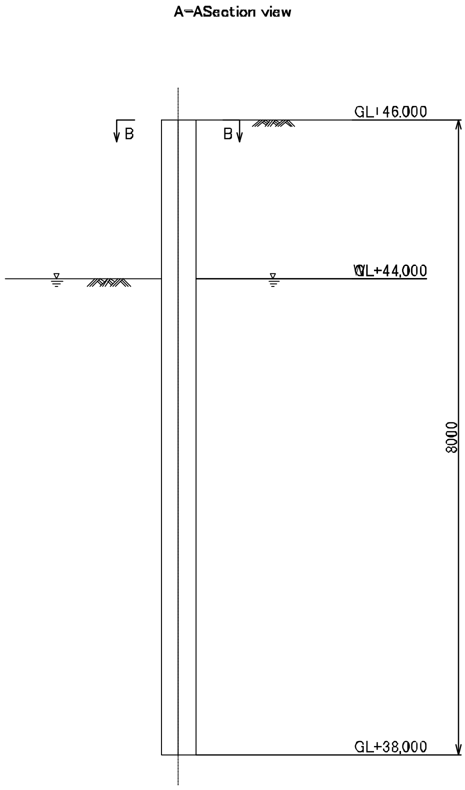


side section shape

	top of wall G.L. m	ground level G.L. m
Right wall	46.000	46.000

Side view

* left-right direction



1.3 method

checking item

bearing capacity check check Do

excavation bottom stability check check Not do

surcharge by slope influence check check Not do

influence on surrounding ground check check Do

Length round up value 0.5m

descrption of conventional method

water pressure distribution triangle

Horizontal modulus of subgrade reaction for self standing Chang's equation Internal calculation

consider rock layer not do

elasto-plastic method concept

wall section change	:	not do
elastic portion rate	:	do
steady state check	:	not do
allowable displacement check	:	not do
analysis method	:	Analysis method 1
calculaion pitch	:	0.50(m)
shape spring input method		considered

H-subgrade reaction force calculation, shape dependant conversion width of load BH 10.000(m) top of wall support condition Free

top of wall support condition Free

bracing combination condition(single wall analysis) rotation constrained No

for elasto-plastic method, latteral pressure

all Standard common

soil thickness above underground structure pressure: soil unit weight under ground water(Gamma -$Gamma_w$)

excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation

correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* right wall

. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m³	water unit wt Gamma' kN/m³	int fric agl Phi Deg	coh Co kN/m²	coh inc K kN/m²	dfrm modul Alp.Eo kN/m²
1	7.000	Sandy	29.0	18.0	9.0	25.00	10.0	0.0	81200
2	5.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m³	water unit wt Gamma' kN/m³	int fric agl Phi Deg	coh Co kN/m²	coh inc K kN/m²	dfrm modul Alp.Eo kN/m²
1	7.000	Sandy	29.0	18.0	9.0	25.00	10.0	0.0	81200
2	5.000	Sandy	50.0	18.0	9.0	25.00	10.0	0.0	140000

1.5 member

wall(steel sheet pile)

material

steel sheet pile material SY295

allowable bending stress 270(N/mm²)

allowable shear stress 150(N/mm²)

Young's modulus $2.00*10^5$(N/mm²)

steel sheet pile effective rate Alpha

for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45

for moment of inertia(displacement calculation, member force) 0.45

section modulus (stress) 0.60

use

	use name	vertical load kN/m
Right wall	28PU+1	0.00

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	0.00

surcharge of finite length

	load condition	load qL kN/m^2	begin position Xs m	length B m	position h m	lateral pressure position	actv failure agl Theta deg.	ltrl prss begin hs m	ltrl prss load L hL m
Right wall	Load	20.00	2.000	5.000	0.000	Active failure angle	40.00	--------	--------

earth pressure coefficient is considered in latteral pressure due to surcharge .Do

surcharge is considered in design for sectional calculation pressure (conventional method).Do

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Self-stand	44.000	44.000	Yes

* 右壁

No	WT G.L.	surcharge kN/m^2		virt sprt pt G.L. m
	natrl grnd	natrl grnd	exv	
1	44.000	20.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
Right wall	Percussion method	2.0	5	Use cohesive

Note:Construction method.

Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 influence on surrounding ground check

common setting

check objective wall :right wall

check case :自立時

check depth

check point No	distance from wall (m)
1	5.000

allowable displacement qt

allowable Horizontal displacement qt:[0.020](m)

allowable Vertical displacement qt:[0.020](m)

allowable inclination angle :[0.001](rad)

judgement on adjacent distance

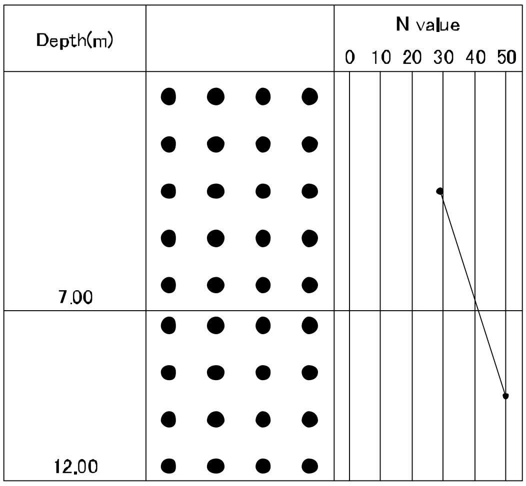
judgement method :derived from deflection(sand ground)

properties for judgement :Phi=[30.00]deg.

self standing virtual support point :downward distance from excavation bottom [1.000]m

1-11.10 boring log

* 右壁



1.11 Design strength

1.11.1 Set value for design

(1) Simplified method

[Standard: Temporary structure construction guideline(H11)]

considered Do 0.3Gamh criteria for active earth pressure clay to calculate embedment length

considered.Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth

self-standing required embedment estimate coefficient : 2.50/Beta

min embedment criteria : Based on design strength

soldier pile

Take 1.00 times of pile width when Beta is calculated.

eth prss ld W under exv btm and side result:Temporary structure construction guideline,Metro.express.H19

bracing reaction force

when excavation: Downward shared method

when removal: Temp. Works Guid.Metro. express.H19

tie rod reaction force: Overhang beam divide method

raker pile

take 1.00 times of pile width for straight pile Beta calculation

coefficient is 2.50/Beta to estimate required embedment length

initiation point of passive slip surface is 1.00/Beta

(2) Earth pressure for section calculation

[Standard: Temp. Works Guid.,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18), Land impro. wall(H5)]

sand 2.000

clay

constituency of clay judgement Nvalue Nx 5.000

soft clay N<=Nx 6.000

stiff clay N> Nx 4.000

(3) Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline,Metro.express.H19]

sandy soil	N<=10 10< N<=30 30< N	1.000 2.000 2.000
cohesive soil	N<=4 4< N<=8 8< N	1.000 1.000 1.000
treatment other than passive earth pressure		= pssv eth prss
side resistance of passive earth pressure		consider:Do

(4) Minimum Embedment depth

[Continuous wall]

self-standing 3.00(m)

when excavation with strut 3.00(m)

[Soldier pile]

self-standing 1.50(m)

when excavation with strut 1.50(m)

(5) Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20

conventional method

wall self-standing allowable displacement

wall self-standing allowable displacement is 3.0% of excavation depth

allowable displacement when checking stiffness 0.300(m)

raker pile allowable displacement 0.300(m)

elasto-plastic

required elastic region ratio 50.0(%)

(6) Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7) Bearing capacity coefficient

[Standard: Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method	1.0	1.0
vibration method	1.0	0.9
prss in	1.0	1.0
pre-boring method(sand filling)	0.0	0.5
pre-boring method(percussion,vibration, prss tip embedment)	1.0	1.0
auger prss method (sad filling)	0.0	0.5
auger prss method(percussion,vibration, prss tip embedment)	1.0	1.0

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method,vibration method kN/m^2	100	150
drill and prss casting method kN/m^2	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximum skin friction upper limit kN/m^2	200	150

(8) Analysis the effect to surrounding soil

simply prediction method; maximum settlement prediction diagram table

turning point No	I: hard line		II: middle, soft line	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.33	0.00	2.00
(2)	0.35	0.40	0.70	0.80
(3)	3.00	0.00	3.00	0.00

I : embedment tip ground strength = hard line

II: embedment tip ground strength = middle, soft line

x-ax: relative stiffness zeta(10^6kN m^2/m)

y-ax: surrounding ground max settlement /excavation depth (%)

max settlement predicition table

turning point No	I: 30.0m under		II: 30.0m over	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.85	0.00	3.50
(2)	0.50	0.25	0.95	0.58
(3)	3.00	0.00	3.00	0.00

I : presumed line for excavation width under 30m

II: presumed line for excavation width over 30m

x-ax: equivalent stiffness xi(10^6kN m^2/m)

y-ax: maximum settlement location surrounding ground /excavation depth

II Calculation results

1 Simplified method

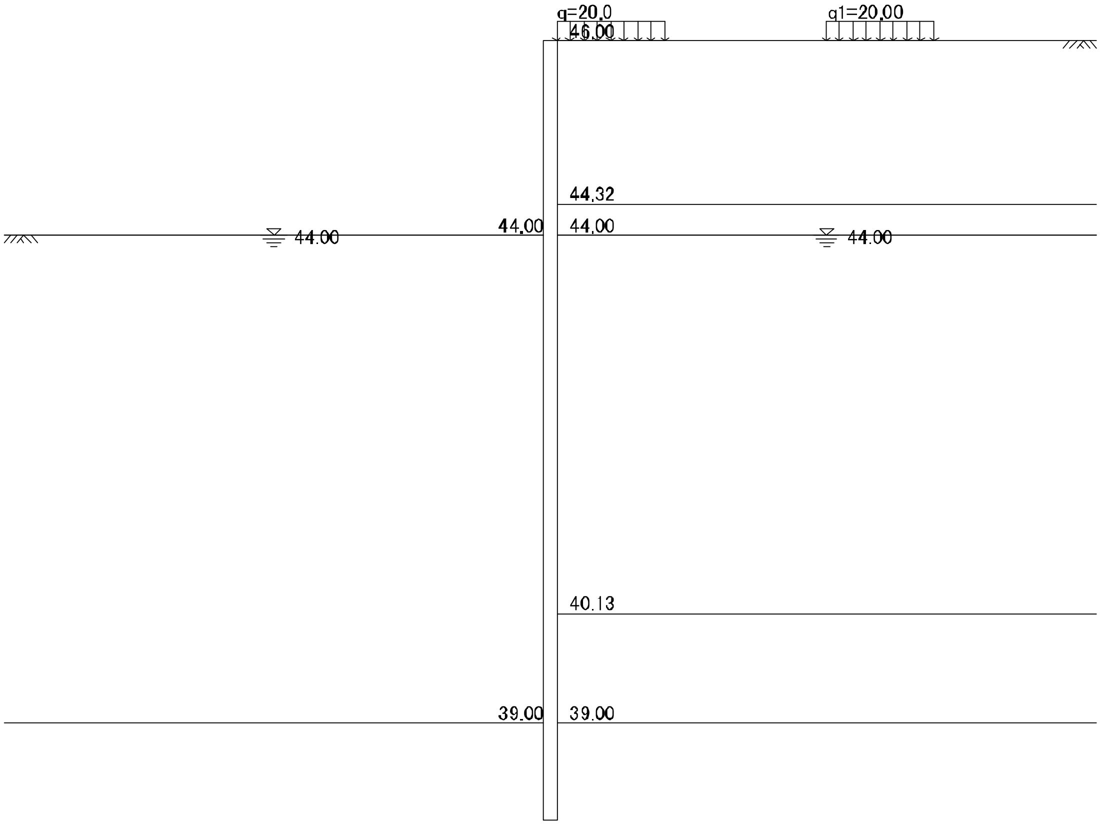
1.1 Right wall design

1.1.1 Self-stand

(1) check condition

state : Self standing

case name: self-stand



1) check condition

natural ground surface	G.L.(m)	46.000
excavation	G.L.(m)	44.000
water table at natural ground	G.L.(m)	44.000
water table at excavation	G.L.(m)	44.000
surcharge at natural ground q	kN/m²	20.00
surcharge at excavation q	kN/m²	0.00

2) ground condition

* natural ground

No	elevation upper G.L.(m)	elevation bottom G.L.(m)	ground type	soil N val	soil unit weight wet wt (kN/m³)	soil unit weight sbmg wt (kN/m³)	internal fric agl (deg.)	wall fric agl (deg.)
1	46.000	44.322	Sandy	29.0	18.0	9.0	25.0	12.5
2	44.322	44.000	Sandy	29.0	18.0	9.0	25.0	12.5
3	44.000	40.127	Sandy	29.0	18.0	9.0	25.0	12.5
4	40.127	39.000	Sandy	29.0	18.0	9.0	25.0	12.5
5	39.000	34.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m^2)	dfrm modul Alp. Eo (kN/m^2)
	Co (kN/m^2)	inc k (kN/m^3)	base G.L.(m)		
1	10.0	0.0	46.000	20.0	81200
2	10.0	0.0	46.000	20.0	81200
3	10.0	0.0	46.000	20.0	81200
4	10.0	0.0	46.000	20.0	81200
5	10.0	0.0	39.000	20.0	140000

* excavation side

No	elevation		ground type	ave N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m^3)	sbmg wt (kN/m^3)		
1	44.000	39.000	Sandy	29.0	18.0	9.0	25.0	12.5
2	39.000	34.000	Sandy	50.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m^2)	dfrm modul Alp. Eo (kN/m^2)
	Co (kN/m^2)	inc k (kN/m^3)	base G.L.(m)		
1	10.0	0.0	46.000	20.0	81200
2	10.0	0.0	39.000	20.0	140000

(2) embedment length calculation

1) result summery

case name: self-stand

analysis mthd : pile L lnger than the L from the eq assuming semi-infinite L pile on elastic grnd.

$$D = \frac{\text{safety coefficient}}{\text{Beta}}$$

excavation depth		(G.L. 44.000) m
req embd L	safety factor	2.50
	characteristic value Beta(m-1)	0.4344
	D= safety factor/Beta	5.756(G.L. 38.244) m
minimum embedment length (m)		2.000(G.L. 42.000) m
final embd L	embedment length (m)	6.000(G.L. 38.000) m
	judge	OK
final all length		8.000m

* calculation of characteristic value Beta

characteristic value Beta is calculated using the next equation.

$$\text{Beta}=\sqrt[4]{\frac{kH^{*}\ B}{4EI\,Alp.}}=\sqrt[4]{\frac{19511^{*}\ 1.000}{4^{*}\ 2.000^{*}\ 10^{8*}\ 0.00068380^{*}\ 1.000}}=\ 0.4344(m\text{-}1)$$

where,

Horizontal modulus of subgrade reaction kH= 19511(kN/m^3)

retaining wall width B = 1.000(m)

Young's modulus E = 2.000* 10^8(kN/m^2)

moment of inertia I = 0.00068380(m^4)

effective rate(for embedment calc) Alp.= 1.000

* Horizontal modulus of subgrade reaction

H modulus of subgrade reaction is an ave value through 1/Beta= 2.3022(m) range using the eq.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: wall type coefficient(= 1.00)

in case of continuous wall Eta= 1

kHo: H modulus of subgrade reaction equivalent to that of a 30cm stiff round plate.

$$kHo = \frac{1}{0.3} \ Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m^2)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m^2)	kHo (kN/m^3)	kH (kN/m^3)	kH* h (kN/m^2)
1	44.000	41.698	2.302	81200	270667	19511	44919
Sig			2.302				44919

ave kH= Sig.(kH* h) / Sig.h= 19511(kN/m^3)

BH conversion width of load 10.0(m)

(3)calculation of member force

1)result summery

case name: 自立時

analysis mthd : Assume a pile a semi-infinite beam on elastic fnd, mbr frc calc from next eq.

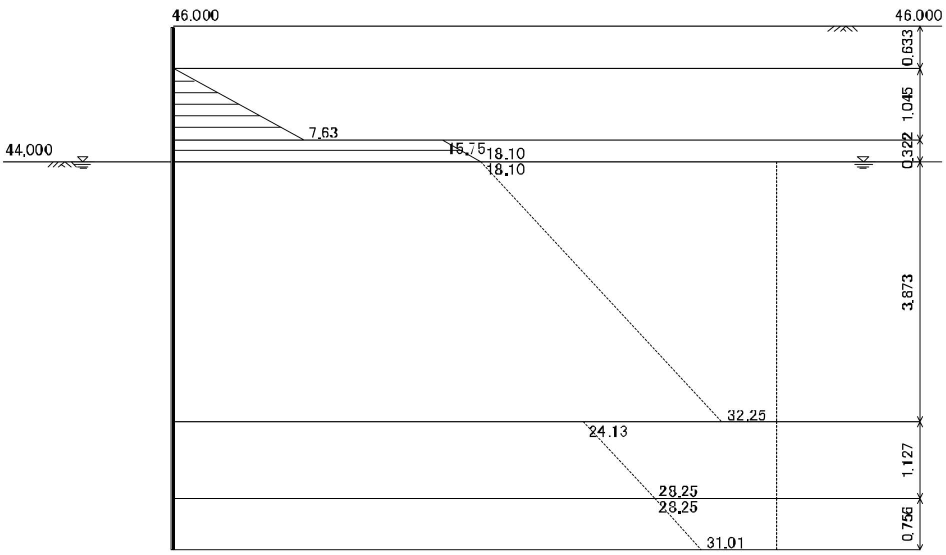
* max BM

$$Mmax = \frac{P}{2 * Beta} * \sqrt{(1+2Betaho)^2+1} * \exp\left(-\tan^{-1}\frac{1}{1+2Betaho}\right)$$

* max bending moment occurring point (from excavation surface)

$$Lm = \frac{1}{Beta} * \left(\tan^{-1}\frac{1}{1+2Betaho}\right)$$

characteristic value	Beta	m^{-1}	0.5306
latteral pressure above excavation	horizontal force P	kN/m	9.44
	moment M	kN m/m	3.53
	action height ho	m	0.374
max bending moment	moment Mmax	kN m/m	8.21
	depth (from excavation)	m	1.171(G.L. 42.829)m
shear force	shear force Smax	kN/m	9.44
	depth (from excavation)	m	0.000(G.L. 44.000)m



* calculation of characteristic value Beta

characteristic value Beta is calculated using the next equation.

$$Beta = \sqrt[4]{\frac{kH^* B}{4EI Alp.}} = \sqrt[4]{\frac{19511^* \ 1.000}{4^* \ 2.000^* \ 10^{8*} \ 0.00068380^* \ 0.450}} = 0.5306(m1)$$

where,

Horizontal modulus of subgrade reaction kH= 19511(kN/m³)

retaining wall width B = 1.000(m)

Young's modulus E = $2.000^* \ 10^8$(kN/m²)

moment of inertia I = 0.00068380(m⁴)

effective rate(for member force, displacement) Alp.= 0.450

* Horizontal modulus of subgrade reaction

H modulus of subgrd rct , is ave value through 1/Beta= 1.8848(m), and calc using next eq.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta= 1

kHo: H modulus of subgrd rct equi to 30cm stiff round plate lding test.

$$kHo = \frac{1}{0.3} Alp.Eo$$

Eo : ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH* h (kN/m²)
1	44.000	42.115	1.885	81200	270667	19511	36773
Sig			1.885				36773

ave kH= Sig.(kH* h) /Sig.h= 19511(kN/m³)

BH: conversion width of load 10.0(m)

2) displacement

displacement is calculated using the next equation.

Del.= Del.1+ Del.2+ Del.3

where,

Del. : displacement at checking position

Del.1: displacement at excavation depth

$$Del.1 = \frac{(1+ Beta^* ho)}{2EI Alp.Beta^3} {}^* P$$

Del.2: displacement at checking point(h) by deflection angle on excavation bottom

$$Del.2 = \frac{(1+ 2^* Beta^* ho)}{2EI Alp.Beta^2} {}^* P^* h$$

Del.3: displacement at the check point (h) on a canti-lever beam above excavation bottom

* equivalent triangular distribution load on base

$$p2' = \frac{6^* Sig.M}{b^2}$$

where,

b: height of top of wall

* Del.3calc eq(refer to the formula manual for mechanics)

$$Del.3 = \frac{p2'^* h^4}{30EI Alp.} \quad ......(i-eq)$$

* check condition

characteristic value Bet.	m-1	0.5306
Young's modulus E	* 10^8kN/m²	2.000
moment of inertia of area I	m⁴	0.00068380
effective ratio(moment of inertia) Alp.	-----	0.45
moment M	kN.m/m	3.53
horizontal force P	kN/m	9.44
horizontal force depth(from excavation) ho	m(G.L.m)	0.374(44.374)
excavation load intensity p2'	kN.m/m	5.30
allowable displacement	m	0.0600

* check result

item	unit	top of wall	ground level	natural ground WT
depth(from excavation) h	m(G.L.m)	2.000(46.000)	----------------	----------------
Del.1	m	0.0006	----------------	----------------
Del.2	m	0.0008	----------------	----------------
Del.3	m	0.0000	----------------	----------------
Del.= Del.1+ Del.2+ Del.3	m	(OK) 0.0014	----------------	----------------

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions	unit	value
section modulus Z	* 10^3(mm³/m)	3000
ditto effective rate Alp.	--------	0.600
cross sectional area A	* 10^2(mm²/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N.mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	8.21	0.00	9.44

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} \le Sig.sa$$

where,

Sig. : bending stress(N/mm²)

Sig.sa: allowable bending stress(N/mm²)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm²	allowable stress N/mm²	Judge
Max.	4.6	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} \le Taua$$

where,

Tau :shear force stress (N/mm²)

Taua:allowable shear stress (N/mm²)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	0.4	150.0	OK

2 Elasto-plastic method

2.1 right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : 28PU+1

using material : SY295

dimensions		unit	value
section modulus	Z	$*10^3(mm^3/m)$	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	$*10^2(mm^2/m)$	226.00

(2) design member force

design member force is as following table.

state	moment M $*10^6$(N mm/m)	axial force N $*10^3$(N/m)	shear force S $*10^3$(N/m)
Max.	11.04	0.00	11.93

(3) bending stress

$$Sig. = \frac{M}{Alp.*Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	6.1	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	0.5	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1) sefl-stand

1)analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	46.000		--------	0.00	----------	--------	-3.14	--------
2	45.500		2.27	2.27	----------	--------	-2.80	--------
3	45.000		4.55	4.55	----------	--------	-2.46	--------
4	44.500		6.82	6.82	----------	--------	-2.13	--------
5	44.322		7.63	15.75	----------	--------	-2.01	--------
6	44.000	Ela.zone	18.10	18.10	9.42	4878	-1.80	8.8
7	43.500	Ela.zone	17.42	17.42	22.61	9755	-1.51	14.7
8	43.000	Ela.zone	16.73	16.73	27.63	9755	-1.24	12.1
9	42.500	Ela.zone	16.05	16.05	32.66	9755	-1.03	10.0
10	42.000	Ela.zone	15.36	15.36	37.69	9755	-0.84	8.2
11	41.500	Ela.zone	14.67	14.67	42.71	9755	-0.69	6.8
12	41.000	Ela.zone	13.99	13.99	47.74	9755	-0.56	5.5
13	40.500	Ela.zone	13.30	13.30	45.79	8516	-0.45	3.8
14	40.127	Ela.zone	12.79	4.67	27.95	4878	-0.37	1.8
15	40.000	Ela.zone	4.50	4.50	36.82	6117	-0.34	2.1
16	39.500	Ela.zone	3.81	3.81	62.82	9755	-0.24	2.3
17	39.000	Ela.zone	3.13	3.13	67.84	13288	-0.14	1.9
18	38.500	Ela.zone	2.44	2.44	72.87	16820	-0.05	0.8
19	38.000	Ela.zone	1.75	--------	38.32	8410	0.04	-0.3

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

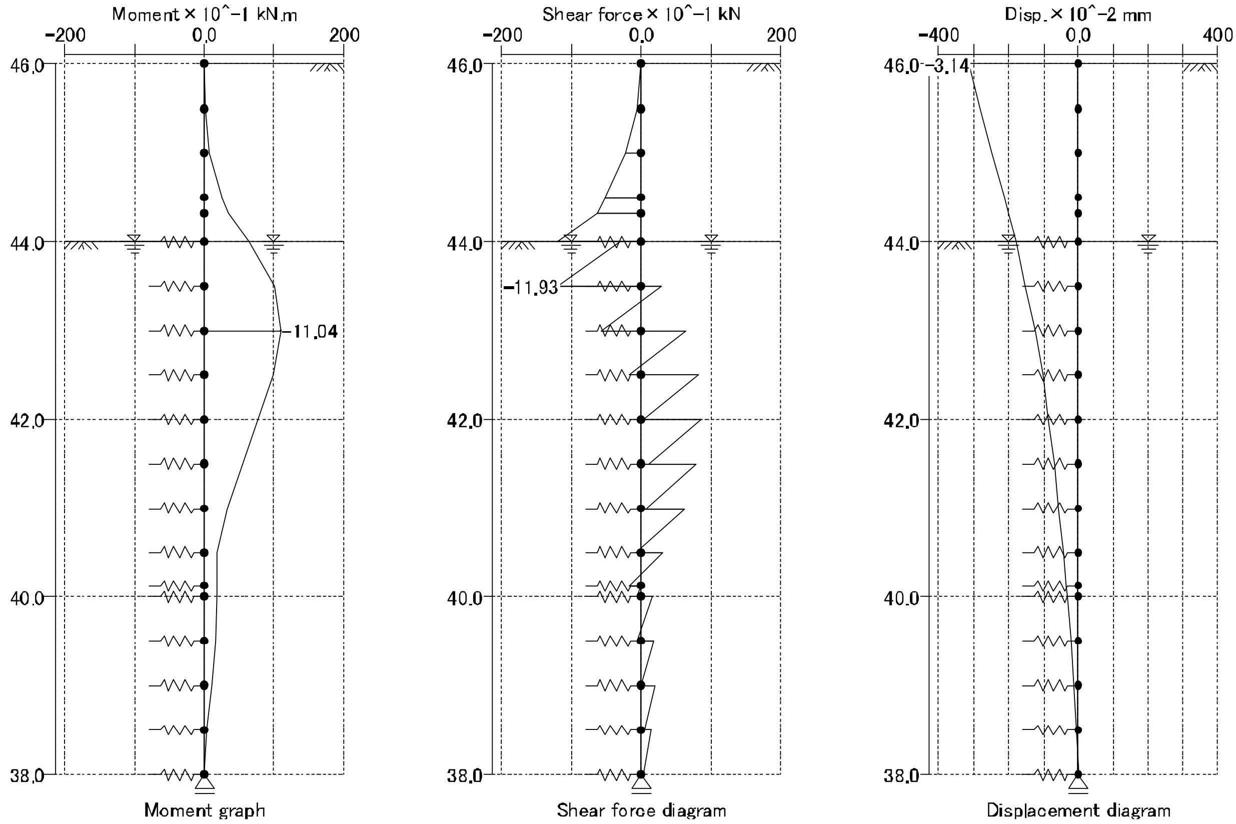
2)self-stand analysis result (member force, displacement)

Mmax = 0.0kN.m/m(working pos G.L. 46.00m) Mmin = -11.0kN.m/m(working pos G.L. 43.00m)

Smax = 8.5kN/m (working pos G.L. 42.00m) Smin = -11.9kN/m (working pos G.L. 43.50m)

Del.max= 0.04mm (working pos G.L. 38.00m) Del.min= -3.14mm (working pos G.L. 46.00m)

node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H rct kN/m
		upper	bottom	upper	bottom		
1	46.000	----------	0.0	----------	0.0	-3.14	----------
2	45.500	-0.1	-0.1	-0.6	-0.6	-2.80	----------
3	45.000	-0.8	-0.8	-2.3	-2.3	-2.46	----------
4	44.500	-2.6	-2.6	-5.1	-5.1	-2.13	----------
5	44.322	-3.6	-3.6	-6.4	-6.4	-2.01	----------
6	44.000	-6.5	-6.5	-11.9	-3.1	-1.80	----------
7	43.500	-10.3	-10.3	-11.9	2.8	-1.51	----------
8	43.000	-11.0	-11.0	-5.8	6.4	-1.24	----------
9	42.500	-9.9	-9.9	-1.8	8.2	-1.03	----------
10	42.000	-7.8	-7.8	0.3	8.5	-0.84	----------
11	41.500	-5.4	-5.4	1.0	7.8	-0.69	----------
12	41.000	-3.3	-3.3	0.6	6.2	-0.56	----------
13	40.500	-2.0	-2.0	-0.7	3.2	-0.45	----------
14	40.127	-1.7	-1.7	-1.7	0.1	-0.37	----------
15	40.000	-1.8	-1.8	-0.5	1.6	-0.34	----------
16	39.500	-1.5	-1.5	-0.5	1.8	-0.24	----------
17	39.000	-1.0	-1.0	0.1	2.0	-0.14	----------
18	38.500	-0.4	-0.4	0.6	1.4	-0.05	----------
19	38.000	0.0	----------	0.3	----------	0.04	----------


Moment × 10^-1 kN.m
-200
0.0
200
46.0
44.0
42.0
40.0
38.0
11.04
Moment graph
Shear force × 10^-1 kN
-200
0.0
200
-11.93
Shear force diagram
Disp. × 10^-2 mm
-400
0.0
400
-3.14
Displacement diagram

3 Bearing capacity

3.1 right wall design

3.1.1 check condition

(1) check method : Temp. Works Guid. H11, Metro. express. H19, Std. Dsgn. Spec. Vol. 2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	38.000
exv bs ps	G.L.(m)	44.000
embd L L	m	6.000

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	1076.80	538.40	0.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	50.0	39.5	40.0	8000.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N-val Ni	Li * Ni
1	40.000	39.000	1.000	29.0	29.00
2	39.000	38.000	1.000	50.0	50.00
Sig			2.000		79.00

3) circumference friction force(Sig.Li * fi)

* sand : fi= 2BetaNs(note; Ns<=50
* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)
* coefficient of skin friction with construction method: Beta= 1.0
* Nvalue <=2 fi= 0.0 in weak soil
* all friction resistance Sig.Li * fi= 896.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li * fi (kN/m)
1	5.000	29.0	-----	58.00	290.00
2	1.000	50.0	-----	100.00	100.00
Sig	6.000				390.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li * fi (kN/m)
1	1.678	29.0	-----	58.00	97.32
2	0.322	29.0	-----	58.00	18.68
3	3.873	29.0	-----	58.00	224.63
4	1.127	29.0	-----	58.00	65.37
5	1.000	50.0	-----	100.00	100.00
Sig	8.000				506.00

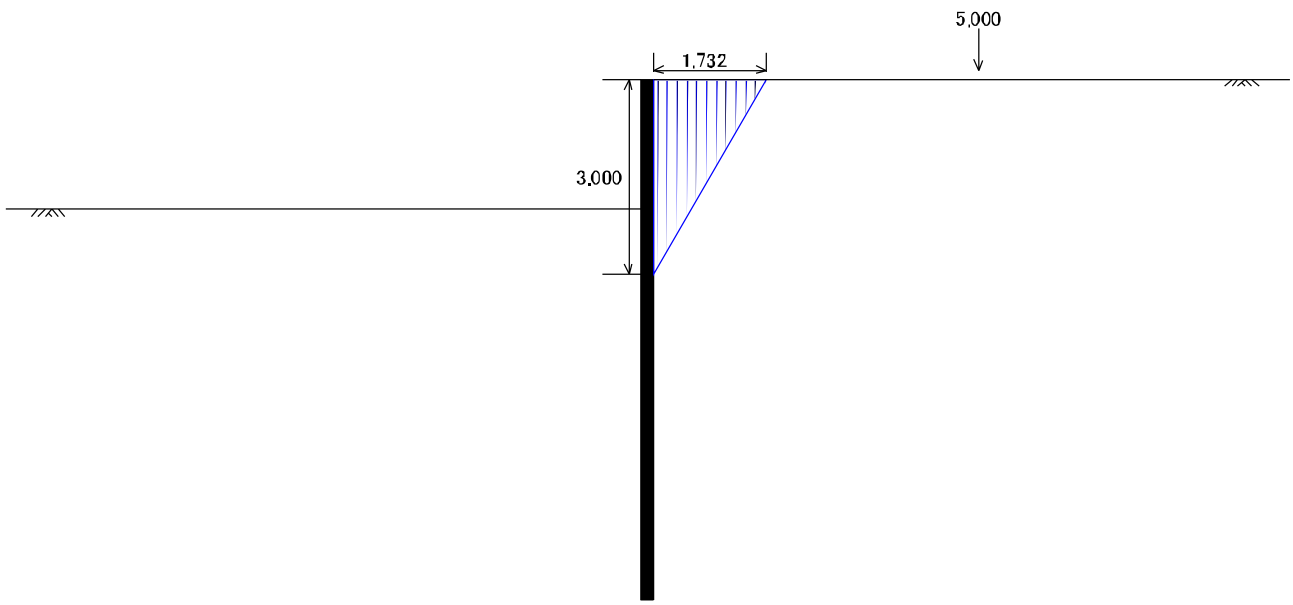
4 influence on surrounding ground

4.1 judgement on adjacent distance

(1) check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	46.000
excavation	G.L.(m)	44.000
virtual support point	G.L.(m)	43.000



(2) judgement on adjacent distance

1) influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{3.000}{\tan\left(45 + \frac{30.00}{2}\right)} = 1.732\ (m)$$

where,

Lxa: influence range on ground deformation by temporary works

dy : depth up to virtual support point of retaining wall

Phi: soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2)judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

Cover
(5) Badraman Canal

I Design condition

1.1 fundamental data

file : Badraman 4

title:

comment:

bracing type Raker pile tie rod type

wall type Steel sheet pile

type Normal

raker pile type H Beam pile(vertical)

applied standard- conventional method road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method: Wall inside-inside distance

plane shape type	Straight line
excavation width B (m) excavation length Le (m)	8.000 9.000

influence of water table	w/Do
base water table(before excavation) G.L.(m)	45.000

erection planning

final excavation depth G.L. 43.000(m)

excavation for installation strut 1.000(m)

tie rod setting point G.L. 47.000(m)

tie rod horizontal spacing 1.800(m)

1.2 shape

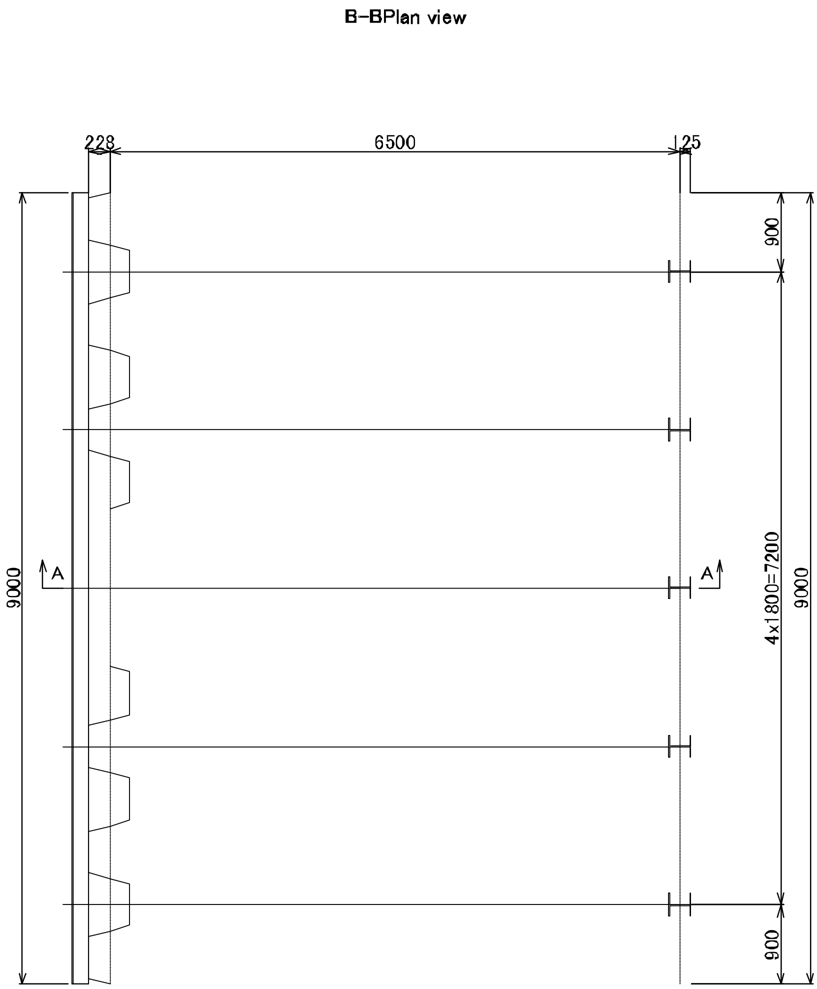
Design wall right wall

plane shape

	interval mm
wall to 1	900
1 to 2	1800
2 to 3	1800
3 to 4	1800
4 to 5	1800
5 to wall	900

tie rod and raker pile relationship: Direct connect

plan



side section shape

	top of wall G.L. m	ground level G.L. m
Right wall	48.000	48.000

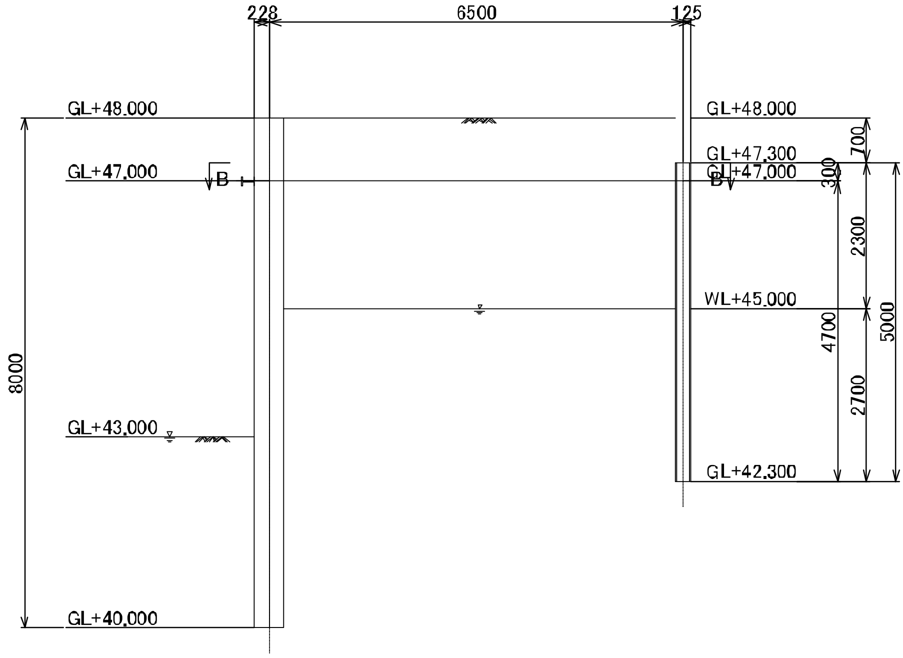
top of raker pile :G.L. 47.300(m)

raker pile installation check range : 20.000(m)

Side view

 * left-right direction

A-ASection view



1.3 method

checking item

bearing capacity check	check Do
excavation bottom stability check	check Not do
surcharge by slope influence check	check Not do
bracing design	check Do
material	SS400
influence on surrounding ground check	check Do
Length round up value	0.5m

description of conventional method

water pressure distribution	triangle
calculation method for earth pressure to evaluate section	For Embedment length
Horizontal modulus of subgrade reaction for raker pile calculation	Internal calculation
Horizontal modulus of subgrade reaction for retaining wall stiffness check	Internal calculation
consider rock layer	not do

elasto-plastic method concept

wall section change : not do

elastic portion rate : do

steady state check : not do

allowable displacement check : not do

analysis method : Analysis method 1

calculation pitch : 0.50(m)

using elasto-plastic latelastoeral pressure, embedment stability check when excavation: Consider S.F. of equi. len.

shape spring input method considered

H-subgrade reaction force calculation, shape dependent conversion width of load BH 10.000(m)

top of wall support condition Free

top of wall support condition Free

bracing combination condition(single wall analysis) rotation constrained No

for elasto-plastic method, lateral pressure

all Standard common

soil thickness above underground structure pressure: soil unit weight under ground water(Gamma - $Gamma_w$)

excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation

correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* right wall

. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	3.000	Sandy	6.0	18.0	9.0	25.00	10.0	0.0	16800
2	8.000	Sandy	14.0	18.0	9.0	25.00	10.0	0.0	39200
3	7.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	3.000	Sandy	6.0	18.0	9.0	25.00	10.0	0.0	16800
2	8.000	Sandy	14.0	18.0	9.0	25.00	10.0	0.0	39200
3	7.000	Sandy	24.0	18.0	9.0	25.00	10.0	0.0	67200

1.5 member

wall(steel sheet pile)

material

steel sheet pile material SY295

allowable bending stress 270(N/mm^2)

allowable shear stress 150(N/mm^2)

Young's modulus $2.00*10^5$(N/mm^2)

steel sheet pile effective rate Alpha

for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45

for moment of inertia(displacement calculation, member force) 0.45

section modulus (stress) 0.60

use

	use name	vertical load kN/m
Right wall	PU28+	0.00

raker pile(H steel pile)

material

material :SS400

allowable bending stress :210(N/mm²)

allowable shear stress :120(N/mm²)

Young's modulus :2.00* 10^5(N/mm²)

use

use name :H−250×250× 9×14

vertical load :0.00(kN/unit)

tie rod

material

material :high tension steel690

allowable tensile stress :264(N/mm²)

Young's modulus :2.00* 10^5(N/mm²)

use

use diameter :28.0(mm)

using number :1

tie rod inclination :none

applied screw

name :M33

effective cross sectional area :694.0(mm²)

E.P. method

H length L m	bracing spring tension charac.	bracing pre load consid	bracing pre loaded kN/memb.	cstrc losnes mm	H-sprg dirct inp Yes/No	H-sprg const kN/m/m
6.500	Yes	Not do	0.01	0	No	----------

waling material

material

material :SS400

allowable bending stress Sig.a :interior calculation

design concept

waling type :U-type

checking equation :TL/10

use

use name : [200×80×7.5×11

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	0.00

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Primary excavation	46.000	45.000	none
2	Final Exc.	1	Completion time	43.000	43.000	Yes

* right wall

No	WT G.L.	surcharge kN/m^2		virt sprt pt G.L. m
	natrlgrnd	natrlgrnd	exv	
1	45.000	10.00	0.00	int calc
2	45.000	10.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
right	Percussion method	2.0	5	Use cohesive

Note:Construction method.

Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 influence on surrounding ground check

common setting

check objective wall :right wall

check case :completiontime

check depth

check point No	distance from wall (m)
1	5.000

allowable displacement qt

allowable Horizontal displacement qt:[0.020](m)

allowable Vertical displacement qt:[0.020](m)

allowable inclination angle :[0.001](rad)

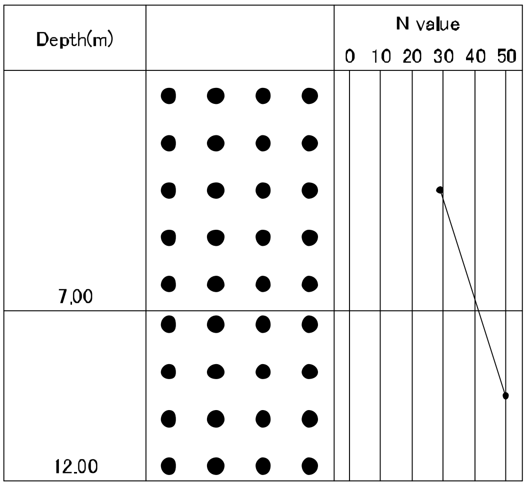
judgement on adjacent distance

judgement method :derived from deflection(sand ground)

properties for judgement :Phi=[30.00]deg.

1.10 boring log

* right wall



1.11 Design strength

1.11.1 Set value for design

(1) Simplified method

[Standard: Temporary structure construction guideline(H11)]

considered Do 0.3Gam h criteria for active earth pressure clay to calculate embedment length

considered. Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth

self-standing required embedment estimate coefficient : 2.50/Beta

min embedment criteria : Based on design strength

soldier pile

Take 1.00 times of pile width when Beta is calculated.

eth prss ld W under exv btm and side result: Temporary structure construction guideline, Metro. express. H19

bracing reaction force

when excavation: Downward shared method

when removal: Temp. Works Guid. Metro. express. H19

tie rod reaction force: Overhang beam divide method

raker pile

take 1.00 times of pile width for straight pile Beta calculation

coefficient is 2.50/Beta to estimate required embedment length

initiation point of passive slip surface is 1.00/Beta

(2) Earth pressure for section calculation

[Standard: Temp. Works Guid., Metro. express. H19, Std. Dsgn. Spec. Vol. 2(H18), Land impro. wall(H5)]

sand 2.000

clay

constituency of clay judgement N value Nx 5.000

soft clay N<=Nx 6.000

stiff clay N> Nx 4.000

(3) Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline, Metro. express. H19]

sandy soil	N<=10 10< N<=30 30< N	1.000 2.000 2.000
cohesive soil	N<=4 4< N<=8 8< N	1.000 1.000 1.000
treatment other than passive earth pressure		= pssv eth prss
side resistance of passive earth pressure		consider: Do

(4) Minimum Embedment depth

[Continuous wall]

self-standing 3.00(m)

when excavation with strut 3.00(m)

[Soldier pile]

self-standing 1.50(m)

when excavation with strut 1.50(m)

(5) Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20

conventional method

wall self-standing allowable displacement

wall self-standing allowable displacement is 3.0% of excavation depth

allowable displacement when checking stiffness 0.300(m)

raker pile allowable displacement 0.300(m)

elasto-plastic

required elastic region ratio 50.0(%)

(6) Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7) Bearing capacity coefficient

[Standard: Temp. Works Guid. H11, Metro. express. H19, Std. Dsgn. Spec. Vol. 2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method	1.0	1.0
vibration method	1.0	0.9
prss in	1.0	1.0
pre-boring method(sand filling)	0.0	0.5
pre-boring method(percussion, vibration, prss tip embedment)	1.0	1.0
auger prss method (sad filling)	0.0	0.5
auger prss method(percussion, vibration, prss tip embedment)	1.0	1.0

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method, vibration method kN/m^2	100	150
drill and prss casting method kN/m^2	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximum skin friction upper limit kN/m^2	200	150

(8) Analysis the effect to surrounding soil

simply prediction method; maximum settlement prediction diagram table

turning point No	I: hard line		II: middle, soft line	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.33	0.00	2.00
(2)	0.35	0.40	0.70	0.80
(3)	3.00	0.00	3.00	0.00

I : embedment tip ground strength = hard line

II: embedment tip ground strength = middle, soft line

x-ax: relative stiffness zeta(10^6kN m^2/m)

y-ax: surrounding ground max settlement / excavation depth (%)

max settlement predicition table

turning point No	I: 30.0m under		II: 30.0m over	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.85	0.00	3.50
(2)	0.50	0.25	0.95	0.58
(3)	3.00	0.00	3.00	0.00

I : presumed line for excavation width under 30m

II: presumed line for excavation width over 30m

x-ax: equivalent stiffness xi(10^6kN m^2/m)

y-ax: maximum settlement location surrounding ground / excavation depth

II Calculation results

1 Simplified method

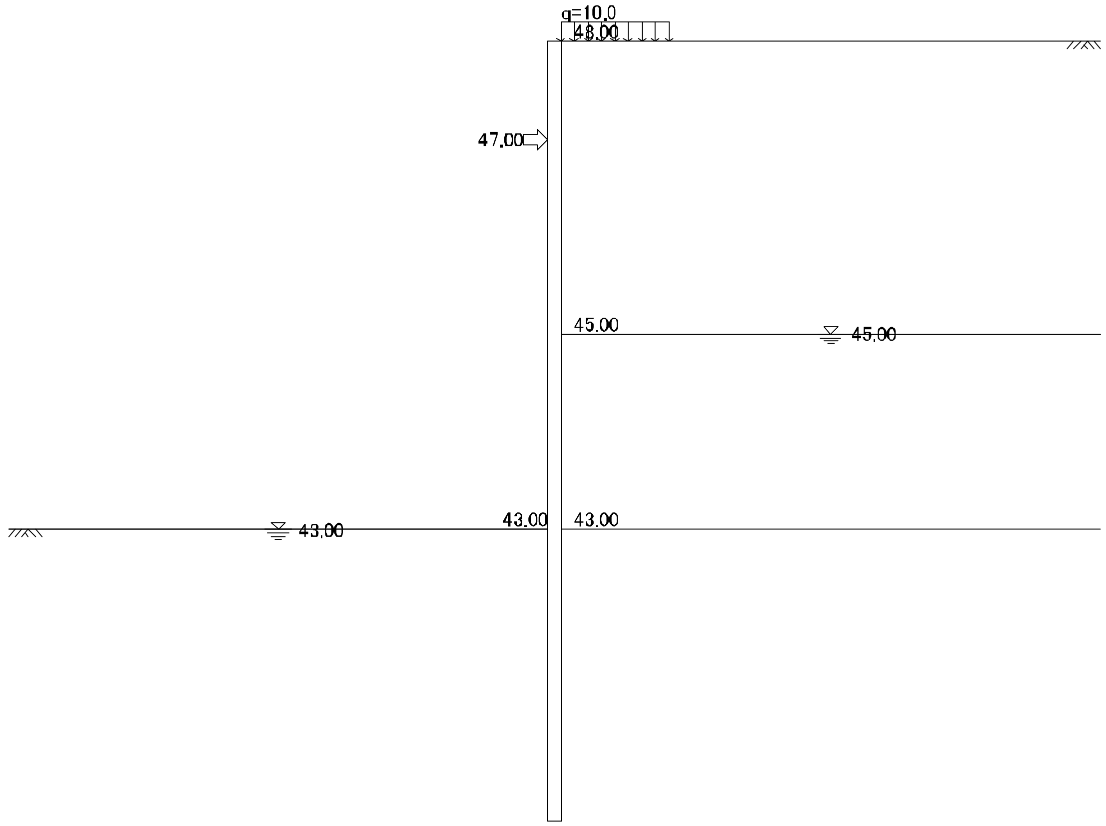
1.1 Right wall design

1.1.1 Completion time

(1) check condition

state : Final excavated time

case name: completion time



1) check condition

natural ground surface	G.L.(m)	48.000
excavation	G.L.(m)	43.000
lowest strut	G.L.(m)	47.000
water table at natural ground	G.L.(m)	45.000
water table at excavation	G.L.(m)	43.000
surcharge at natural ground q	kN/m^2	10.00
surcharge at excavation q	kN/m^2	0.00

2) ground condition

* natural ground

No	elevation		ground type	soil N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m^3)	sbmg wt (kN/m^3)		
1	48.000	45.000	Sandy	6.0	18.0	9.0	25.0	12.5
2	45.000	43.000	Sandy	14.0	18.0	9.0	25.0	12.5
3	43.000	37.000	Sandy	14.0	18.0	9.0	25.0	12.5
4	37.000	30.000	Sandy	24.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m²)	dfrm modul Alp. Eo (kN/m²)
	Co (kN/m²)	inc k (kN/m³)	base G.L.(m)		
1	10.0	0.0	48.000	20.0	16800
2	10.0	0.0	45.000	20.0	39200
3	10.0	0.0	45.000	20.0	39200
4	10.0	0.0	37.000	20.0	67200

* excavation side

No	elevation		ground type	ave N val	soil unit weight		internal fric agl (deg.)	wall fric agl (deg.)
	upper G.L.(m)	bottom G.L.(m)			wet wt (kN/m³)	sbmg wt (kN/m³)		
1	43.000	37.000	Sandy	14.0	18.0	9.0	25.0	12.5
2	37.000	30.000	Sandy	24.0	18.0	9.0	25.0	12.5

No	cohesion			unc cmpr strg qu (kN/m²)	dfrm modul Alp. Eo (kN/m²)
	Co (kN/m²)	inc k (kN/m³)	base G.L.(m)		
1	10.0	0.0	45.000	20.0	39200
2	10.0	0.0	37.000	20.0	67200

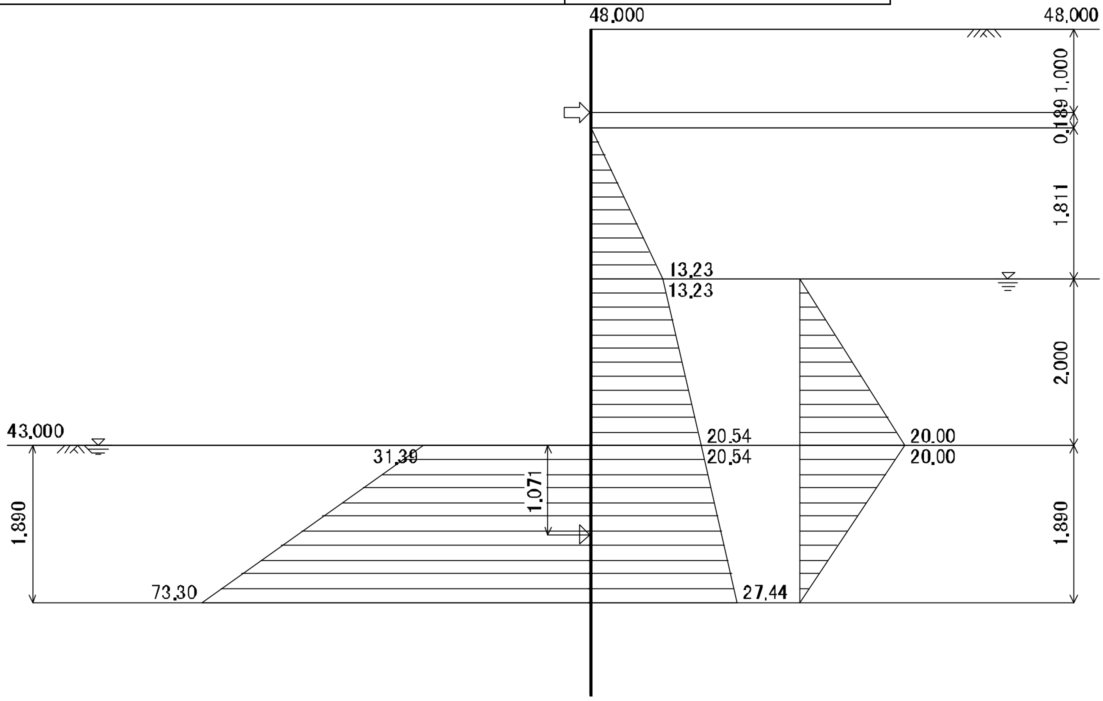
(2) embedment length calculation

1) result summery

case name: completion time

analysis method : embedment length is calculated from moment balance at lowest strut

excavation depth		(G.L. 43.000)m
req embd L	safety factor F	1.200
	balance depth Z(m)	1.890(G.L. 41.110)m
	required embedment length D(m)	2.268(G.L. 40.732)m
	virtual support point depth Y(m)	1.071(G.L. 41.929)m
minimum embedment length (m)		3.000(G.L. 40.000)m
final embd L	final embedment length L (m)	3.000(G.L. 40.000)m
	judge	OK
final all length		8.000m



* sum of external forces at the balanced depth (G.L. 41.110)m

item	moment		horizontal force	
Active side Compre. side	Ma+Mw(kN.m/ m) Mp(kN.m/m)	500.94 501.73	Pa(kN/m) Pp(kN/m)	130.00 98.94
ratio(Mp/(Ma+ Mw))			1.0	
virtual support point depth (Y) m			1.071	

Mp is a moment at lowest strut, so assumed bearing depth Y is modified by the next equation.
virtual support point depth (Y) = Mp/Pp- (lowest strut place - excavation base).

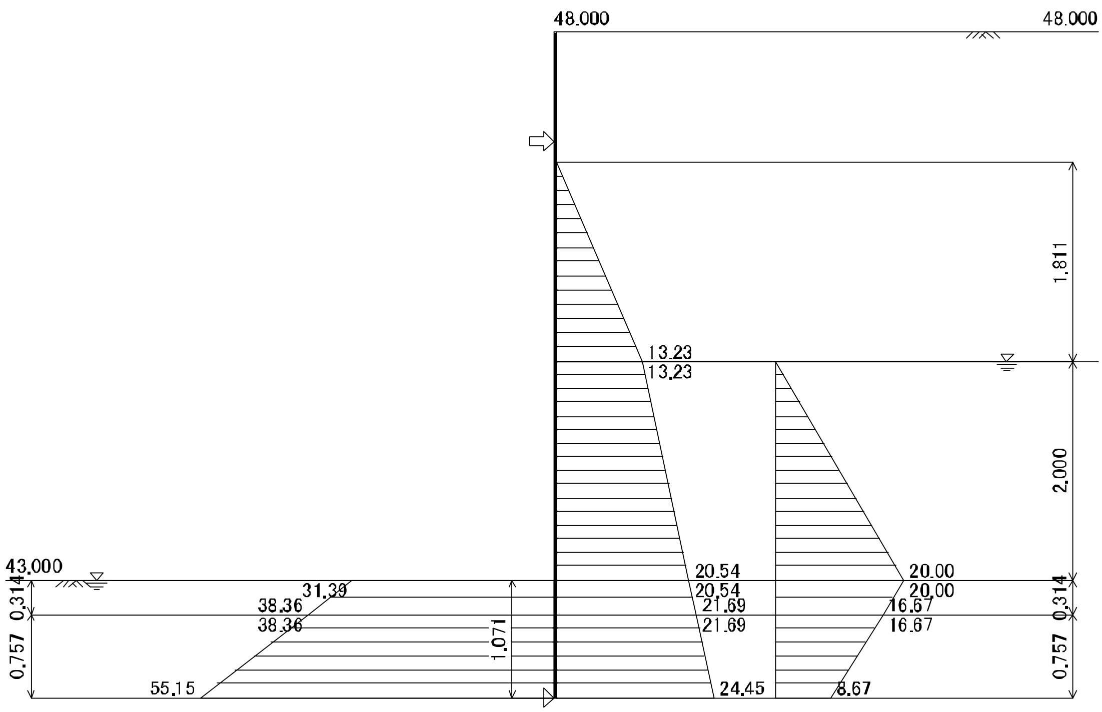
(3)calculation of member force

1)result summery

case name: completion time

analysis method : check as a simple beam with a span between strut and virtual support point.

earth pressure is taken the earth pressure for embedment length calculation.



* single span supported at lowest strut and virtual support point

lowest strut depth		m	(G.L. 47.000)m
virtual support point depth		m	(G.L. 41.929)m
simple beam span		m	5.071
max bending moment	moment Mmax	kN.m/m	59.42
	depth(from strut)	m	2.888(G.L. 44.112)m
shear force	shear force Smax	kN/m	38.07
	depth(from strut)	m	5.071(G.L. 41.929)m
reaction	upper reaction force RA	kN/m	29.12
	lower reaction force RB	kN/m	38.07
*max displacement	displacement Del.max	m	0.0025
	depth(from strut)	m	2.536(G.L. 44.464)m

*reference value

3)retaining wall stiffness check

nevertheless wall stress has allowance, not to deform retaining wall within a certain level, checking enough stiffness assured. so displacement must be satisfied the following equation.

Del.= Del.1+ Del.2<=Del.a

where,

Del. : total retaining wall displacement

Del.1: maximum displacement calculated as a simple beam

$$Del.1 = \frac{5*w*L^4}{384*EI Alp.}$$

Del.2: influence displacement at elastic support

Del.2' = R/K

Del.2 = Del.2' /2

Del.a: allowable displacement

calculating model is SS beam at top strut and an elastic support of half of embeded depth, load is taken earth pressure for section check and water pressure throughout a span.

if a ld has trapezoidal dstr, convert to an conversion uniform dstr ld with the same intensity.

rigid support level (top strut)		G.L.(m)	47.000
virtual support point depth Y		m	1.071
1/2 of virtual support point depth		G.L.(m)	42.464
simple beam span L		m	4.536
intensity applied on a simple beam P		kN/m	86.49
Del.1	Young's modulus E	* 10^8 kN/m²	2.000
	moment of inertia of area I	m⁴/m	0.00068380
	effective rate(displacement) Alp.	-----	0.450
	deformation of center in span Del.1	m	0.0017
Del.2	modulus of subgrade reaction kH	kN/m³	9419
	wall width B	m	1.000
	side area of spring block pile A= B* Y	m²	1.0711
	spring constant K= kH* A	kN/m²	10089
	reaction force R= w* L/2	kN/m	43.24
	elastic support displacement Del.2' = R/K	m	0.0043
total wall displacement Del. = Del.1+ Del.2		m	0.0039
position (a half of span)		G.L.(m)	44.732
allowable displacement Del.a		m	0.300
Judge		-----	OK

* total intensity applied on a simple beam(P)

No	depth GL(m)	thk h (m)	action load p kN/m²	load P kN/m
1	47.000 46.811	0.189	0.00 0.00	0.00
2	46.811 45.000	1.811	0.00 13.23	11.98
3	45.000 43.000	2.000	13.23 40.54	53.77
4	43.000 42.686	0.314	40.54 38.36	12.39
5	42.686 42.464	0.222	38.36 36.82	8.35
Sig				86.49

* Horizontal modulus of subgrade reaction

Horizontal modulus of subgrade reaction is an average value to virtual support point, using the equation

$$kH = Eta kHo \left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta= 1

kHo: H modulus of subgrade reaction equivalent to that of a 30cm stiffness round plate.

$$kHo = \frac{1}{0.3} Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH*h (kN/m²)
1	43.000	41.929	1.071	39200	130667	9419	10089
Sig			1.071				10089

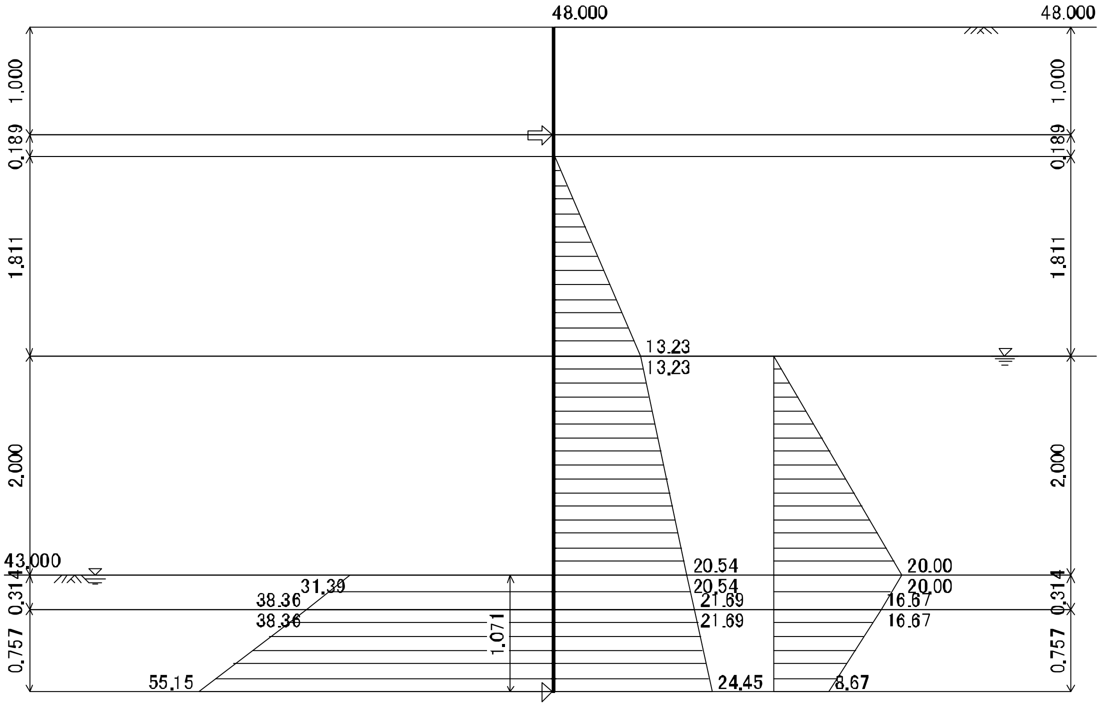
ave kH= Sig.(kH* h) /Sig.h= 9419(kN/m³)

BH: conversion width of load 10.0(m)

(4)calculation of bracing reaction force

1)result summery

analysis method : Overhang strut method



No	depth G.L. (m)		support G.L. (m)	reaction force kN/m	bracing reaction force kN/m
1	47.000	up span	--------	--------------	29.12
		low span	41.929	29.12	

timbering reaction= timbering No.(n)up spansprt rct+ reaction of lower support

up span bt focusing bracing and just above. Support at bracing above tmb No(n).

up span bt focusing bracing and just below. Support at bracing below tmb No(n).

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm³/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm²/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	59.42	0.00	38.07

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	33.0	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	1.7	150.0	OK

2 Elasto-plastic method

2.1 right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+

using material : SY295

dimensions		unit	value
section modulus	Z	* 10^3(mm^3/m)	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	* 10^2(mm^2/m)	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	56.97	0.00	38.51

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm²	allowable stress N/mm²	Judge
Max.	31.6	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} \leq Taua$$

where,

Tau :shear force stress (N/mm²)

Taua:allowable shear stress (N/mm²)

state	stress Tau N/mm²	allowable stress Taua N/mm²	Judge
Max.	1.7	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1) primary excavation

1) analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	48.000		--------	0.00	----------	--------	-3.23	--------
2	47.500		1.48	1.48	----------	--------	-2.85	--------
3	47.000		2.96	2.96	----------	--------	-2.48	--------
4	46.500		4.45	4.45	----------	--------	-2.11	--------
5	46.000	Ela.zone	5.93	5.93	10.20	1009	-1.74	1.8
6	45.500	Ela.zone	4.38	4.38	28.89	2018	-1.39	2.8
7	45.000	Ela.zone	2.84	2.84	39.41	3364	-1.07	3.6
8	44.500	Ela.zone	2.15	2.15	45.23	4710	-0.79	3.7
9	44.000	Ela.zone	1.47	1.47	50.25	4710	-0.54	2.6
10	43.500	Ela.zone	0.78	0.78	55.28	4710	-0.34	1.6
11	43.000	Ela.zone	0.10	0.10	33.77	2685	-0.18	0.5
12	42.930	Ela.zone	0.00	0.00	30.96	2355	-0.16	0.4
13	42.500	Ela.zone	0.00	0.00	60.91	4379	-0.05	0.2
14	42.000	Ela.zone	0.00	0.00	70.36	4710	0.05	-0.2
15	41.500	Ela.zone	0.00	0.00	75.38	4710	0.13	-0.6
16	41.000	Ela.zone	0.00	0.00	80.41	4710	0.20	-1.0
17	40.500	Ela.zone	0.00	0.00	85.44	4710	0.27	-1.3
18	40.000	Ela.zone	0.00	--------	44.60	2355	0.33	-0.8

note1: effective passive lateral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

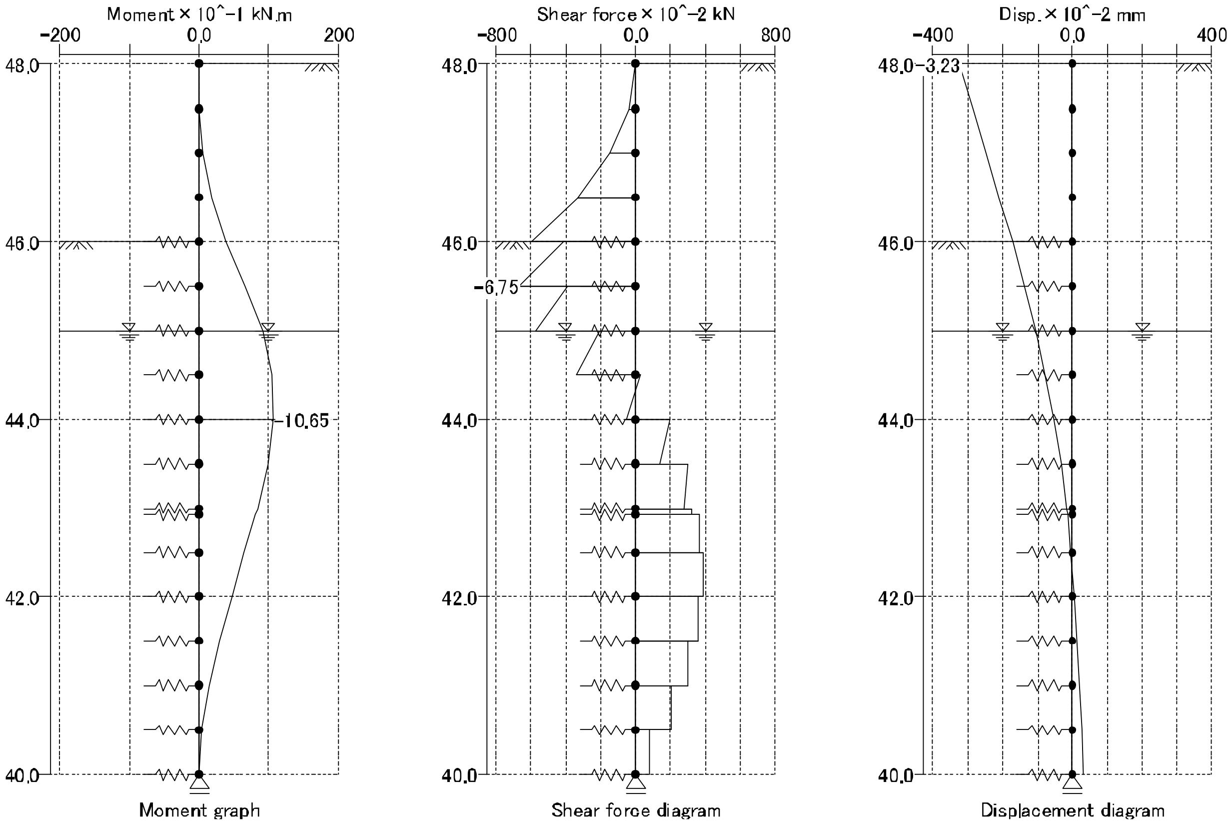
note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive lateral pressure in elastic range is no loading in analysis.

2) primary excavation analysis result (member force, displacement)

Mmax =----------kN m/m (working pos G.L.---------m) Mmin = -10.7kN m/m (working pos G.L. 44.00m)
Smax = 3.8kN/m (working pos G.L. 42.50m) Smin = -6.7kN/m (working pos G.L. 45.50m)
Del.max= 0.33mm (working pos G.L. 40.00m) Del.min= -3.23mm (working pos G.L. 48.00m)

node No	G.L.	moment kN m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	48.000	----------	0.0	----------	0.0	-3.23	----------
2	47.500	-0.1	-0.1	-0.4	-0.4	-2.85	----------
3	47.000	-0.5	-0.5	-1.5	-1.5	-2.48	----------
4	46.500	-1.7	-1.7	-3.3	-3.3	-2.11	----------
5	46.000	-4.0	-4.0	-5.9	-4.2	-1.74	----------
6	45.500	-6.7	-6.7	-6.7	-3.9	-1.39	----------
7	45.000	-9.2	-9.2	-5.7	-2.1	-1.07	----------
8	44.500	-10.6	-10.6	-3.4	0.3	-0.79	----------
9	44.000	-10.7	-10.7	-0.6	2.0	-0.54	----------
10	43.500	-9.8	-9.8	1.4	3.0	-0.34	----------
11	43.000	-8.4	-8.4	2.8	3.3	-0.18	----------
12	42.930	-8.2	-8.2	3.2	3.6	-0.16	----------
13	42.500	-6.6	-6.6	3.6	3.8	-0.05	----------
14	42.000	-4.7	-4.7	3.8	3.6	0.05	----------
15	41.500	-2.9	-2.9	3.6	3.0	0.13	----------
16	41.000	-1.4	-1.4	3.0	2.0	0.20	----------
17	40.500	-0.4	-0.4	2.0	0.8	0.27	----------
18	40.000	0.0	----------	0.8	----------	0.33	----------



* pre-displacement and loading equivalent to pre-displacement

when strut is effective after next step, a load for pre-displacement is applied.

node No	displacement Del.x mm	release Del.L mm	preceding displacement Del.o mm	bracing spring Ks kN/m	preceding displacement load kN/m
3	-2.48	0.00	-2.48	10525.7	-26.08

where,

Del.x: wall displacement at strut level(->)+)

Del.L: construction release

Del.o: pre-disp(->)+) Del.o=Del.x-Del.L

(2) Completion time

1)analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	48.000		--------	0.00	----------	--------	-4.52	--------
2	47.500		2.21	2.21	----------	--------	-5.16	--------
3	47.000	Strut	4.41	4.41	-26.08	10526	-5.81	35.0
4	46.500		6.62	6.62	----------	--------	-6.44	--------
5	46.000		8.82	8.82	----------	--------	-7.02	--------
6	45.500		11.03	11.03	----------	--------	-7.47	--------
7	45.000		13.23	13.23	----------	--------	-7.77	--------
8	44.500		18.61	18.61	----------	--------	-7.86	--------
9	44.000		23.98	23.98	----------	--------	-7.72	--------
10	43.500		29.35	29.35	----------	--------	-7.35	--------
11	43.000	Pla.zone	34.73	34.73	1.25	331	-6.78	0.0
12	42.930	Pla.zone	34.28	34.28	9.59	2355	-6.68	0.0
13	42.500	Pla.zone	31.54	31.54	21.18	4379	-6.04	0.0
14	42.000	Ela.zone	28.36	28.36	27.63	4710	-5.20	24.5
15	41.500	Ela.zone	25.17	25.17	32.66	4710	-4.32	20.3
16	41.000	Ela.zone	21.98	21.98	37.69	4710	-3.40	16.0
17	40.500	Ela.zone	18.80	18.80	42.71	4710	-2.49	11.7
18	40.000	Ela.zone	15.61	--------	23.24	2355	-1.57	3.7

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

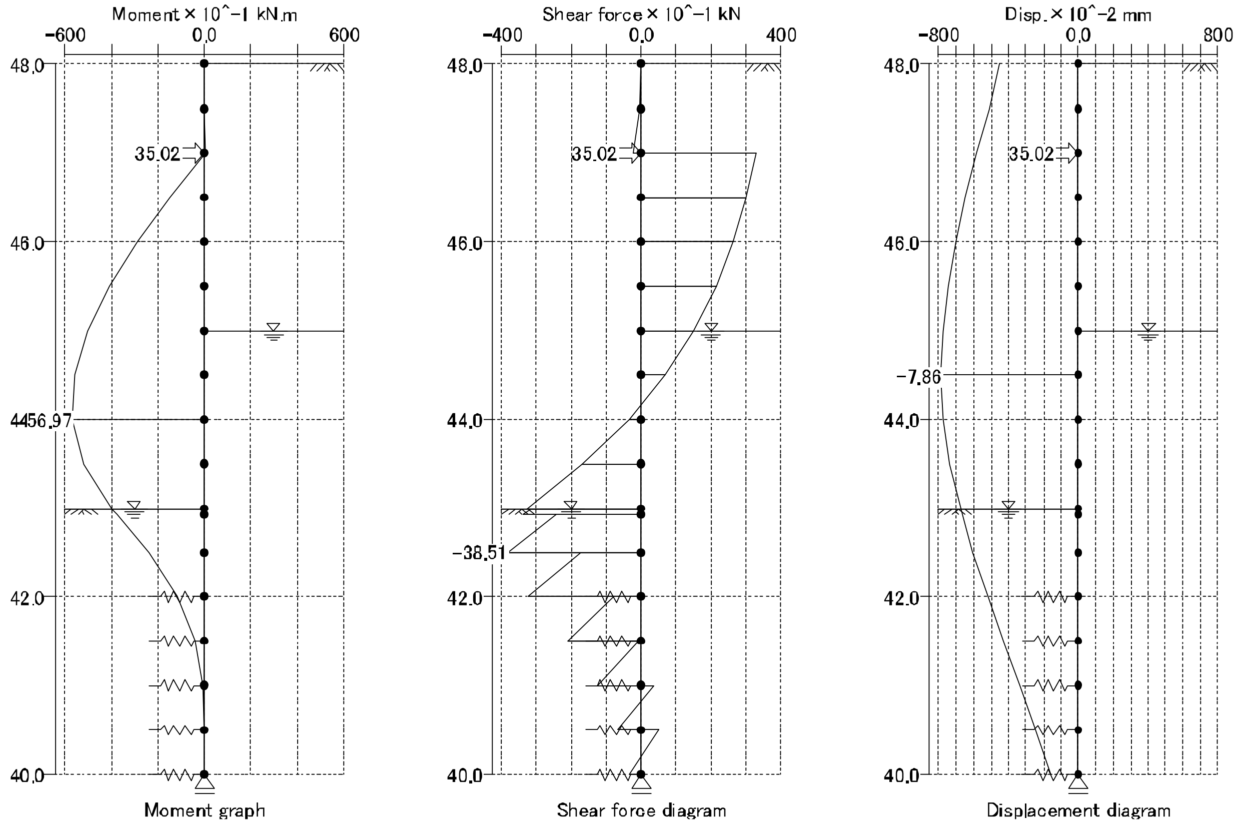
2) Completion time analysis result (member force, displacement)

Mmax = 57.0kN m/m (working pos G.L. 44.00m) Mmin = -0.7kN m/m (working pos G.L. 47.00m)

Smax = 32.8kN/m (working pos G.L. 47.00m) Smin = -38.5kN/m (working pos G.L. 42.50m)

Del.max=-------- mm (working pos G.L.--------m) Del.min= -7.86mm (working pos G.L. 44.50m)

node No	G.L.	moment kN m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	48.000	----------	0.0	----------	0.0	-4.52	----------
2	47.500	-0.1	-0.1	-0.6	-0.6	-5.16	----------
3	47.000	-0.7	-0.7	-2.2	32.8	-5.81	35.0
4	46.500	15.0	15.0	30.1	30.1	-6.44	----------
5	46.000	29.1	29.1	26.2	26.2	-7.02	----------
6	45.500	41.0	41.0	21.2	21.2	-7.47	----------
7	45.000	50.2	50.2	15.2	15.2	-7.77	----------
8	44.500	55.9	55.9	7.2	7.2	-7.86	----------
9	44.000	57.0	57.0	-3.4	-3.4	-7.72	----------
10	43.500	52.0	52.0	-16.8	-16.8	-7.35	----------
11	43.000	39.8	39.8	-32.8	-31.5	-6.78	----------
12	42.930	37.5	37.5	-34.0	-24.4	-6.68	----------
13	42.500	23.9	23.9	-38.5	-17.3	-6.04	----------
14	42.000	11.4	11.4	-32.3	-7.8	-5.20	----------
15	41.500	4.1	4.1	-21.2	-0.8	-4.32	----------
16	41.000	0.7	0.7	-12.6	3.4	-3.40	----------
17	40.500	-0.2	-0.2	-6.8	4.9	-2.49	----------
18	40.000	0.0	----------	-3.7	----------	-1.57	----------



Moment × 10^-1 kN.m
-600
0.0
600
48.0
46.0
44
56.97
42.0
40.0
35.02
Moment graph
Shear force × 10^-1 kN
-400
0.0
400
-38.51
Shear force diagram
Disp. × 10^-2 mm
-800
0.0
800
-7.86
Displacement diagram

3 Bearing capacity

3.1 Bearing capacity

3.1.1 check condition

(1) check method : Temp. Works Guid.H11, Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	40.000
exv bs ps	G.L.(m)	43.000
embd L L	m	3.000

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	323.28	161.64	0.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	14.0	14.0	14.0	2800.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N-val Ni	Li * Ni
1	42.000	40.000	2.000	14.0	28.00
Sig			2.000		28.00

3) circumference friction force(Sig.Li * fi)

* sand : fi= 2BetaNs(note; Ns<=50

* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)

* coefficient of skin friction with construction method: Beta= 1.0

* N value <=2 fi= 0.0 in weak soil

* all friction resistance Sig.Li * fi= 260.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m^2)	skin friction Li* fi (kN/m)
1	3.000	14.0	-----	28.00	84.00
Sig	3.000				84.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m^2)	skin friction Li* fi (kN/m)
1	3.000	6.0	-----	12.00	36.00
2	2.000	14.0	-----	28.00	56.00
3	3.000	14.0	-----	28.00	84.00
Sig	8.000				176.00

4 Bracing, Raker pile calculation

4.1 tie rod design

(1) applied member

using tie rod diameter : tie rod diameterPhi 28.0(mm)* using # n=1

using material : high tension steel 690

allowable tensile stress : Sig.a = 264(N/mm^2)

tie rod installation spacing : L = 1.800(m)

screw part(listed, effective cross sectional area) : M33(A = 694.0mm^2)

(2) tie rod calculation of member force

tie rod tension is calculated with tie rod reaction and spacing using the following equation.

T = Ra* L = 28.10* 1.800 = 50.58(kN/unit)

where,

T : tie rod tension(kN/unit)

Ra: tie rod reaction force(kN/m)

La: tie rod installation interval (m)

(3) tie rod stress calc

tie rod stress should be satisfied the following equation.

$$Sig. = \frac{T* 10^3}{n* A} <= Sig.a$$

where,

Sig. : tie rod stress.(N/mm^2)

Sig.a: allowable tensile stress(N/mm^2)

n : using number

A : using cross sectional area (mm^2)

$$Sig. = \frac{50.58* 10^3}{1* 694.0} = 72.88\ (N/mm^2) <= Sig.a = 264(N/mm^2)...\quad OK$$

4.2 Design of raker pile

4.2.1 Dimensions of a pile

Dimensions of a pile are as follows.

(1) using material

Type : H steel pile(B = 250mm)

Use : H−250×250× 9×14

Dimensions	Unit	Value
Cross sectional area A	cm^2/m	91.43
Moment of inertia I	cm^4/m	10700
Section modulus Z	cm^3/m	860

(2) material

Using material : SS400

Young's modulus : $E = 2.000 * 10^8 (kN/m^2)$

4.2.2 Calculate installation layout

(1) calculate necessary installation distance

Rake pile is placed on actv failure plane starting from virtual support point and pssv failure plane starting from 1.00/Beta of depth below tie rod intersect above the location of tie rod.

In this, actv and pssv failure planes intersect at tie rod depth is called a req inst distance.

1) active failure plane

Act. fail. plane on back side starting from a sup. pointed of a rt wl (GL41.929m) is described.

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	actv failure agl zetaa(Deg.) = 45+Phi/2	failure line width Ldi(m) = hi* cotzetaa
2	45.000	41.929	3.071	25.00	57.50	1.957
1	47.000	45.000	2.000	25.00	57.50	1.274
Si.			5.071			3.231

2) passive failure plane

Passive failure on back side starting from the position 1.00/Beta below rake pile tie rod is.

$$\text{Starting position of raker pile} = \text{tie rod position of raker pile} - \frac{1.00}{\text{Beta}}$$

$$= \text{G.L.}47.000 - \frac{1.00}{0.545842} = \text{G.L.}45.168(m)$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	int fric agl Phi (Deg.)	pssv failure agl zetap(Deg.) = 45-Phi/2	failure line width Ldi(m) = hi* cotzetap
1	47.000	45.168	1.832	25.00	32.50	2.876
Si.			1.832			2.876

3) required installation distance

Required installation distance Ldmin is given as following equation.

Ldmin = Sig.hi* cotzetaa + Sig.hi* cotzetap =3.231 +2.876 =6.107(m)

(2) installation position of raker pile

From above, raker pile is installed Ld =6.107(m) on backside.

Ld =6.500(m) =>Ldmin =6.107(m)... It is safe.

(3) calculate a characteristic value Beta to determine required installation position.

Beta at raker pile instl at distance from req instl distance Ldmin = 6.107(m) from rt wl is given.

1) calculate characteristic value Beta

Characteristic value Beta is calculated using the following equation.

$$\text{Beta} = \sqrt[4]{\frac{kH * B}{4EI\,Alp.}} = \sqrt[4]{\frac{30423.0 * 250.0 * 10^{-3}}{4 * 2.000 * 10^{8} * 10700 * 10^{-8} * 1.000}} = 0.545842(m^{-1})$$

where,

Horizontal subgrade reaction coefficient kH = $30423.0 (kN/m^3)$

width of raker pile B = $250.0 * 10^{-3} (m)$

B is flange WB in case of H steel, or [1.00] times of pile diameter in case of st pipe pile.

Young's modulus E = $2.000 * 10^8 (kN/m^2)$

Moment of inertia of area I = $10700 * 10^{-8} (m^4)$

effective rate(for embedment calculation) Alp. = 1.000

2) calculation of horizontal subgrade reaction coefficient

H-subgrade reaction coefficient is an average value within 1/Beta= 47.000(m) from G.L.1.832(m) using the following equation.

$$kH = EtakHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta :coefficient regarding to wall type (1.00 in case of raker pile)

kHo: H-subgrade reaction coefficient equi to plate bear test result by stiffness round plate of 30cm diameter

$$kHo = \left(\frac{1}{0.3}\right)Alp.Eo$$

where,

Eo: ground modulus of deformation(kN/m^2)

Alp.: coefficient to calculate subgrade reaction coefficent

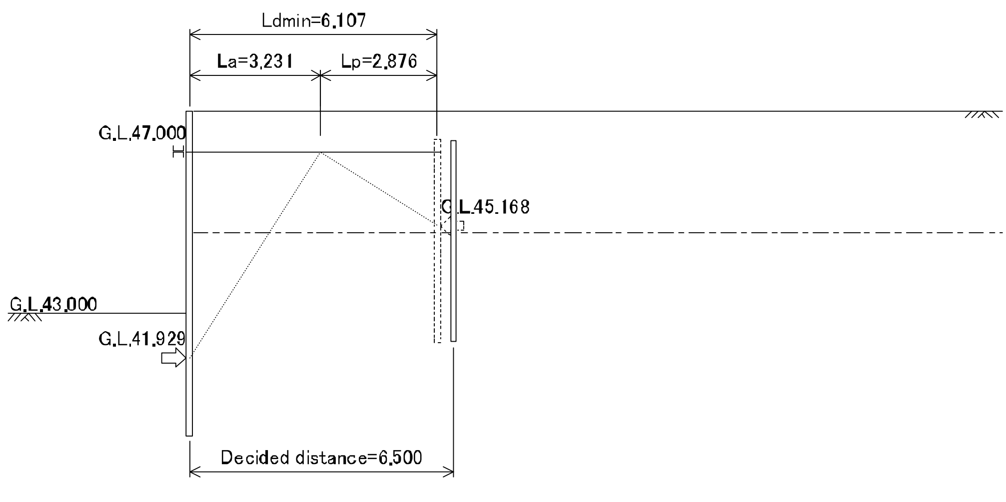
BH: conversion width of load is calculated using the following equation.

$$BH = \sqrt{\frac{D}{Beta}} = \sqrt{\frac{250*10^{-3}}{0.545842}} = 0.6768(m)$$

where, D is flange WB in case of H steel pile, or a pile diameter D of steel pipe pile.

$$\text{Average kH within the range of } \frac{1}{Beta} = \frac{Sig.kH*h}{Sig.h} = \frac{55736}{1.832} = 30423.0\ (kN/m^3)$$

No	upper G.L.(m)	bottom G.L.(m)	thk h (m)	Alp.Eo kN/m^2	kHo kN/m^3	kH kN/m^3	kH*h kN/m^2
1	47.000	45.168	1.832	16800	56000	30423	55736
Si.			1.832				55736



4.2.3 calculate embedment length

(1)length of raker pile

Pile L to include embd L req from the calc as an infinite pile on elastic grnd as described below.

$$D = \text{Safety coefficient}\frac{}{Beta} = \frac{2.50}{0.545842} = 4.580(m) <= \text{real embedment length} = 4.700(m) ...\quad OK$$

raker pile head EL rake pile tie rod position EL raker pile design ground level		(G.L. 47.300)m (G.L. 47.000)m (G.L. 47.000)m
required embedment length	safety coeff chra Beta(m^{-1}) D= safety coeff/Beta	2.50 0.545842 4.580(G.L. 42.420)m
final embedment length	real length (m)	4.700(G.L. 42.300)m
	judgement	OK
final total length		5.000m

(2)calculate Beta at raker pile installed position

It follows the result of Beta=0.545842(m^{-1}) obtained in calculating a necessary distance.

4.2.4 calculation of member force

(1)calculation of member force

1)maximum bending moment

$$Mmax = 0.3224\frac{H}{Beta} = 0.3224*\frac{50.58}{0.545842} = 29.87$$

where,

H:horizontal force acting on a raker pile

tension frc per single tie rod is given as H = Ra* L* secTheta (Theta: tie rod inc agl).

2)location of maximum bending moment induced (lower than design ground level)

$$Lm = \frac{Pi}{4Beta} = \frac{Pi}{4*\ 0.545842} = 1.439$$

Summery of member force calculation is shown in the table below.

characteristic value	Beta	m^{-1}	0.545842
induced force	horizontal force H height(from design GL) h	kN/M m	50.58 0.000
maximum bending moment	moment Mmax location(from design GL)	kN.m/M m	29.87 1.439(G.L. 45.561)m
shear force	shear force Smax location(from design GL)	kN/M m	50.58 0.000(G.L. 47.000)m

(2)calculation of Beta

It is the same Beta as the result of calculating embedment length.

(3)calculation of displacement

Displacement at the location of tie rod must be satisfied the following equation.

$$Del. = \frac{H}{2EIAlp.Beta^3} <= Del.a$$

where,

characteristic value Beta Young's modulus E moment of inertia I eff ratio (for moment of inertia) Alp.	m^{-1} $* 10^8$ kN/m^2 $* 10^{-8}m^4$/M -----	0.545842 2.000 10700 1.000
Horizontal force H height (from design GL) h	kN/M m(G.L.m)	50.58 0.000(G.L. 47.000)m
allowable displacement Del.a	m	0.300

$$Del. = \frac{H}{2EIAlp.Beta^3} = \frac{50.58}{2*\ 2.000*\ 10^8*\ 10700*\ 10^{-8}*\ 1.000*\ 0.545842^3}$$

Del. =0.007(m) <=Del.a=0.300(m)... OK

4.2.5 stresses of raker pile

(1)using section

type : H-steel pile

use : H-250×250×9×14

using material : SS400

dimensions	unit	value
section height Hf	(mm)	250
web thickness t1	(mm)	9
flange thickness t2	(mm)	14
section modulus Z	* 10^3(mm^3)	860
crs sectional area A	* 10^2(mm^2)	91.43

(2) design member force

design member forces are shown in the following table.

moment M * 10^6(N.mm)	axial force N * 10^3(N)	shear force S * 10^3(N)
29.87	0.00	50.58

(3) bending stress

bending stress must satisfy the following equation.

$$Sig. = \frac{M}{Z} + \frac{N}{A} <= Sig.ba$$

where,

Sig. : bending stress(N/mm^2)

Sig.ba : allowable bending stress(N/mm^2)

L= 4.700* 10^3(mm) (L is a length from tie rod position to raker pile tip.)

b= 250 (mm) (b is flange width)

from 4.5< L/b<=30

$$Sig.ba=Sig.a-3.6\left(\frac{L}{b}-4.5\right)=210-3.6\left(\frac{4.700*10^3}{250}-4.5\right)=158(N/mm^2)$$

z : using section modulus

A : using cross sectional area

$$Sig. = \frac{29.87*10^6}{860.0*10^3} + \frac{0.00*10^3}{91.43*10^2} = 34.74\ (N/mm^2) <= Sig.ba=158(N/mm^2)...\quad OK$$

(4) shear stress

shear stress must satisfy the following equation.

$$Tau = \frac{S}{Aw} <= Taua$$

where,

Tau : shear stress(N/mm^2)

Taua : allowable shear stress(N/mm^2)

Aw : using web section area(mm^2) (hf-2* t2)* t1

$$Tau = \frac{50.58*10^3}{1998} = 25.32\ (N/mm^2) <= Taua=120(N/mm^2)...\quad OK$$

4.3 waling design

(1) applied member

use : [200×80×7.5×11

using material : SS400

allowable bending stress : Sig.a = 145.2(N/mm^2)

(2) moment calculation

moment working on waling is calculated using the following equation.

$$M = \frac{T*L}{10} = \frac{50.58*1.800}{10} = 9.10(kN.m/m)$$

where,

M BM (kN m/m)

T: tie rod tension(kN/unit)

L: tie rod installation spacing (m)

(3) stress

waling stress should be satisfied the following equation.

$$Sig. = \frac{M^* 10^6}{Z^* 10^3} <= Sig.a$$

where,

Sig. : waling stress(N/mm²)

Sig.a: allowable bending stress(N/mm²)

4.5< L/b<=30, Sig.a=[140- 2.4(L/b- 4.5)]* 1.5 (N/mm²)

=[140- 2.4(1.800/0.080- 4.5)]* 1.5=145.2(N/mm²)

M : BM (kN m/m)

Z : sct modulus (= 195* 2cm³) *two makes one set, double of registered steel sct modulus.

$$Sig. = \frac{9.10^* 10^6}{390^* 10^3} = 23.34(N/mm^2) <= Sig.a = 145.2(N/mm^2) \ldots \quad OK$$

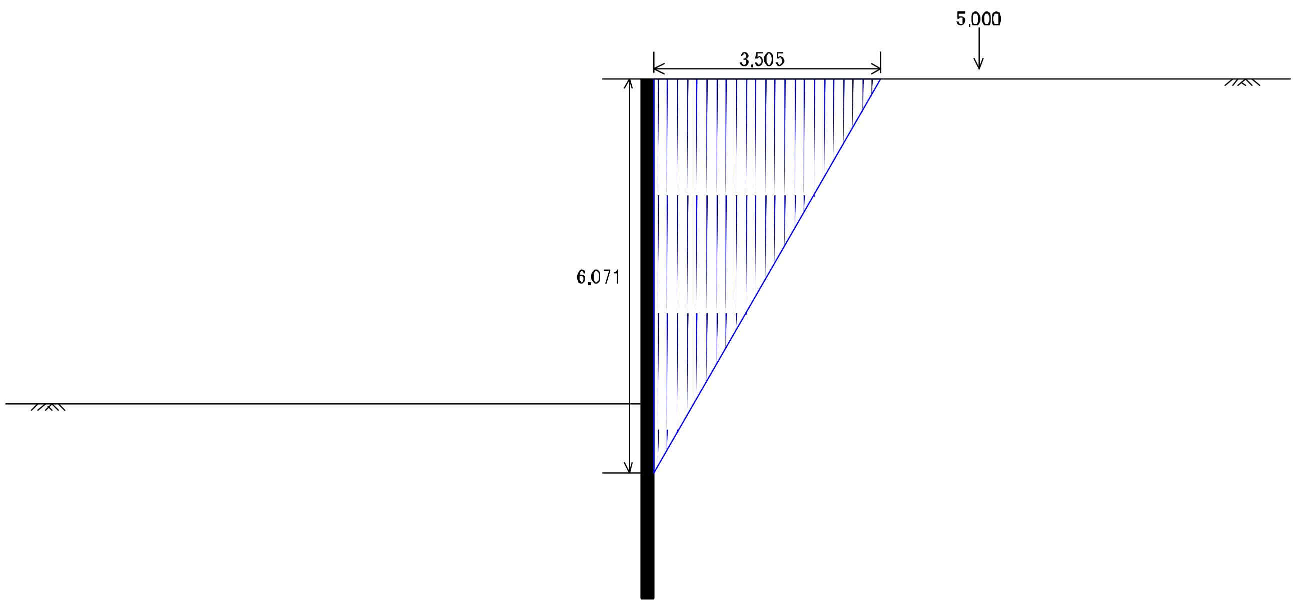
5 influence on surrounding ground

5.1 judgement on adjacent distance

(1) check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	48.000
excavation	G.L.(m)	43.000
virtual support point	G.L.(m)	41.929



(2) judgement on adjacent distance

1) influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{6.071}{\tan\left(45 + \frac{30.00}{2}\right)} = 3.505 \text{ (m)}$$

where,

Lxa: influence range on ground deformation by temporary works dy : depth up to virtual support point of retaining wall

Phi: soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2)judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

Cover

(6) Abo Gabal & Saheylia Canal

I Design condition

1.1 fundamental data

file : AboGabal 1

title:

comment:

bracing type　　Strut bracing

wall type　　Steel sheet pile

type　　Normal

applied standard- conventional method　road earthwork manual - temporary structure construction guideline

- elasto-plastic method Road earthwork manual - temporary structure construction guideline H11/3

Exca.w method:　Wall inside-inside distance

plane shape type	Straight line
excavation width B (m) excavation length Le (m)	2.044 12.000

influence of water table	w/Do
base water table(before excavation) G.L.(m)	46.000

erection planning

final excavation depth　　G.L.　44.000(m)

excavaion for installation strut　　0.500(m)

removal check　　check Not do

bracing No.	bracing depth G.L. m
1	46.500

strut layout

layout #　　6#

layout spacing　　2.000(m)

1.2 shape

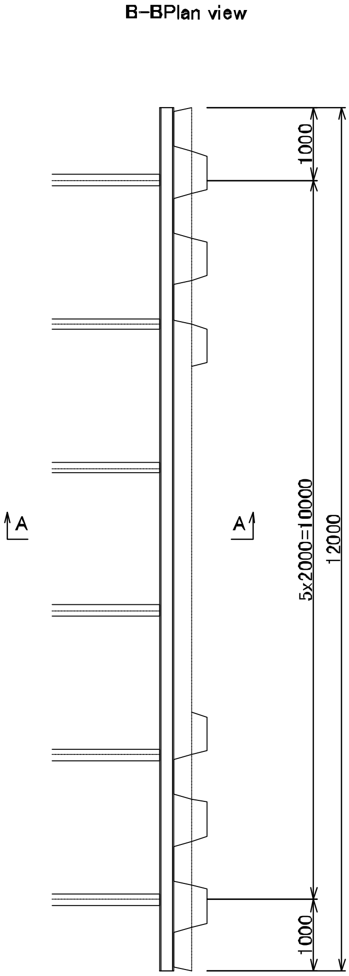
Design wall　right wall

1 th plane shape (strut bracing)

strut

方向 direction	interval mm
wall- 1	1000
1- 2	2000
2- 3	2000
3- 4	2000
4- 5	2000
5- 6	2000
6- wall	1000

plan

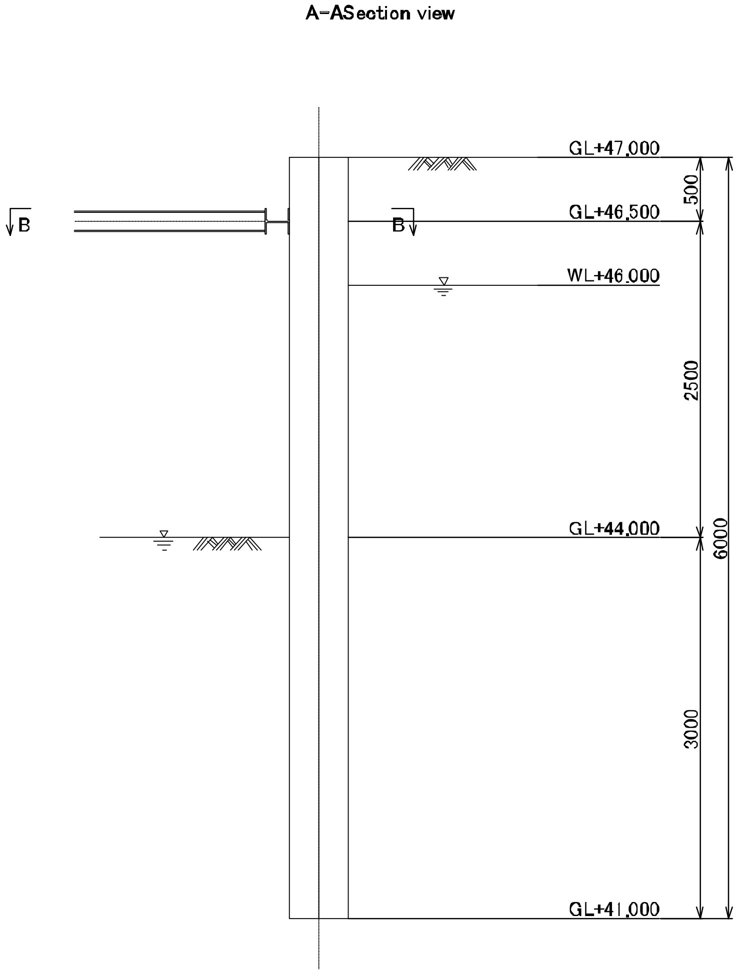


side section shape

	top of wall G.L. m	ground level G.L. m
Right wall	47.000	47.000

Side view

* left-right direction



1.3 method

checking item

bearing capacity check check Do

excavation bottom stability check check Do

surcharge by slope influence check check Not do

bracing design check Do

material SS400

influence on surrounding ground check check Do

Length round up value 0.5m

description of conventional method

water pressure distribution triangle

calculation of bracing reaction force case Final excavation and removal

Horizontal modulus of subgrade reaction for self-standing Chang's equation Internal calculation

Horizontal modulus of subgrade reaction for retaining wall stiffness check Internal calculation

consider rock layer not do

elasto-plastic method concept
wall section change : not do
elastic portion rate : do
steady state check : not do
allowable displacement check : not do
analysis method : Analysis method 1
calculaion pitch : 0.50(m)
using elasto-plastic lateral pressure, embedment stability check when excavation: Consider S.F. of equi. len.
shape spring input method considered
H subgrade reaction force calculation, shape dependant conversion width of load BH 10.000(m)
top of wall support condition Free
top of wall support condition Free
bracing combination condition(single wall analysis) rotation constrained No
strut release coefficient 1.0

for elasto-plastic method, lateral pressure
all Standard common
soil thickness above underground structure pressure: soil unit weight under ground water(Gamma - $Gamma_w$)
excavation side, cnf ground water pressure(sandy lyr between clay lyrs) WT considered: After excavation
correction method when clay bottom water pressure exceeds cover pressure: Not correction

1.4 Layer

* right wall

. Natural ground

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m³	water unit wt Gamma' kN/m³	int fric agl Phi Deg	coh Co kN/m²	coh inc K kN/m²	dfrm modul Alp.Eo kN/m²
1	1.000	Sandy	3.0	18.0	9.0	10.00	10.0	0.0	8400
2	2.000	Sandy	25.0	18.0	9.0	20.00	10.0	0.0	70000
3	2.000	Sandy	23.0	18.0	9.0	20.00	10.0	0.0	64400
4	2.000	Sandy	5.0	18.0	9.0	10.00	10.0	0.0	14000
5	1.000	Sandy	17.0	18.0	9.0	20.00	10.0	0.0	47600
6	1.000	Sandy	19.0	18.0	9.0	20.00	10.0	0.0	53200
7	1.000	Sandy	19.0	18.0	9.0	20.00	10.0	0.0	53200
8	1.000	Sandy	42.0	18.0	9.0	30.00	10.0	0.0	117600
9	1.000	Sandy	49.0	18.0	9.0	30.00	10.0	0.0	137200
10	1.000	Sandy	59.0	18.0	9.0	30.00	10.0	0.0	165200
11	1.000	Sandy	24.0	18.0	9.0	30.00	10.0	0.0	67200
12	1.000	Sandy	38.0	18.0	9.0	30.00	10.0	0.0	106400

. Excavated side

No	thk m	soil type	ave N val	Soil wet unit wt Gamma kN/m^3	water unit wt Gamma' kN/m^3	int fric agl Phi Deg	coh Co kN/m^2	coh inc K kN/m^2	dfrm modul Alp.Eo kN/m^2
1	1.000	Sandy	3.0	18.0	9.0	10.00	10.0	0.0	8400
2	2.000	Sandy	25.0	18.0	9.0	20.00	10.0	0.0	70000
3	2.000	Sandy	23.0	18.0	9.0	20.00	10.0	0.0	64400
4	2.000	Sandy	5.0	18.0	9.0	10.00	10.0	0.0	14000
5	1.000	Sandy	17.0	18.0	9.0	20.00	10.0	0.0	47600
6	1.000	Sandy	19.0	18.0	9.0	20.00	10.0	0.0	53200
7	1.000	Sandy	19.0	18.0	9.0	20.00	10.0	0.0	53200
8	1.000	Sandy	42.0	18.0	9.0	30.00	10.0	0.0	117600
9	1.000	Sandy	49.0	18.0	9.0	30.00	10.0	0.0	137200
10	1.000	Sandy	59.0	18.0	9.0	30.00	10.0	0.0	165200
11	1.000	Sandy	24.0	18.0	9.0	30.00	10.0	0.0	67200
12	1.000	Sandy	38.0	18.0	9.0	30.00	10.0	0.0	106400

1.5 member

wall(steel sheet pile)

material

steel sheet pile material SY295

allowable bending stress 270(N/mm^2)

allowable shear stress 150(N/mm^2)

Young's modulus 2.00* 10^5(N/mm^2)

steel sheet pile effective rate Alpha

for embedment calculation, Beta calculation(conventional method) 1.00

for member force , dispcalc, Beta calculation(conventional method) 0.45

for moment of inertia(displacement calculation, member force) 0.45

section modulus (stress) 0.60

use

	use name	vertical load kN/m
Right wall	PU28+	10.00

waling material

material

material SS400

allowable bending stress Sig.a 210(N/mm^2)

allowable stress for buckling Sig.cal 210(N/mm^2)

allowable shear stress Taua 120(N/mm^2)

design concept

temperature axial force Nt 150(kN)

bending applied in plane buckling check do

bending applied out plane buckling check do (Buckling span in inner-plane)

bending span calculation method Temporary structure construction guideline

height of spacing Hk 10(mm)

applied member

* left-right direction

BM calculation eq: (1/8)wL^2

bracing No	depth G.L. m	steel name	fold	layer
1	46.500	H-200×200× 8×12	1	1

strut material

material

material SS400

allowable bending stress Sig.a 210(N/mm²)

allowabel stress for buckling Sig.cal 210(N/mm²)

Young's modulus 2.00* 10^5(N/mm²)

design method

temperature axial force Nt 150(kN)

vertical load w 5.00(kN/m)

bending applied in plane buckling check do

bending applied out plane buckling check do

applied member

* left-riht direction

bracing No	depth G.L. m	steel name	layer
1	46.500	H-150×150× 7×10	1

bracing No	bracing spring tension charac.	bracing pre load Conside	bracing pre loaded kN/m	cstrc losnes mm	bracing H spc m	H sprg dirct inp Yes/no	H sprg const kN/m/m
1	Yes	Not do	0.01	0	2.000	No	----------

1.6 Load

vertical load applies on retaining wall

	vertical load kN/m
Right wall	10.00

1.7 check case

check case in excavation

No	construction condition	bracing No	case name	exv surf G.L. m	exv WT G.L. m	simplified method
1	Ex sf-stnd	--	Primary excavation	46.000	46.000	none
2	Final Exc.	1	Final excavation	44.000	44.000	Yes

* right wall

No	WT G.L.	surcharge kN/m²		virt sprt pt G.L. m
	natrl grnd	natrl grnd	exv	
1	46.000	10.00	0.00	int calc
2	46.000	10.00	0.00	int calc

1.8 bearing capacity

check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

wall	construction method	allw bear cap FS	good soil assumed N lower limit	maximum skin friction of cohesive soil
Right wall	Percussion method	2.0	5	Use cohesive

Note:Construction method.

Auger combined press-fit(1)...sand filing

Auger combined press-fit(2)...tip processed by striking-vibrating-press fit

Note:For soft layer(N<=2), skin fiction is ignored.

1.9 stability of excavation bottom

boiling

check method : Terzaghi

wall	req FS
Right wall	1.2

piping

wall	deduction gravel length on natural ground L(m)
Right wall	0.000

heaving

check method : Load Balance method

wall	from exc surf to aquiclude top h1	aquiclude thk h2 m	cnf wtr hd Hw m	req FS Fs
Right wall	0.000	0.001	0.001	1.1

1.10 influence on surrounding ground check

common setting

check objective wall :right wall

check case :final excavation

check depth

check point No	distance from wall (m)
1	5.000

allowable displacement qt

allowable Horizontal displacement qt:[0.020](m)

allowable Vertical displacement qt:[0.020](m)

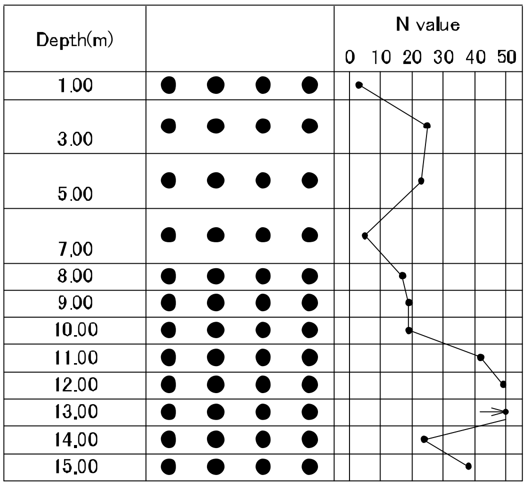
allowable inclination angle :[0.001](rad) judgement on adjacent distance

judgement method : derived from deflection(sand ground)

properties for judgement : Phi=[30.00] deg.

1.11 boring log

* 石礫



1.12 Design strength

1.12.1 Set value for design

(1) Simplified method

[Standard: Temporary structure construction guideline(H11)]

considered Do 0.3Gam h criteria for active earth pressure clay to calculate embedment length

considered. Not do same height to surcharge ld for excavation depth when coeff is calc for excavation depth

self-standing required embedment estimate coefficient : 2.50/Beta

min embedment criteria : Based on design strength

soldier pile

Take 1.00 times of pile width when Beta is calculated.

eth prss ld W under exv btm and side result: Temporary structure construction guideline, Metro.express.H19

bracing reaction force

when excavation: Downward shared method

when removal: Temp. Works Guid.Metro. express.H19

tie rod reaction force: Overhang beam divide method

raker pile

take 1.00 times of pile width for straight pile Beta calculation

coefficient is 2.50/Beta to estimate required embedment length

initiation point of passive slip surface is 1.00/Beta

(2) Earth pressure for section calculation

[Standard: Temp. Works Guid., Metro. express.H19, Std.Dsgn.Spec.Vol.2(H18), Land impro. wall(H5)]

sand 2.000

clay

constituency of clay judgement Nvalue Nx 5.000

soft clay N<=Nx 6.000

stiff clay N> Nx 4.000

(3) Raker pile earth press coefficient of load width

[Standard: Temporary structure construction guideline, Metro. express. H19]

sandy soil	N<=10 10< N<=30 30< N	1.000 2.000 2.000
cohesive soil	N<=4 4< N<=8 8< N	1.000 1.000 1.000
treatment other than passive earth pressure		= pssv eth prss
side resistance of passive earth pressure		consider: Do

(4) Minimum Embedment depth

[Continuous wall]

self-standing 3.00(m)

when excavation with strut 3.00(m)

[Soldier pile]

self-standing 1.50(m)

when excavation with strut 1.50(m)

(5) Safety factor

required embedment length from equilibrium, checking factor of safety Fs 1.20

conventional method

wall self-standing allowable displacement

wall self-standing allowable displacement is 3.0% of excavation depth

allowable displacement when checking stiffness 0.300(m)

raker pile allowable displacement 0.300(m)

elasto-plastic

required elastic region ratio 50.0(%)

(6) Water weight

water unit weight

For static water pressure(soil pressure and water pressure calculation) 10.00(kN/m^3)

Other than static water pressure(excavation bottom stability) 10.00(kN/m^3)

(7) Bearing capacity coefficient

[Standard: Temp. Works Guid. H11, Metro. express. H19, Std. Dsgn. Spec. Vol. 2(H18)]

coefficient by Construction method

construction method	Alp.	Beta
percussion driving method vibration method prss in pre-boring method(sand filling) pre-boring method(percussion, vibration, prss tip embedment) auger prss method (sad filling) auger prss method(percussion, vibration, prss tip embedment)	1.0 1.0 1.0 0.0 1.0 0.0 1.0	1.0 0.9 1.0 0.5 1.0 0.5 1.0

steel pipe pile retaining wall: maximum skin friction upper limit

construction method	sand	cohesive
percussion driving method, vibration method kN/m^2	100	150
drill and prss casting method kN/m^2	50	100

continuous underground wall: maximum skin friction upper limit

	sand	cohesive
maximum skin friction upper limit kN/m^2	200	150

(8) Analysis the effect to surrounding soil

simply prediction method; maximum settlement prediction diagram table

turning point No	I: hard line		II: middle, soft line	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.33	0.00	2.00
(2)	0.35	0.40	0.70	0.80
(3)	3.00	0.00	3.00	0.00

I : embedment tip ground strength = hard line

II: embedment tip ground strength = middle, soft line

x-ax: relative stiffness zeta(10^6kN m^2/m)

y-ax: surrounding ground max settlement /excavation depth (%)

max settlement predicition table

turning point No	I: 30.0m under		II: 30.0m over	
	x-ax	y-ax	x-ax	y-ax
(1)	0.00	1.85	0.00	3.50
(2)	0.50	0.25	0.95	0.58
(3)	3.00	0.00	3.00	0.00

I : presumed line for excavation width under 30m

II: presumed line for excavation width over 30m

x-ax: equivalent stiffness xi(10^6kN m^2/m)

y-ax: maximum settlement location surrounding ground /excavation depth

II Calculation results

1 Simplified method

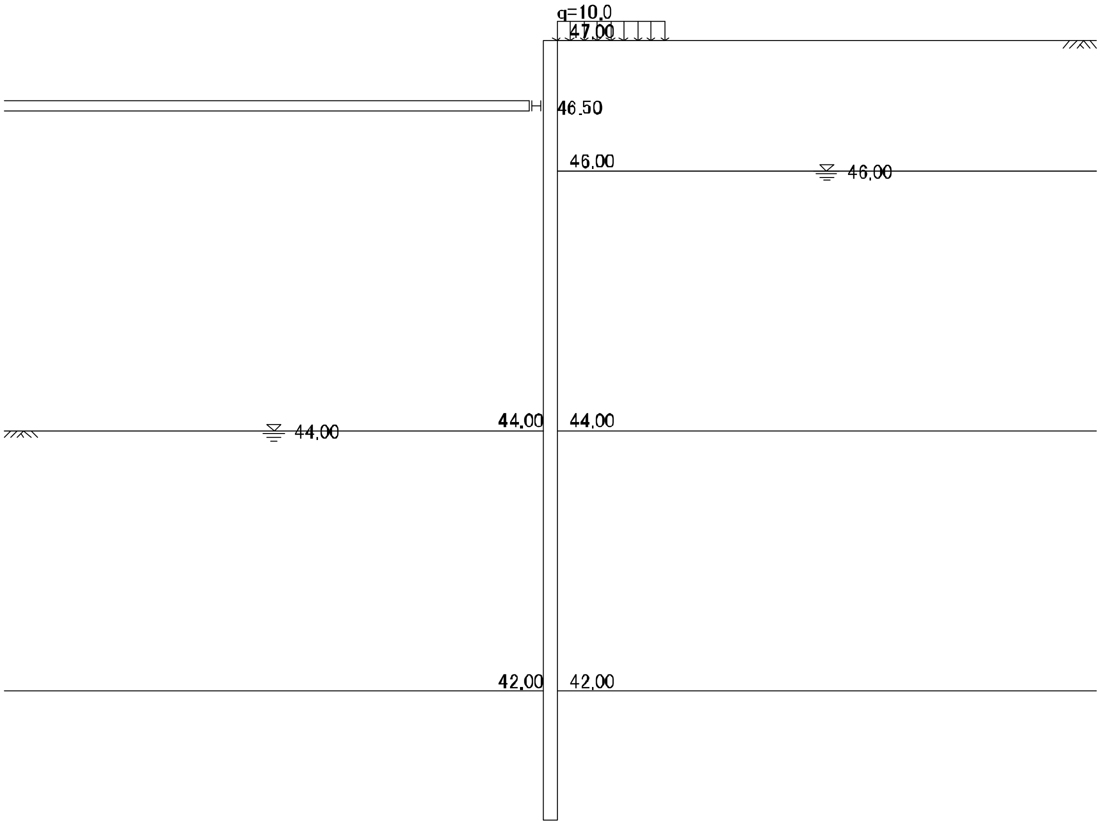
1.1 Right wall design

1.1.1 final excavation

(1) check condition

state : Final excavated time

case name: final excavation



1) check condition

natural ground surface	G.L.(m)	47.000
excavation	G.L.(m)	44.000
lowest strut	G.L.(m)	46.500
water table at natural ground	G.L.(m)	46.000
water table at excavation	G.L.(m)	44.000
surcharge at natural ground q	kN/m^2	10.00
surcharge at excavation q	kN/m^2	0.00

2) ground condition

* natural ground

No	elevation upper G.L.(m)	elevation bottom G.L.(m)	ground type	soil N val	soil unit weight wet wt (kN/m³)	soil unit weight sbmg wt (kN/m³)	internal fric agl (deg.)	wall fric agl (deg.)
1	47.000	46.000	Sandy	3.0	18.0	9.0	10.0	5.0
2	46.000	44.000	Sandy	25.0	18.0	9.0	20.0	10.0
3	44.000	42.000	Sandy	23.0	18.0	9.0	20.0	10.0
4	42.000	40.000	Sandy	5.0	18.0	9.0	10.0	5.0
5	40.000	39.000	Sandy	17.0	18.0	9.0	20.0	10.0
6	39.000	38.000	Sandy	19.0	18.0	9.0	20.0	10.0
7	38.000	37.000	Sandy	19.0	18.0	9.0	20.0	10.0
8	37.000	36.000	Sandy	42.0	18.0	9.0	30.0	15.0
9	36.000	35.000	Sandy	49.0	18.0	9.0	30.0	15.0
10	35.000	34.000	Sandy	59.0	18.0	9.0	30.0	15.0
11	34.000	33.000	Sandy	24.0	18.0	9.0	30.0	15.0
12	33.000	32.000	Sandy	38.0	18.0	9.0	30.0	15.0

No	cohesion Co (kN/m²)	cohesion inc k (kN/m³)	cohesion base G.L.(m)	unc cmpr strg qu (kN/m²)	dfrm modul Alp.Eo (kN/m²)
1	10.0	0.0	47.000	20.0	8400
2	10.0	0.0	46.000	20.0	70000
3	10.0	0.0	44.000	20.0	64400
4	10.0	0.0	42.000	20.0	14000
5	10.0	0.0	40.000	20.0	47600
6	10.0	0.0	39.000	20.0	53200
7	10.0	0.0	38.000	20.0	53200
8	10.0	0.0	37.000	20.0	117600
9	10.0	0.0	36.000	20.0	137200
10	10.0	0.0	35.000	20.0	165200
11	10.0	0.0	34.000	20.0	67200
12	10.0	0.0	33.000	20.0	106400

* excavation side

No	elevation upper G.L.(m)	elevation bottom G.L.(m)	ground type	ave N val	soil unit weight wet wt (kN/m³)	soil unit weight sbmg wt (kN/m³)	internal fric agl (deg.)	wall fric agl (deg.)
1	44.000	42.000	Sandy	23.0	18.0	9.0	20.0	10.0
2	42.000	40.000	Sandy	5.0	18.0	9.0	10.0	5.0
3	40.000	39.000	Sandy	17.0	18.0	9.0	20.0	10.0
4	39.000	38.000	Sandy	19.0	18.0	9.0	20.0	10.0
5	38.000	37.000	Sandy	19.0	18.0	9.0	20.0	10.0
6	37.000	36.000	Sandy	42.0	18.0	9.0	30.0	15.0
7	36.000	35.000	Sandy	49.0	18.0	9.0	30.0	15.0
8	35.000	34.000	Sandy	59.0	18.0	9.0	30.0	15.0
9	34.000	33.000	Sandy	24.0	18.0	9.0	30.0	15.0
10	33.000	32.000	Sandy	38.0	18.0	9.0	30.0	15.0

No	cohesion Co (kN/m²)	inc k (kN/m³)	base G.L.(m)	unc cmpr strg qu (kN/m²)	dfrm modul Alp. Eo (kN/m²)
1	10.0	0.0	44.000	20.0	64400
2	10.0	0.0	42.000	20.0	14000
3	10.0	0.0	40.000	20.0	47600
4	10.0	0.0	39.000	20.0	53200
5	10.0	0.0	38.000	20.0	53200
6	10.0	0.0	37.000	20.0	117600
7	10.0	0.0	36.000	20.0	137200
8	10.0	0.0	35.000	20.0	165200
9	10.0	0.0	34.000	20.0	67200
10	10.0	0.0	33.000	20.0	106400

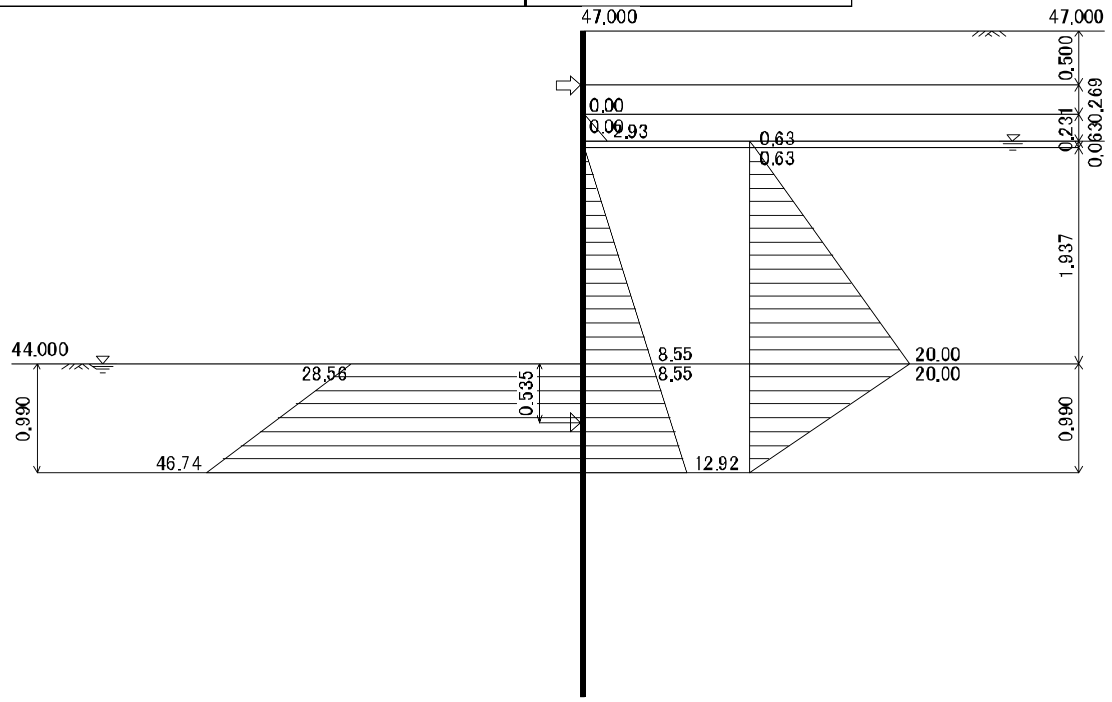
(2) embedment length calculation

1) result summery

case name: final excavation

analysis method : embedment length is calculated from moment balance at lowest strut

excavation depth		(G.L. 44.000)m
req embd L	safety factor F	1.200
	balance depth Z(m)	0.990(G.L. 43.010)m
	required embedment length D(m)	1.188(G.L. 42.812)m
	virtual support point depth Y(m)	0.535(G.L. 43.465)m
minimum embedment length (m)		3.000(G.L. 41.000)m
final embd L	final embedment length L (m)	3.000(G.L. 41.000)m
	judge	OK
final all length		6.000m



* sum of external forces at the balanced depth (G.L. 43.010)m

item	moment		horizontal force	
Active side Compre.side	Ma+Mw(kN.m/ m) Mp(kN.m/m)	112.37 113.12	Pa(kN/m) Pp(kN/m)	49.15 37.27
ratio(Mp/(Ma+ Mw))			1.0	
virtual support point depth (Y) m			0.535	

Mp is a moment at lowest strut, so assumed bearing depth Y is modified by the next equation.
virtual support point depth (Y) = Mp/Pp- (lowest strut place - excavation base).

(3)calculation of member force

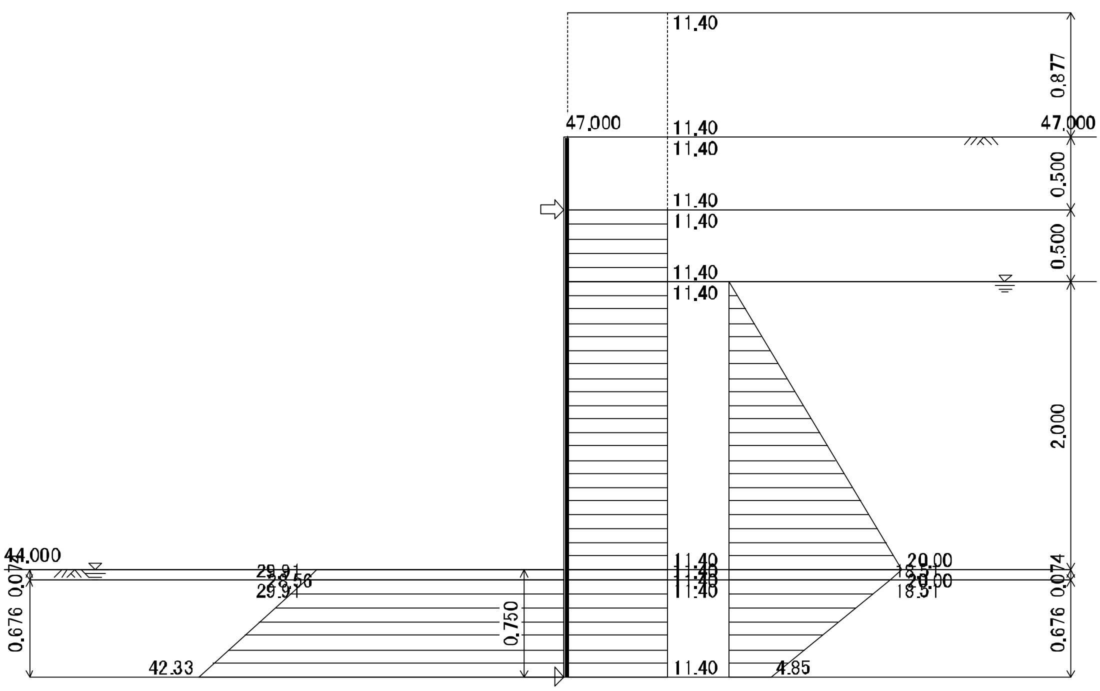
1)result summery

case name: final excavation

analysis method : check as a simple beam with a span between strut and virtual support point.

top of wall ground surface excavation soil average unit weight Gam surcharge q/Gam		G.L.m G.L.m G.L.m kN/m³ m	(G.L. 47.000)m (G.L. 47.000)m (G.L. 44.000)m 11.40 0.877(G.L. 47.877)m
excavation depth coefficient a	excavation depth H surcharge q/Gam calc excavation depth H' H' coefficient a	m ------ m ------	3.000 No 3.000 0.500
geology coefficient b	grand type bottom for grand type geology coefficient b	------ m ------	Sandy soil 3.750(G.L. 43.250)m 2.000
earth pressure p= a* b* Gam		kN/m²	11.40

*bottom for grand type = virtual support point



* single span supported at lowest strut and virtual support point

virtual support point is corrected 0.535(m) to 0.750(m) from embedment length calculation.

lowest strut depth		m	(G.L. 46.500)m
virtual support point depth		m	(G.L. 43.250)m
simple beam span		m	3.250
max bending moment	moment Mmax	kN.m/m	25.32
	depth(from strut)	m	1.687(G.L. 44.813)m
shear force	shear force Smax	kN/m	26.28
	depth(from strut)	m	0.000(G.L. 46.500)m
reaction	upper reaction force RA	kN/m	26.28
	lower reaction force RB	kN/m	22.33
*max displacement	displacement Del.max	m	0.0004
	depth(from strut)	m	1.462(G.L. 45.038)m

*reference value

3)retaining wall stiffness check

nevertheless wall stress has allowance, not to deform retaining wall within a certain level, checking enough stiffness assured. so displacement must be satisfied the following equation.

Del.= Del.1+ Del.2<=Del.a

where,

Del. : total retaining wall displacement

Del.1: maximum displacement calculated as a simple beam

$$Del.1 = \frac{5*w*L^4}{384*EI\,Alp.}$$

Del.2: influence displacement at elastic support

Del.2' = R/K

Del.2 = Del.2' /2

Del.a: allowable displacement

calculating model is SS beam at top strut and an elastic support of half of embeded depth, load is taken earth pressure for section check and water pressure throughout a span.

if a ld has trapezoidal dstr, convert to an conversion uniform dstr ld with the same intensity.

rigid support level (top strut)		G.L.(m)	46.500
virtual support point depth Y		m	0.750
1/2 of virtual support point depth		G.L.(m)	43.625
simple beam span L		m	2.875
intensity applied on a simple beam P		kN/m	58.86
equivalent uniform distribution load w= P/L		kN/m^2	20.472
Del.1	Young's modulus E	*10^{8}kN/m^2	2.000
	moment of inertia of area I	m^4/m	0.00068380
	effective rate(displacement) Alp.	-----	0.450
	deformation of center in span Del.1	m	0.0003
Del.2	modulus of subgrade reaction kH	kN/m^3	15474
	wall width B	m	1.000
	side area of spring block pile A= B*Y	m^2	0.7500
	spring constant K= kH*A	kN/m^2	11606
	reaction force R= w*L/2	kN/m	29.43
	elastic support displacement Del.2' = R/K	m	0.0025
	support displacement influence Del.2 = Del.2'/2	m	0.0013
total wall displacement Del. = Del.1+ Del.2		m	0.0016
position (a half of span)		G.L.(m)	45.063
allowable displacement Del.a		m	0.300
Judge		-----	OK

* total intensity applied on a simple beam(P)

No	depth GL(m)	thk h (m)	action load p kN/m²	load P kN/m
1	46.500 46.000	0.500	11.40 11.40	5.70
2	46.000 44.000	2.000	11.40 31.40	42.80
3	44.000 43.926	0.074	31.40 29.91	2.27
4	43.926 43.625	0.301	29.91 23.83	8.09
Sig				58.86

* Horizontal modulus of subgrade reaction

Horizontal modulus of subgrade reaction is an average value to virtual support point, using the equation

$$kH = Eta\,kHo\left(\frac{BH}{0.3}\right)^{\left(-\frac{3}{4}\right)}$$

where,

Eta: coefficient for wall type(= 1.00)

in case of continuous wall Eta= 1

kHo: H modulus of subgrade reaction equivalent to that of a 30cm stiffness round plate.

$$kHo = \frac{1}{0.3}\ Alp.Eo$$

Eo: ground deformation modulus of deformation(kN/m²)

Alp.: coefficient for ground deformation stiffness

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH* h (kN/m²)
1	44.000	43.250	0.750	64400	214667	15474	11606

No	upper G.L.(m)	bottom G.L.(m)	thickness h (m)	Alp.Eo (kN/m²)	kHo (kN/m³)	kH (kN/m³)	kH* h (kN/m²)
Sig			0.750				11606

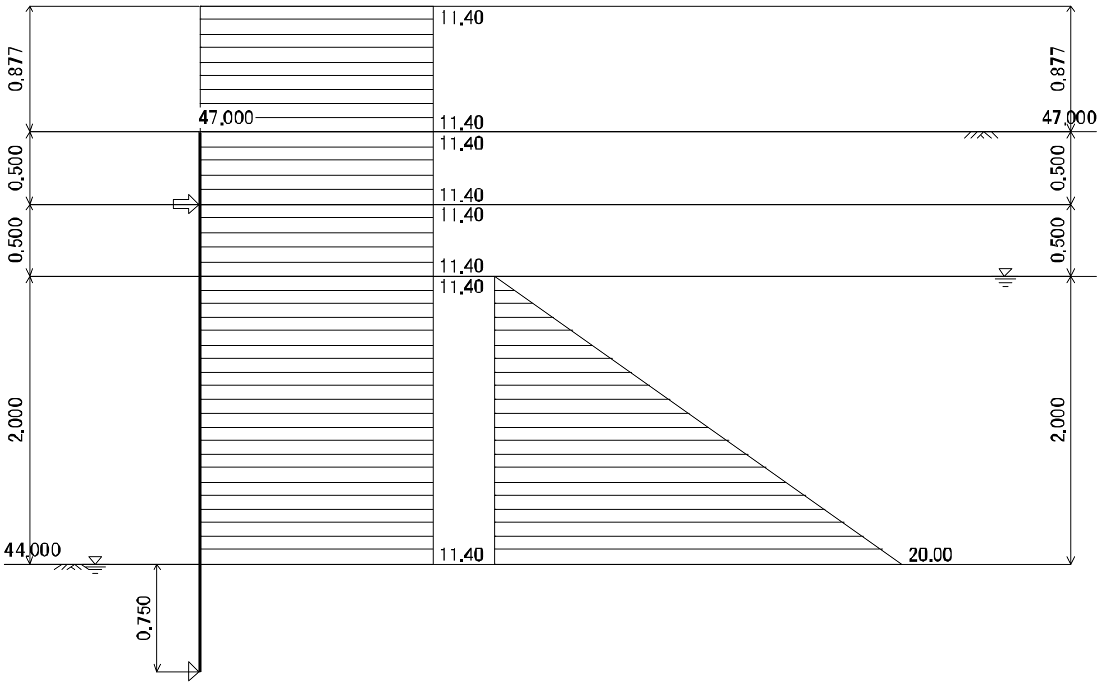
ave kH= Sig.(kH* h) /Sig.h= 15474(kN/m³)

BH: conversion width of load 10.0(m)

(4)calculation of bracing reaction force

1)result summery

analysis method : lower share method



No	depth G.L. (m)	sharing range		bracing reaction force kN/m
		upper G.L. (m)	lower G.L. (m)	
1	46.500	47.877	44.000	64.20

2) external force table

No	depth GL(m)	thk h (m)	passive eth prss pp kN/m²	active eth prss pa kN/m²	water prss pw kN/m²	action load p kN/m²
1	47.877 47.000	0.877	0.00 0.00	11.40 11.40	0.00 0.00	11.40 11.40
2	47.000 46.500	0.500	0.00 0.00	11.40 11.40	0.00 0.00	11.40 11.40
3	46.500 46.000	0.500	0.00 0.00	11.40 11.40	0.00 0.00	11.40 11.40
4	46.000 44.000	2.000	0.00 0.00	11.40 11.40	0.00 20.00	11.40 31.40
5	44.000 43.926	0.074	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
6	43.926 43.250	0.676	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
7	43.250 43.010	0.240	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

*load applied at beam is sum of active side [active earth pressure] + [water pressure] deducted passive side [passive earth pressure] (p= pa+ pw- pp).

1.1.2 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+

using material : SY295

dimensions		unit	value
section modulus	Z	$*\ 10^3(mm^3/m)$	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	$*\ 10^2(mm^2/m)$	226.00

(2) design member force

design member force is as following table.

state	moment M $*\ 10^6$(N mm/m)	axial force N $*\ 10^3$(N/m)	shear force S $*\ 10^3$(N/m)
Max.	25.32	10.00	26.28

(3) bending stress

$$Sig. = \frac{M}{Alp. * Z} + \frac{N}{A} <= Sig.sa$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	14.5	270.0	OK

(4) shear force stress

$$Tau = \frac{S}{A} <= Taua$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	1.2	150.0	OK

2 Elasto-plastic method

2.1 Right wall design

2.1.1 wall member stress

(1) applied member

material type : Steel sheet pile

use : PU28+

using material : SY295

dimensions		unit	value
section modulus	Z	$*\ 10^3(mm^3/m)$	3000
ditto effective rate	Alp.	--------	0.600
cross sectional area	A	$*\ 10^2(mm^2/m)$	226.00

(2) design member force

design member force is as following table.

state	moment M * 10^6(N mm/m)	axial force N * 10^3(N/m)	shear force S * 10^3(N/m)
Max.	13.35	10.00	17.69

(3) bending stress

$$\text{Sig.} = \frac{M}{\text{Alp.} * Z} + \frac{N}{A} <= \text{Sig.sa}$$

where,

Sig. : bending stress(N/mm^2)

Sig.sa: allowable bending stress(N/mm^2)

Z : applied section modulus

A : applied cross sectional area

state	stress N/mm^2	allowable stress N/mm^2	Judge
Max.	7.9	270.0	OK

(4) shear force stress

$$\text{Tau} = \frac{S}{A} <= \text{Taua}$$

where,

Tau :shear force stress (N/mm^2)

Taua:allowable shear stress (N/mm^2)

state	stress Tau N/mm^2	allowable stress Taua N/mm^2	Judge
Max.	0.8	150.0	OK

2.1.2 Elastic-Plastic analysis results

(1)primary excavation

1)analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m² top	 bottom	effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
1	47.000		--------	0.00	----------	--------	-0.18	--------
2	46.500		1.47	1.47	----------	--------	-0.14	--------
3	46.000	Ela.zone	2.93	0.00	8.18	4205	-0.11	0.5
4	45.500	Ela.zone	0.00	0.00	18.96	8410	-0.08	0.7
5	45.000	Ela.zone	0.00	0.00	22.44	8410	-0.05	0.5
6	44.500	Ela.zone	0.00	0.00	25.92	8410	-0.03	0.3
7	44.000	Ela.zone	0.00	0.00	29.40	8073	-0.01	0.1
8	43.500	Ela.zone	0.00	0.00	32.88	7737	0.00	0.0
9	43.000	Ela.zone	0.00	0.00	36.36	7737	0.01	-0.1
10	42.500	Ela.zone	0.00	0.00	39.84	7737	0.02	-0.2
11	42.000	Ela.zone	0.00	0.00	33.07	4710	0.03	-0.1
12	41.500	Ela.zone	0.00	0.00	24.74	1682	0.04	-0.1
13	41.000	Ela.zone	0.00	--------	12.89	841	0.05	0.0

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

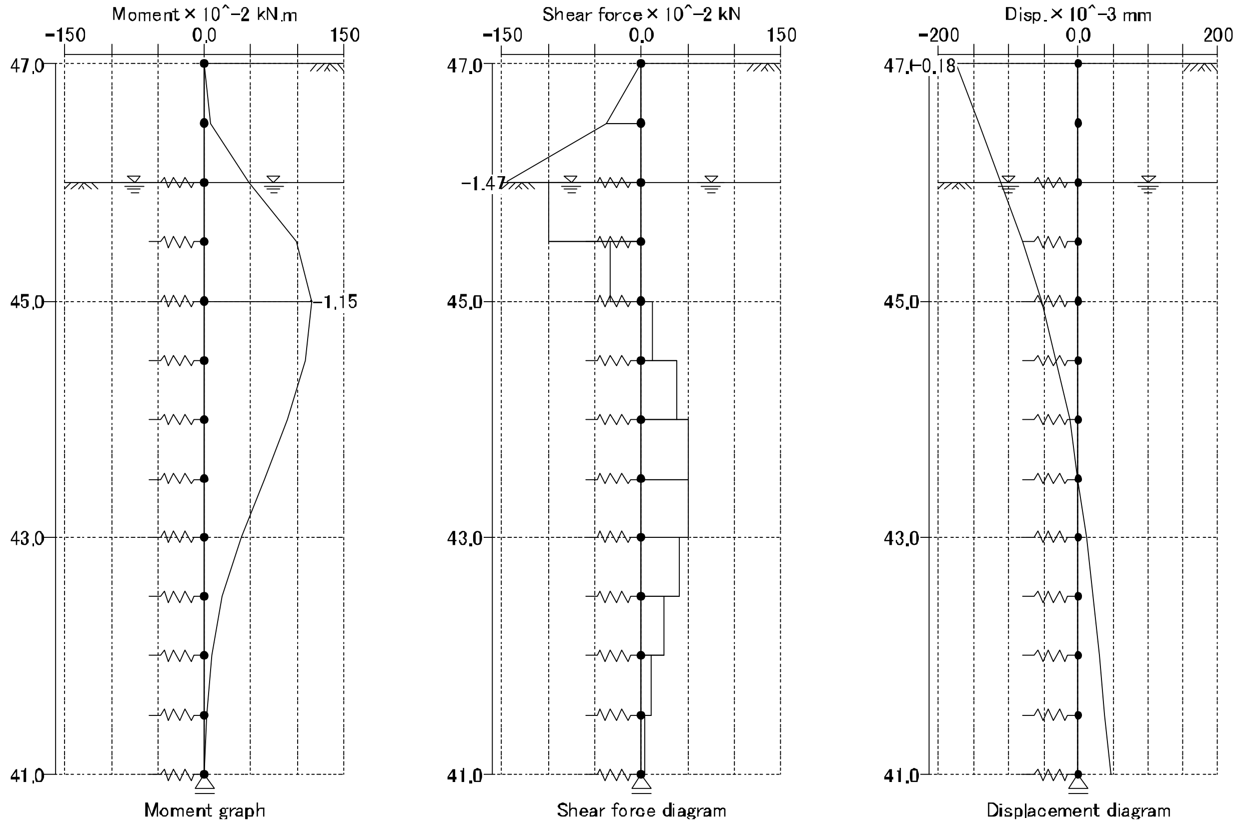
2)primary excavation analysis result (member force, displacement)

Mmax = 0.0kN.m/m(working pos G.L. 41.00m) Mmin = -1.2kN.m/m(working pos G.L. 45.00m)

Smax = 0.5kN/m (working pos G.L. 44.00m) Smin = -1.5kN/m (working pos G.L. 46.00m)

Del.max= 0.05mm (working pos G.L. 41.00m) Del.min= -0.18mm (working pos G.L. 47.00m)

node No	G.L.	moment kN.m/m		shear force kN/m		disp mm	brc H-rct kN/m
		upper	bottom	upper	bottom		
1	47.000	----------	0.0	----------	0.0	-0.18	----------
2	46.500	-0.1	-0.1	-0.4	-0.4	-0.14	----------
3	46.000	-0.5	-0.5	-1.5	-1.0	-0.11	----------
4	45.500	-1.0	-1.0	-1.0	-0.3	-0.08	----------
5	45.000	-1.2	-1.2	-0.3	0.1	-0.05	----------
6	44.500	-1.1	-1.1	0.1	0.4	-0.03	----------
7	44.000	-0.9	-0.9	0.4	0.5	-0.01	----------
8	43.500	-0.6	-0.6	0.5	0.5	0.00	----------
9	43.000	-0.4	-0.4	0.5	0.4	0.01	----------
10	42.500	-0.2	-0.2	0.4	0.2	0.02	----------
11	42.000	-0.1	-0.1	0.2	0.1	0.03	----------
12	41.500	0.0	0.0	0.1	0.0	0.04	----------
13	41.000	0.0	----------	0.0	----------	0.05	----------



* pre-displacement and loading equivalent to pre-displacement

when strut is effective after next step, a load for pre-displacement is applied.

node No	displacement Del.x mm	release Del.L mm	preceding displacement Del.o mm	bracing spring Ks kN/m	preceding displacement load kN/m
2	-0.14	0.00	-0.14	387964.8	-55.34

where,

Del.x: wall displacement at strut level(->)+)

Del.L: construction release

Del.o: pre-disp(->)+) Del.o=Del.x-Del.L

(2) Final excavation

1)analysis results (lateral pressure, elastic reaction force, displacements)

node No	GL m	state	eff active ltrl pressure Pae kN/m²		effective passive ltrl pressure Ppe kN/m	grnd spr kH kN/m/m	disp Del. mm	elst rct R kN/m
			top	bottom				
1	47.000		--------	0.00	----------	--------	0.16	--------
2	46.500	Strut	1.47	1.47	-55.34	387965	-0.17	11.2
3	46.000		2.93	0.00	----------	--------	-0.50	--------
4	45.500		5.64	5.64	----------	--------	-0.81	--------
5	45.000		11.28	11.28	----------	--------	-1.08	--------
6	44.500		16.93	16.93	----------	--------	-1.30	--------
7	44.000	Ela.zone	22.57	22.57	8.18	3869	-1.46	5.6
8	43.500	Ela.zone	19.40	19.40	18.96	7737	-1.59	12.3
9	43.000	Ela.zone	16.23	16.23	22.44	7737	-1.70	13.1
10	42.500	Ela.zone	13.06	13.06	25.92	7737	-1.81	14.0
11	42.000	Ela.zone	9.89	17.24	23.36	4710	-1.94	9.1
12	41.500	Ela.zone	14.25	14.25	19.22	1682	-2.08	3.5
13	41.000	Ela.zone	11.26	--------	10.13	841	-2.22	1.9

note1: effective passive latteral pressure in effective strut is a load for pre-displacement.

note2: ground spring constant in effective strut is bracing spring constant.

note3: displacement + is shown as ->) reaction force + is shown as ->).

note4: effective passive latteral pressure in elastic range is no loading in analysis.

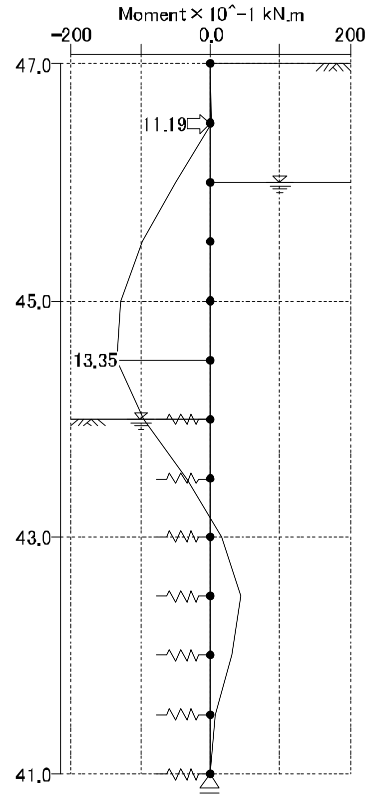
2)final excavation analysis result (member force, displacement)

Mmax = 13.4kN m/m (working pos G.L. 44.50m) Mmin = -4.3kN m/m (working pos G.L. 42.50m)

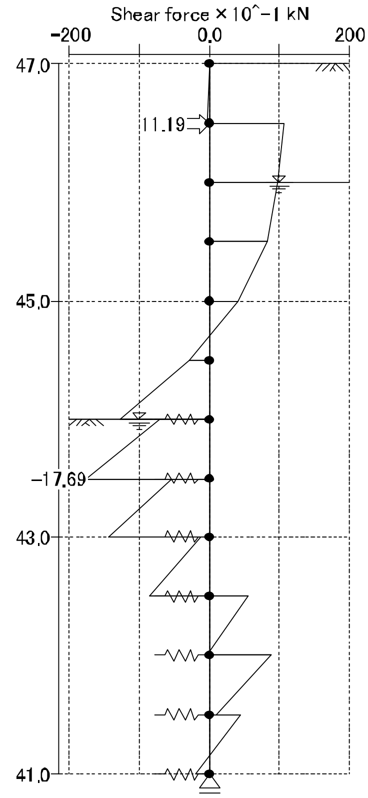
Smax = 10.8kN m (working pos G.L. 46.50m) Smin = -17.7kN m (working pos G.L. 43.50m)

Del.max= 0.16mm (working pos G.L. 47.00m) Del.min= -2.22mm (working pos G.L. 41.00m)

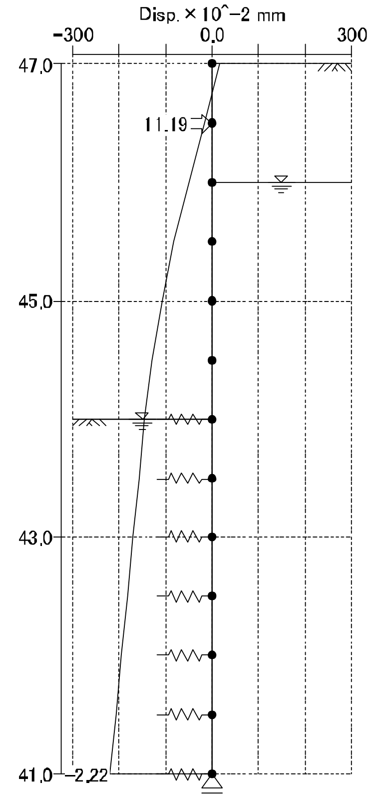
node No	G.L.	moment kN m/m		shear force kN/m		disp mm	brc H-rct kN m
		upper	bottom	upper	bottom		
1	47.000	----------	0.0	----------	0.0	0.16	----------
2	46.500	-0.1	-0.1	-0.4	10.8	-0.17	11.2
3	46.000	5.1	5.1	9.7	9.7	-0.50	----------
4	45.500	9.7	9.7	8.3	8.3	-0.81	----------
5	45.000	13.0	13.0	4.1	4.1	-1.08	----------
6	44.500	13.4	13.4	-3.0	-3.0	-1.30	----------
7	44.000	9.5	9.5	-12.8	-7.2	-1.46	----------
8	43.500	3.2	3.2	-17.7	-5.4	-1.59	----------
9	43.000	-1.8	-1.8	-14.3	-1.2	-1.70	----------
10	42.500	-4.3	-4.3	-8.5	5.5	-1.81	----------
11	42.000	-3.0	-3.0	-0.2	8.9	-1.94	----------
12	41.500	-0.6	-0.6	1.0	4.5	-2.08	----------
13	41.000	0.0	----------	-1.9	----------	-2.22	----------



Moment graph



Shear force diagram



Displacement diagram

3 Bearing capacity

3.1 Right wall design

3.1.1 check condition

(1) check method : Temp. Works Guid.H11,Metro. express.H19,Std.Dsgn.Spec.Vol.2(H18)

(2) construction method: Percussion method

(3) check condition: Decided depth of embedment checking results

check ps	G.L.(m)	41.000
exv bs ps	G.L.(m)	44.000
embd L L	m	3.000

3.1.2 vertical bearing capacity checking

(1) allowable vertical bearing capacity(Ra)

$$Ra = \frac{1}{n} Ru >= N$$

FS n	soil ultimate bear cap Ru (kN)	allw V-bear cap Ra (kN)	V-load N (kN)	Judge
2.00	352.94	176.47	10.00	OK

(2) ultimate bearing capacity(Ru)

Ru = qd * A + U * Sum(Li * fsi)

1) retaining wall tip area and perimeter

tip area A (m^2)	perimeter U (m)
0.0226	1.0000

2) ultimate bearing capacity qd

qd= 200Alp.N

$$N = \frac{N1+N2}{2} \quad (<=40)$$

* average Nvalue (N2) range : 2m over tip

bearing capacity factor by construction condition Alp.	tip ground N value			ultimate bearing capacity qd (kN/m^2)
	tip Nvalue N1	average N value N2	tip ground N value N	
1.0	5.0	14.0	9.5	1900.00

Calculation base on Nvalue (N2) around tip

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	N val N	Li * Ni
1	43.000	42.000	1.000	23.0	23.00
2	42.000	41.000	1.000	5.0	5.00
Sig			2.000		28.00

3) circumference friction force(Sig.Li* fi)

* sand : fi= 2BetaNs(note; Ns<=50
* clay (by cohesion) : fi= BetaNc(note; Nc<=150kN/m^2)
* coefficient of skin friction with construction method: Beta= 1.0
* N value <=2 fi= 0.0 in weak soil
* all friction resistance Sig.Li* fi= 310.00(kN/m)

(excavation side)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li* fi (kN/m)
1	2.000	23.0	-----	46.00	92.00
2	1.000	5.0	-----	10.00	10.00
Sig	3.000				102.00

(natural ground)

No	thk Li (m)	sand N val Ns	clay coh Nc	max skin friction fi (kN/m²)	skin friction Li* fi (kN/m)
1	1.000	3.0	-----	6.00	6.00
2	2.000	25.0	-----	50.00	100.00
3	2.000	23.0	-----	46.00	92.00
4	1.000	5.0	-----	10.00	10.00
Sig	6.000				208.00

4 Bottom stability

4.1 Right wall design

4.1.1 Boiling

(1) check condition

1) method : Terzaghi method

2) check condition

top of natural ground	G.L.(m)	47.000
wall tip depth	G.L.(m)	41.000
excavation bottom depth	G.L.(m)	44.000
embedment length Ld	m	3.000
water table at natural ground	G.L.(m)	46.000
excavation side water table	G.L.(m)	44.000
difference in water level hw	m	2.000
water unit weight Gam w	kN/m³	10.0
exv side surcharge q	kN/m²	0.000

(2) stability checking

1) FS calculation

the next equation must be satisfied to prevent from boiling..

$$Fs = \frac{W+q}{U} >= Fsa$$

soil effective weight W+ q (kN/m²)	average excess pore pressure U (kN/m²)	safety factor Fs	required factor Fsa	judge
48.00	20.00	2.40	1.20	OK

2) soil effective weight(wall embedment of excavation side)

W= 2.0* Gam' * Ld= 48.00(kN/m²)

Gam' : soil ave ut wt qt(kN/m³) under WT (wet wt - wtr ut wt), over WT (wet wt).

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	soil unit wt Gam' (kN/m³)	soil eff wt Gam' iLi (kN/m²)
1	44.000	42.000	2.000	8.0	16.00
2	42.000	41.000	1.000	8.0	8.00
Sig			3.000		24.00

3) average excess pore pressure

U = Gam w* hw = 20.00(kN/m²)

4.1.2 Piping

(1) check condition

checking condition: checking result on final length

natural ground surface		G.L.(m)	47.000
tip of wall		G.L.(m)	41.000
excavation		G.L.(m)	44.000
embedment length	Ld	m	3.000
water table at natural ground		G.L.(m)	46.000
water table at excavation		G.L.(m)	44.000
water table difference	hw	m	2.000
deduction gravel length on natural ground	L	m	0.000
path of natural ground to excavation	Lr	m	2.000

Lr: distance from lwr level either natural ground surf or WT at natural ground to exv btm

(2) checking result on final length

1) equation to check piping

The following equation must be satisfied to prevent from piping.

Lh+ Ld>=2.0* hw

where,

hw: difference in water level

Lh: - path L (m)

distance from lwr level either natural ground level or back side WT to embd tip.

note; the thickness of high permeable layer is excluding.

hence,

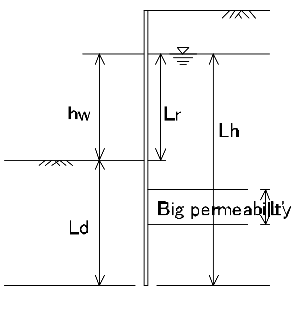
Lh= Ld+ Lr- L

where,

Ld: length from excavation bottom to embedment (m)

2) checking result on final length

natural ground path Lh (m)	embedment length Ld (m)	Lh+ Ld (m)	2.0* hw (m)	Judge
5.000	3.000	8.000	4.000	OK



4.1.3 Bottom rising

(1) check condition

1) check method : Load Balance method

2) check condition

excavation bottom depth		G.L.(m)	44.000
aquiclude top depth		G.L.(m)	44.000
ditto bottom depth		G.L.(m)	43.999
confined pressure head	hw	m	0.001
water unit weight	Gam w	kN/m^3	10.0
excavation side surcharge	q	kN/m^2	0.000

(2) heaving check

1) heaving checking equation

the next equation should be satisfied to prevent from heaving

$$Fs = \frac{w+q}{u} >= Fsa$$

soil abv str load w + q (kN/m²)	confined wtr prss u (kN/m²)	FS Fs	req FS Fsa	judge
0.02	0.01	1.80	1.10	OK

2) soil thickness above underground structure load

e-cover ld of strata from exv btm with aquiclude (exv side grnd cond) is given.

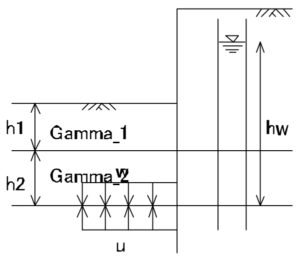
w = Sig.(Gami * Li) = 0.02(kN/m²)

Gam : soil wet unit weight(kN/m³)

No	upper G.L.(m)	bottom G.L.(m)	thk Li (m)	soil unit wt Gam' (kN/m³)	soil eff wt Gam' iLi (kN/m²)
1	44.000	43.999	0.001	18.0	0.02
Sig			0.001		0.02

3) confined ground water pressure

u = Gam w* hw= 0.01(kN/m²)

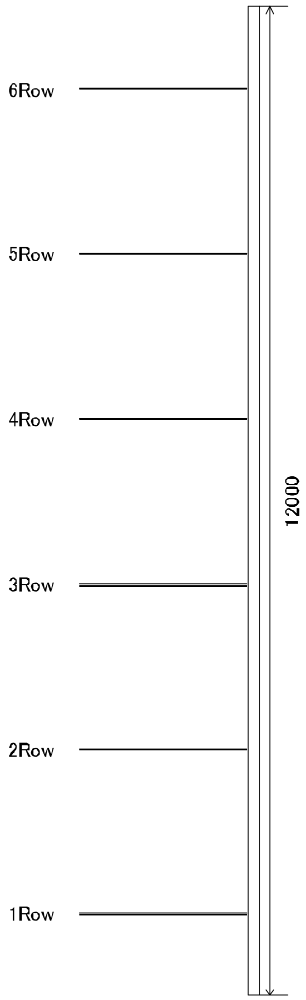


5 Strut bracing calculation

5.1 left-right direction design

5.1.1 Checking position

(1) First plan



(2) design point table

1) final wall to adopt bracing reaction force

Right wall side

2) waling

waling checking depth is as follows

No.	layer	Span
1	1	1

5.1.2 design condition

(1) bracing reaction force

layer	reaction force (kN/m)
1	10.04

(2) methods

method by Temporary Construction standard, JSCE, Sewage Org, Metro Hyway, Combination Culvert

(3) waling

check member

No.	layer	number	use steel No.	axial force B (m)	bending span L (m)	buckling span in plane Ly (m)	buckling span out-plane Lz (m)
1	1	1	5	0.00	1.80	1.80	1.80

material SS400

temperature axial force Nt = 150 kN

buckling check method Temporary structure construction guideline

allowable shear stress Taua = 120 N/mm²

local buckling allowable stress Sig.cal = 210 N/mm²

BM calculation equation $(1/8)wL^2$

5.1.3 waling material

(1) 1 th layer Waling

1) design condition

reaction force R = 10.04 kN/m

bending span L = 1.80 m

axial force distribution width B = 0.00 m

temperature axial force Nt = 150 kN

2) member force

axial force $N = R*B + Nt = 10.04*0.00+150 = 150.00$ kN

bending moment $M = \frac{R*L^2}{8} = \frac{10.04*1.80^2}{8} = 4.07$ kN m

shear force $S = \frac{R*L}{2} = \frac{10.04*1.80}{2} = 9.04$ kN

3) use : H-200×200×8×12

cross sectional area A = 63.53 cm^2 section modulus Z = 472 cm^3

4) stress

compression stress $Sig.c = \frac{N}{A} = \frac{150.00*10^3}{6353} = 24$ N/mm^2

bending stress $Sig.bc = \frac{M}{Z} = \frac{4.07*10^6}{472000} = 9$ N/mm^2

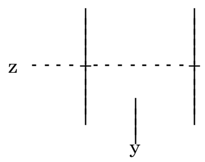
shear force stress $Tau = \frac{S}{(H-2tf)*tw} = \frac{9.04*10^3}{1408} = 6 <= 120$ N/mm^2... OK

5) buckling check

buckling span(bending applied in plane) Ly = 1.80 m

buckling span(bending applied out plane) Lz = 1.80 m

use H-200×200×8×12



Ly /ry = 1800.0/86.2 = 20.9

Lz /rz = 1800.0/50.2 = 35.9

then, zAx with bigger L/r is weak axis, check buckling around zAx axis.

checking equation(1)

$$\frac{Sig.c}{Sig.caz} + \frac{Sig.bcy}{Sig.bagy\left(1-\frac{Sig.c}{Sig.eay}\right)} <= 1$$

$$\frac{24}{188} + \frac{9}{194\left(1-\frac{24}{2752}\right)} = 0.17 <= 1 \ ...\ \text{OK}$$

checking equation(2)

$$Sig.c + \frac{Sig.bcy}{\left(1-\frac{Sig.c}{Sig.eay}\right)} <= Sig.cal$$

$$24+\frac{9}{\left(1-\frac{24}{2752}\right)}= 32 <= 210 \ldots \text{OK}$$

where, Sig.c :axial direction compression stress

Sig.bcy :bending compression stress

Sig.caz :allowable axial direction compression stress

L/r= 1800.0/50.2= 35.9 (L:buckling span, r: radius of gyration of area)

18< L/r<=92 Sig.caz= { 140- 0.82(L/r- 18) }* 1.5

= { 140- 0.82(35.9- 18) }* 1.5= 188

Sig.bagy:allowable bending compression stress

Lb/b= 1800.0/200= 9.0 (Lb:distance between flange fixed pt (=Lz), b=flange W)

4.5< Lb/b<=30 Sig.bagy= { 140- 2.4(Lb/b- 4.5) }* 1.5

= { 140- 2.4(9.0- 4.5) }* 1.5= 194

Sig.eay :Euler buckling stress

Ly/ry= 1800.0/86.2= 20.9 (Ly:buckling span, ry: radius of gyration of area)

Sig.eay= { 1,200,000/(Ly/ry)^2 }

= { 1,200,000/20.9^2 }= 2752

Sig.cal :compression flange for local bucking allowable stress

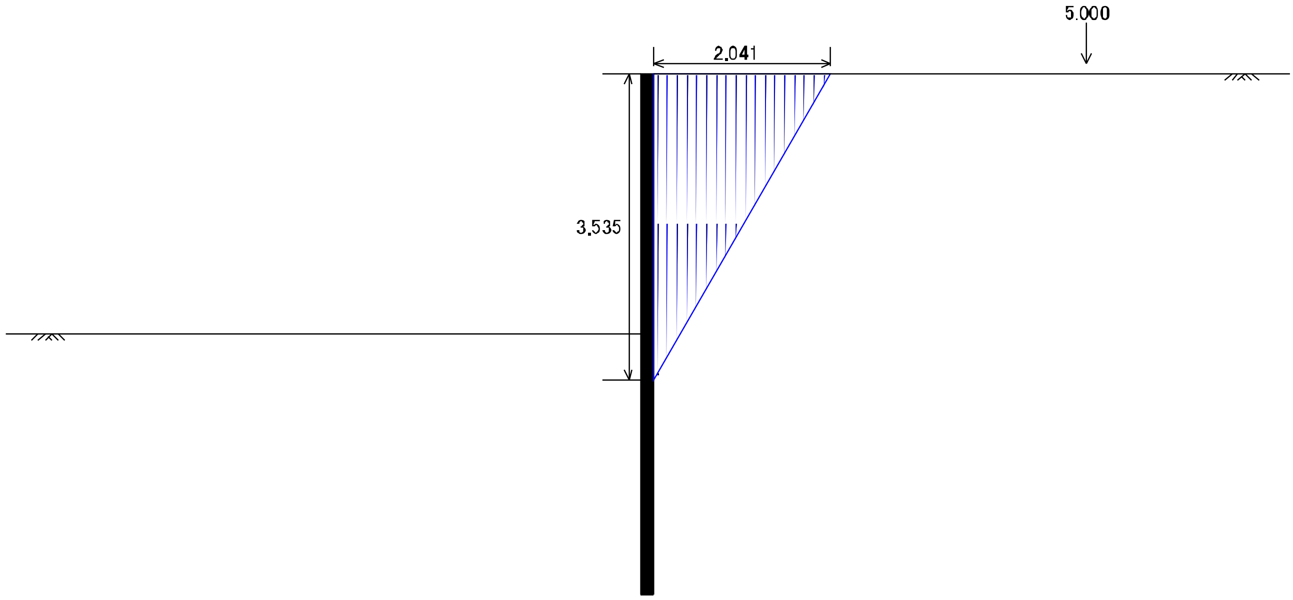
6 influence on surrounding ground

6.1 judgement on adjacent distance

(1) check condition

judgement on adjacent distance checked as the influence (sandy ground) of retaining wall deflection.

natural ground surface	G.L.(m)	47.000
excavation	G.L.(m)	44.000
virtual support point	G.L.(m)	43.465



(2) judgement on adjacent distance

1) influence range on ground deformation by construction of temporary works

influence range on ground deformation by temporary works follows the next equation.

$$Lxa = \frac{dy}{\tan\left(45 + \frac{Phi}{2}\right)} = \frac{3.535}{\tan\left(45 + \frac{30.00}{2}\right)} = 2.041 \ (m)$$

where,

Lxa: influence range on ground deformation by temporary works

dy : depth up to virtual support point of retaining wall

Phi: soil shear resistance angle 30.00(deg.) *ground failure angle Theta= 45Deg.+Phi/2

2) judgement of checking point

Examine a check point in range of influence about grnd deformation by adjacent temp const works.

No.	check point Lxn(m)	judge
1	5.000	Out range

APPENDIX D-4

Structural Calculations of Temporary Bridges

Cover

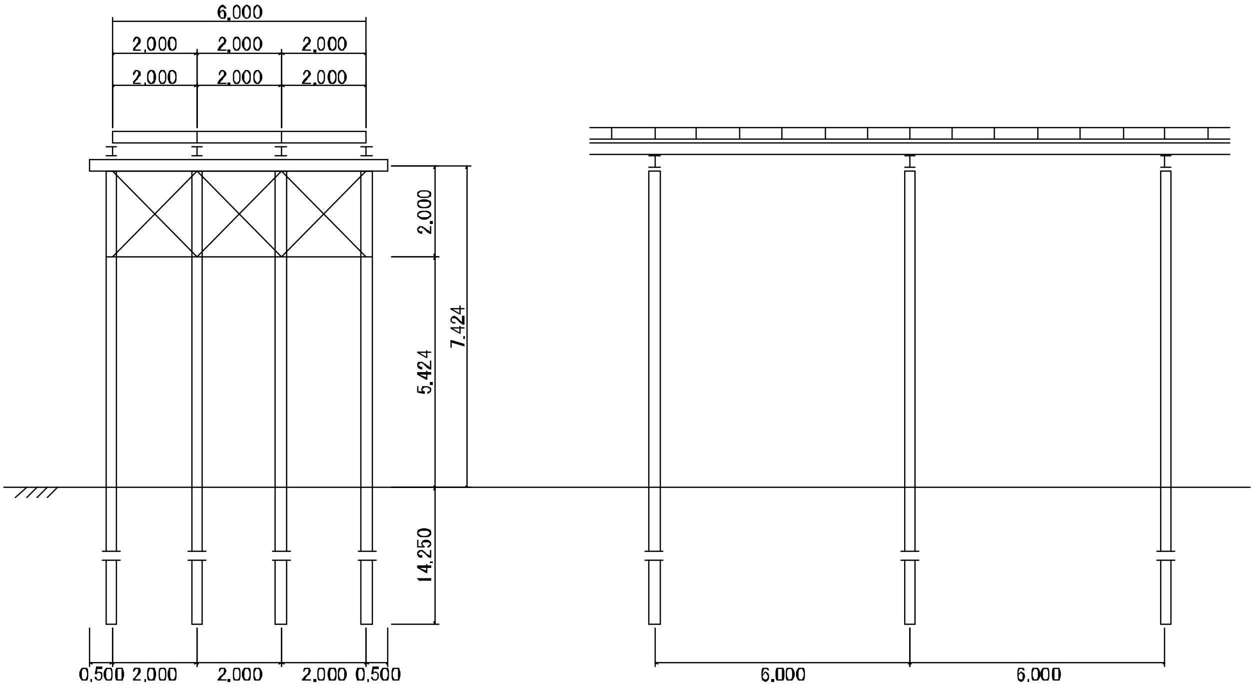
Contents

1 Input data export

1.1 Title

file : Bahr Yusef 40c6mDE.F8K
title: Dairout Bahr Yusef 40c6mDE

1.2 Shape data



1. 4 Design condition

basic condition

Applied standard	C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
type of working platform	Type i(widthMain girder orthogonal)
adjacent span	Yes
Support pile Foundation type	Support pile

steel deck, coefficient

type of steel deck	Steel deck type 2(Old Metro-deck)
At Steel deck designMain girder treatment	Not consider
impact coefficient steel deck	0.400
other than steel deck	0.300
Horizontal coefficient fixed load	0.200
load truck	= 0.200
heavy equipment	= 0.200

Use horizontal coefficient when truck crane is moving.

impact when horizontal load is calculated	include impact
impact when deflection is calculated	include impact

1.4 Member design condition

Beam seatSteel specification	H-Beam
Beam seatCheck share stress	Checking
Beam seat, Support piledesign guideline	Main girder load distribution is considered.
allowable deflection	length of a span/ 400.000
maximum deflection	2.500 (cm)
dead load when deflection is calculated	Consider
Eq of deflection for single live load	Calculation equation for 1 member
Support piledesign	Examine
Support pileDesign time axial force	maximum axial force / 1
Support pileself weight treatment	Total length
other vertical load	0.000 (kN/ a member)
Support pileHorizontal force load status	Use vertical load when horizontal force is max.
Hori. jointhorizontal force	1 memberHori. jointshare(by before member)
Hori. joint	both sides install
Beam seatunderneathHori. jointinstall:	Not do
Hori. jointJoint part	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)
Hori. joint,brace horizontal force calculation method	Use vertical load when horizontal force is max.
brace member	Design as compressive member
brace connection	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)

1. 4 Design condition

live load

increment of live load movement of live load when member section is calculated for live load Del.L 0.010 (m)

crawler crane load Linear load

Support piledesign

Incase of Penetration length is not satisfied with Beta L >= 2.50 :design as limited length pile

increase rate pile top free bending moment	1.00
displacement	1.25
pile top fixed bending moment	1.10
displacement	1.20

FORUM8

1.6 Live load for steel deck design

	Main girder orthogonal to		Main girder parallel to	
	1000* 2000	1000* 3000	1000* 2000	1000* 3000
truck load	NG	NG	OK	NG
crawler crane moving	NG	NG	OK	NG
crawler crane 0 degree	NG	NG	OK	NG
crawler crane 90 degree	NG	NG	OK	NG
crawler crane 45 degree	NG	NG	OK	NG
truck crane moving	NG	NG	OK	NG
truck crane working	NG	NG	NG	NG
reinforcing beam	NG		NG	

OK : design NG : not design

1.7 Live loads for member design

	Main girder orthogonal to	Main girder parallel to
truck load	NG	OK
crawler crane moving	NG	OK
crawler crane 0 degree	NG	OK
crawler crane 90 degree	NG	OK
crawler crane 45 degree	NG	OK
truck crane moving	NG	OK
truck crane working	NG	NG

OK : design NG : not design

1.8 working platform data

Span* adjacent span data

item	symbol	unit	value
main span length	--	m	6.000
adjacent span length	--	m	6.000

Main girder spacing data

No. N	Main girder spacing(m)
1	2.000
2	2.000
3	2.000

steel deck layout data

No. F	steel deck size (m)
1	2
2	2
3	2

Support pile spacing

No. S	Support pile spacing(m)
1	2.000
2	2.000
3	2.000

width, overhang

item	symbol	unit	value
road width	--	m	6.000
gap	--	m	0.000
left overhang length	LL	m	0.500
right overhang length	LR	m	0.500

1.9 frame data

with or without Hori. brace [none]
with or without Vert. brace [Yes]
elevation

No. h	frame spacing (m)
1	2.000
2	5.424

item	symbol	unit	value
Support pilepenetration length	hL	m	14.250
ground level G.L.	--	m	39.000

1.10 Support piledesign condition

Sand layer with N-value more than 30 or delluvial clay with more than 10
embedded more than 3m in the bearing layer Not allow
Pile construction method (not embedded by written above) Striking construction method
Directly input Alp.* Beta No
Pile moment using vertical brace
Calculation method Chang equation
Specify upper limit of N-value in pile tip ground Based on the design strength
Direct input N-value at pile tip ground No
embedment length 14.25 (m)
Young's modulus of pile * 10^5 2.00 (N/mm²)
Modulus of subgrade lateral reaction 0.00 (kN/m³)
Assume sound layer when pile tip bearing capacity is calculated
Lower limit of N-value 20.000
Factor of Safey when allowable bearing capacity is calculated 2.0

1.11 Strata data

No.	layer type	layer thickness	average N-value	coh soil unc cmpr strg(kN/m²)	Alp.* Eo (kN/m²)	cohesion (kN/m²)
1	Sandy soil	5.000	11.000	100.000	30800.00	50.000
2	Sandy soil	4.000	11.000	100.000	30800.00	50.000
3	Sandy soil	4.000	8.000	100.000	22400.00	50.000
4	Sandy soil	3.000	16.000	100.000	44800.00	50.000
5	Sandy soil	3.000	52.000	200.000	145600.00	100.000

1.12 steel deck load distribution ratio specification

* truck load distribution ratio

	Main girder orthogonal to	Main girder parallel to
truck	0.40	0.40

* Crawler crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
0 degree	0.25	0.20
45 degree	0.25	0.20
60 degree	0.25	0.20

Note)use the value of front hang when moving.

* Truck crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
moving	0.40	0.40
working	0.40	0.40

1.13 Steel deck material data

height of steel deck 200(mm)

* in case of 1000* 2000
  1)name of steel deck Steel deck type 2
  2)Aw 8.10 (cm²)
  3)Z 312.0 (cm³)
* in case of 1000* 3000
  1)name of steel deck Steel deck type 2
  2)Aw 8.10 (cm²)
  3)Z 312.0 (cm³)

Note: Web section area, section modulus are input data per one H steel.

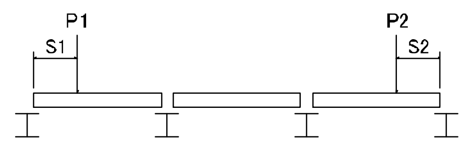
1.14 Reinforcement girder material data

1)name of using material
2)Aw 54.00 (cm²)
3)Z 2720.0 (cm³)
4)self-weight 1880.0 (N/m)
5)span length 2.0 (m)
6)comment (description)

1.15 Beam seat Joint part bolt data

Support pile part
bolt is not designed.

1.16 Bridge face(dead) load



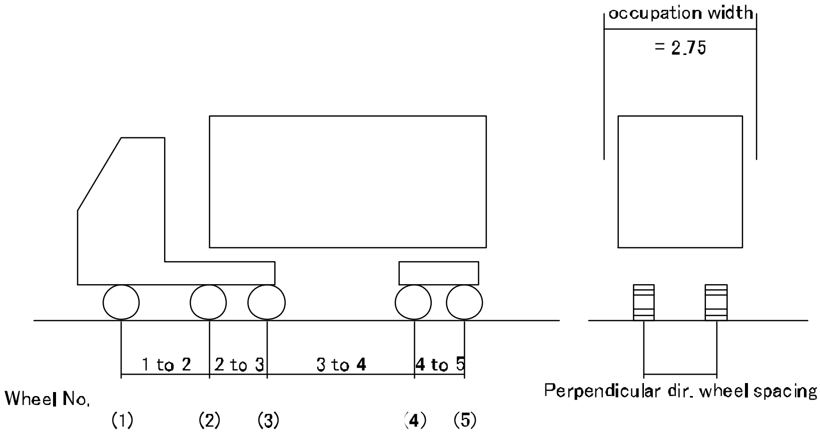
1)left loading position 0.000 (m)
2)right loading position 0.000 (m)
3)left load intensity 0.000 (kN/m)
4)right load intensity 0.000 (kN/m)

1.17 Steel deck/Nominal load

1)steel deck self-weight	1000	*	2000	2.000 (kN/m²)
	1000	*	3000	2.000 (kN/m²)
other				2.000 (kN/m²)
2)nominal load				0.000 (kN/m²)
3)attachment unit				0.100

1.18 Select truck load

* bridge axis direction



1) load selection Input load
2) registration name T20
3) axis spacing in perpendicular direction 1.75 (m)
4) number of wheels 2
5) axis spacing in moving direction (m)

1 - 2	4.000

6) load intensity (one side) (kN)

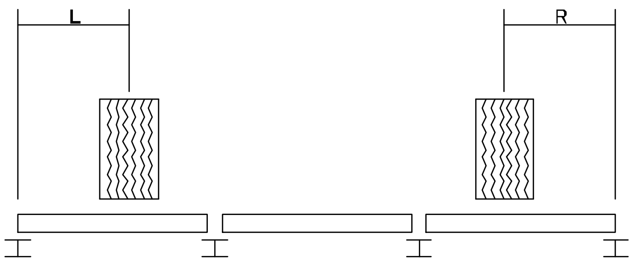
1	20.000
2	80.000

* perpendicular to bridge axis direction
1) load selection Input load
2) load type
P1 T20
P2 T20
P3 T20

1.19 Truck load condition setting

* bridge axis direction
1) train load is considered No
2) Number in perpendicular direction 2

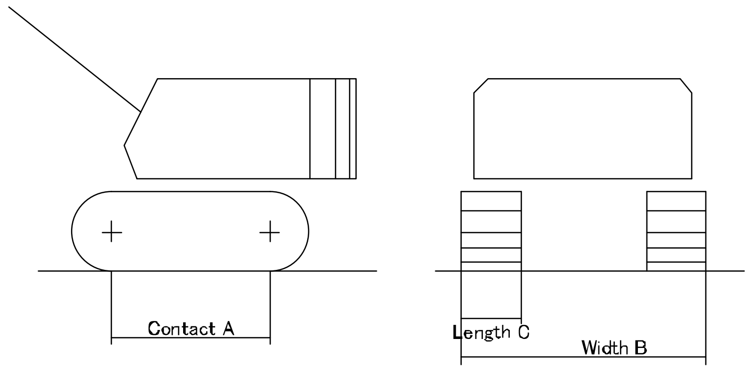
1.20 Width of truck load setting



1) load on one side Consider
2) non-width of load (left) 0.000 (m)
3) non-width of load (right) 0.000 (m)

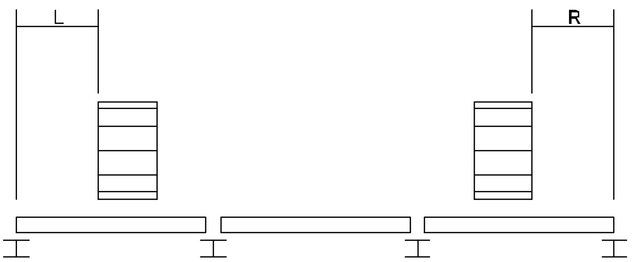
1.21 Crawler crane load selection

1)registration name D408S



2)self-weight	480.000 (kN)
3)hoisting self-weight	50.000 (kN)
4)contact A	4.470 (m)
5)width B	4.000 (m)
6)contact width C	0.800 (m)
7)apportionment on lateral operation side	0.750
8)contact when hoisting forward	0.750
9)apportionment on operation side in orthogonal direction	0.700
10)contact on operation side in orthogonal direction	0.900

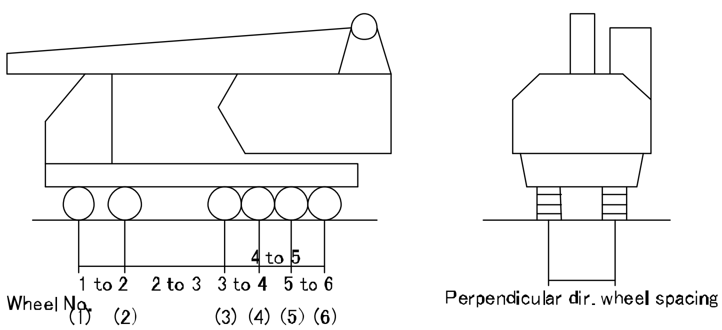
1.22 Width of Crawler crane non-load setting



1)load on one side	Not consider
2)non-width of load (left)	1.000 (m)
3)non-width of load (right)	1.000 (m)
4)location of heavy equipment in bridge axis direction	not specify

1.23 Truck crane load selection

* at moving



1)registration name	KA-900
2)wheel spacing in perpendicular direction	2.30 (m)
3)number of wheels	4

4)wheel spacing in moving direction (m)

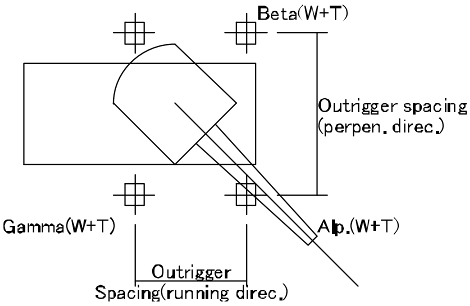
1 - 2	1.650

2 - 3	2.400
3 - 4	1.650

5) load intensity(one side) (kN)

1	38.850
2	38.850
3	27.250
4	27.250

* at operating



1) self-weight W 264.400 (kN)
2) hoisting self-weight T 800.000 (kN)
3) outrigger spacing (moving) 8.700 (m)
4) outrigger spacing (perpendicular) 7.400 (m)
5) load distribution ratio Alp. 0.700
6) load distribution ratio Beta 0.150
7) load distribution ratio Gam 0.150
8) outrigger width 0.500 (m)

1.24 Width of Truck crane non-load setting

truck crane load is not considered.

1.25 Dead load arbitrary position

Dead load at any location is not input.

1.26 Specify allowable stress

steel type name SS400

load factor of allowable stress 1.50

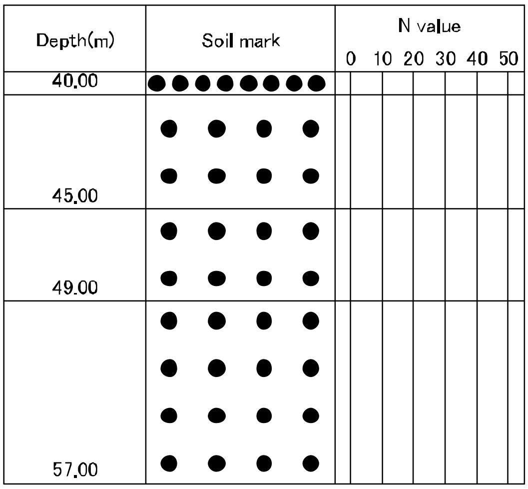
allowable stress

	direct input of allowable stress			
	bend cmpr (N/mm^2)	ax cmpr (N/mm^2)	ax tns (N/mm^2)	shear (N/mm^2)
steel deck	Auto calc	----	----	Auto calc
Main girder	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)H-Beam	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)U shape steel	210.00	----	----	Auto calc
Support pile	Auto calc	Auto calc	----	Auto calc
Hori. joint	----	Auto calc	----	----
brace	----	Auto calc	Auto calc	----

allowable stress automatic calculation(calculate from fixed number in the middle of a member)

	fixed number of middle		member length	
	distance flange fixed	effective buckling length	distance fixed (cm)	effective buckling length(cm)
steel deck	----	----	----	----
Main girder	0	----	0.00	----
Beam seat(Support pilepart)H-Beam	0	----	0.00	----
Beam seat(Support pilepart)U shape steel	0	----	0.00	----
Support pile	0	0	0.00	0.00
Hori. joint	----	0	----	0.00
brace	----	----	----	----

1.27 Borehole log of strata



FORUM8

1.28 Initial input

1)applied standard C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
2)abutment type Type i
3)adjacent span Yes
4)Support pile Foundation type bearing pile embedment length 14.250(m)
5)shape data
* width 6.000(m)
* left overhang 0.500(m)
* right overhang 0.500(m)
* span 6.000(m)
* working platform height 7.424(m)
* steel deck size 2.000(m)
* Support pileBasic spacing 2.000(m)
* frame basic spacing 3.000(m)
6)Design Support pile
* Foundation data
  1.pile construction method driven casting
* Soil data

No.	type	thickness (m)	ave N value	coh soil cmpr strg (kN/m²)	Alp.* Eo (kN/m²)	cohension (kN/m²)
1	Sandy soil	5.000	11.000	100.000	30800.00	50.000
2	Sandy soil	4.000	11.000	100.000	30800.00	50.000
3	Sandy soil	4.000	8.000	100.000	22400.00	50.000
4	Sandy soil	3.000	16.000	100.000	44800.00	50.000
5	Sandy soil	3.000	52.000	200.000	145600.00	100.000

2 Calculation result export

2.1 Steel deck type 2 design (Old Metro-deck)

2.1.1 Sum up bending stress for each load

load status			Bending stress 1000 * 2000 (N/mm²)
truck load		parallel	75.426
		orthogonal	----------
crawler crane	moving	parallel	19.915
		orthogonal	----------
	working 0 degree	parallel	48.928
		orthogonal	----------
	working 90 degree	parallel	32.563
		orthogonal	----------
	working 45 degree	parallel	58.621
		orthogonal	----------
truck crane	moving	parallel	31.148
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			210.000

2.1.2 bending stress calculation

calculate stresses when the load condition induces bending stress maximum

1)load condition Truck load(Parallel)

2)steel deck Steel deck type 2 (1000*2000)

3)bending moment by fixed load (per a steel deck)

$Md = w * l^2 / 8 =$ 1.000 (kN.m)

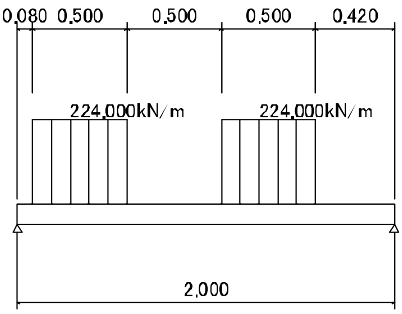
where

w : fixed load intensity applied on a steel deck

(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)

l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4) Truck load(Parallel) of bending moment



Mmax = 58.332 (kN m)

where

w : load intensity

w_1 = 224.000 (kN/m)

w_2 = 224.000 (kN/m)

5) in case of Truck load(Parallel), bending moment per single steel sheet

steel deck type2 1000 * 2000

Sig.M = Mmax * 0.400 + Md * 20/100 = 23.533 (kN m)

6) stresses in a steel deck

Sig. = Sig.M / Z = 75.426 (N/mm²)

where

Z: section modulus = 312.000 (cm³)

FORUM8

2.1.3 Sum up shear stress for each load

load status			shear stress 1000 * 2000 (N/mm²)
truck load		parallel	69.630
		orthogonal	----------
crawler crane	moving	parallel	15.342
		orthogonal	----------
	working 0 degree	parallel	37.692
		orthogonal	----------
	working 90 degree	parallel	25.086
		orthogonal	----------
	working 45 degree	parallel	45.160
		orthogonal	----------
truck crane	moving	parallel	23.996
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			120.000

2.1.4 Shear stress calculation

calculate stresses when the load condition induces Shear stress maximum

1) load condition Truck load(Parallel)

2) steel deck Steel deck type 2 (1000*2000)

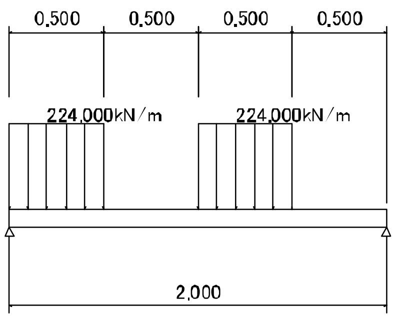
3) Shear force by fixed load (per a steel deck)

$Sd = w * l / 2 =$ 2.000 (kN)

where

w : fixed load intensity applied on a steel deck
(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)
l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4) Truck load(Parallel) of Shear force



Smax = 140.000 (kN)

where

w : load intensity
w_1 = 224.000 (kN/m)
w_2 = 224.000 (kN/m)

FORUM8

5) in case of Truck load(Parallel), Shear force per single steel sheet

steel deck type2 1000 * 2000

Sig.S = Smax * 0.400 + Sd * 20/100 = 56.400 (kN)

6) stresses in a steel deck

Tau = Sig.S / A = 69.630 (N/mm²)

where

A: cross sectional area = 8.100 (cm²)

2.2 Main girder Design

2.2.1 bending moment sum up for each load

load status		Main girder No.	bending moment (kN.m)
truck load	orthogonal	--------	------------
	parallel	G 2	279.092
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	231.160
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	308.616
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	366.064
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	399.891
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	146.068
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.2 bending moment calculation

Calculate load condition when bending moment is maximum

1)load condition Crawler crane diagonal hang(Parallel)

2)design Main girder number 2

3)stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

Main girder Self weight = 1.687

----

total wd = 5.687 (kN/m)

using Main girder H-400x400x13x21

* stresses by fixed load

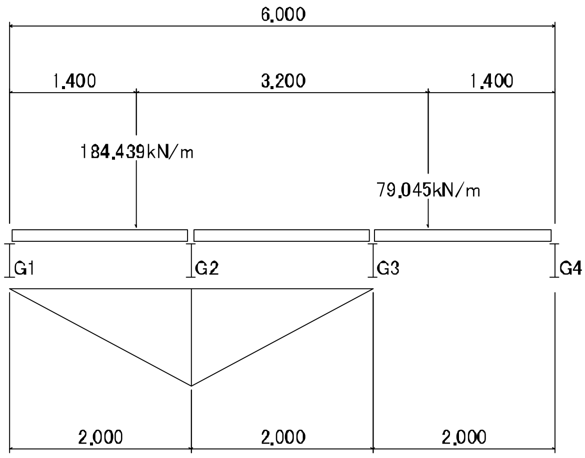
bending moment

$Md = wd * l^2 / 8 + Mo = 5.687 * 6.000^2 / 8 + 0.000 = 25.592$ (kN.m)

FORUM8

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side

triangular distribution front side   p1 = (W + T) * 0.700 / (0.900 * lb * 1/2) = 184.439 (kN/m)

triangular distribution front side   p1' = 0.000 (kN/m)

crawler crane load intensity on non-operation side

triangular distribution front side   p2 = (W + T) * 0.300 / (0.900 * lb * 1/2) = 79.045 (kN/m)

triangular distribution front side   p2' = 0.000 (kN/m)

load intensity on focus Main girder

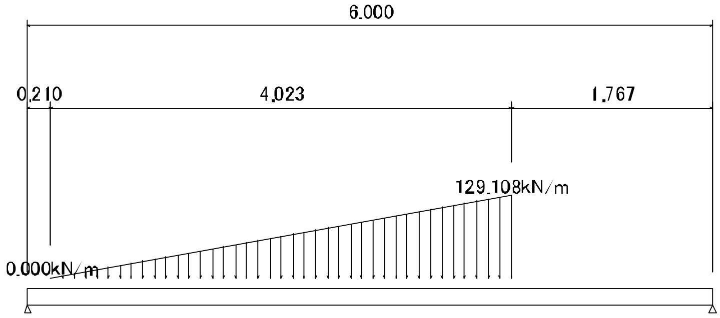
triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2 = 129.108 (kN/m)

triangular distribution front side   q1' = 0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	0.70000
Eta2	: crawler influence value on non-operation side	=	0.00000

* crawler crane (slant hoisting) bending moment



crawler crane bending moment
Mmax = 287.922 (kN m)
where
lmax : Mmax location = 3.105 (m)

* crawler crane bending moment

fixed load		=	25.592(kN m)
crawler crane load		=	287.922(kN m)
impact	287.922 * 0.300	=	86.377(kN m)
total	M	=	399.891(kN m)

2.2.3 Shear force sum up for each load

load status		Main girder No.	Shear force (kN)
truck load	orthogonal	--------	------------
	parallel	G 2	200.144
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	154.107
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	213.038
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	244.043
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	279.215
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	117.466
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.4 Shear force calculation

Calculate load condition when Shear force is maximum

1)load condition Crawler crane diagonal hang(Parallel)

2)design Main girder number 2

3)stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

```
steel deck self-weight* nominal load    2.000 *   2.000 /   2.000 =   2.000
steel deck self-weight* nominal load    2.000 *   2.000 /   2.000 =   2.000
Main girder Self weight                                             =   1.687
--------------------------------------------------------------------------------
total                                                  wd   =   5.687 (kN/m)
      using Main girder       H-400x400x13x21
```

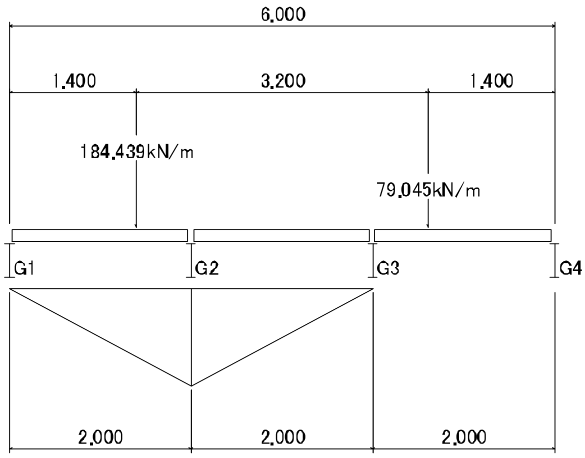
* stresses by fixed load

Shear force

Sd = wd * l / 2 + So = 5.687 * 6.000 / 2 + 0.000 = 17.061(kN)

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side
triangular distribution front side   p1 = (W + T) * 0.700
/(0.900 * lb * 1/2) = 184.439 (kN/m)
triangular distribution front side   p1' = 0.000 (kN/m)

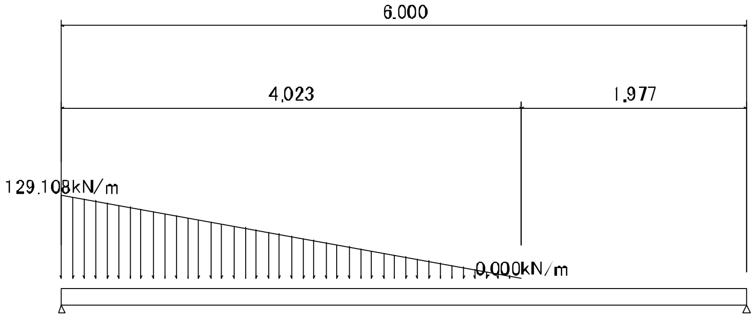
crawler crane load intensity on non-operation side
triangular distribution front side   p2 = (W + T) * 0.300
/(0.900 * lb * 1/2) = 79.045 (kN/m)
triangular distribution front side   p2' = 0.000 (kN/m)

load intensity on focus Main girder
triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2 = 129.108 (kN/m)
triangular distribution front side   q1' = 0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	0.70000
Eta2	: crawler influence value on non-operation side	=	0.00000

* crawler crane (slant hoisting) Shear force



crawler crane Shear force
Smax = 201.657 (kN)

* crawler crane Shear force

fixed load			=	17.061(kN)
crawler crane load			=	201.657(kN)
impact	201.657 * 0.300		=	60.497(kN)
total		S	=	279.215(kN)

FORUM8

2.2.5 Allowable stress calculation

steel material for structure SS400
using member H-400x400x13x21
allowable bending stress
Sig.ba = 172.200 (N/mm^2)
l/b<= 4.5 Sig.ba = 210 (N/mm^2)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm^2)
where
l : buckling span between compressive flange supports = 600.000 (cm)
b : cross sectional area of compressive flange = 40.000 (cm)
l/b : = 15.000
allowable shear stress
Taua = 120.000

2.2.6 Main girder stress calculation

using member H-400x400x13x21
bending stress
Sig. = M/ Z = 120.087 (N/mm^2) <= 172.200 (N/mm^2)
where
M: design bending moment = 399.891 (kN.m)
(Crawler crane diagonal hang(Parallel))
Z : section modulus = 3330.000 (cm^3)
shear stress
Tau = S / Aw = 59.995 (N/mm^2) <= 120.000 (N/mm^2)
where
S : design shear force = 279.215 (kN)
(Crawler crane diagonal hang(Parallel))
Aw : web section area = 46.540 (cm^2)

2.2.7 Deflection calculation

Calculate deflection when bending moment is maximum

$$Del. = \frac{5Mmaxl^2}{48EI} * (1.0+i) + \frac{5Mdl^2}{48EI} = 1.126 \text{ (cm)} <= 1.500 \text{ (cm)}$$

where
Mmax: bending moment by load = 287.922 (kN.m)
(Crawler crane diagonal hang(Parallel))
Md : bending moment by dead load = 25.592 (kN.m)
i : impact coefficient = 0.300
l : span length = 600.000 (cm)
I : moment of inertia of area = 66600.000 (cm^4)
E : Young's modulus = $2.0 * 10^5$ (N/mm^2)

2.3 Beam seat Design

2.3.1 Sum up bending moment for each load

load condition		section	bending moment (kN m)
truck load	orthogonal	----------------------	----------
	parallel	section- 2 Simple beam part	0.662
crawler crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	0 degree-orthogonal	----------------------	----------
	0 degree-parallel	section- 2 Simple beam part	0.662
	90 degree-orthogonal	----------------------	----------
	90 degree-parallel	section- 2 Simple beam part	0.662
	45 degree-orthogonal	----------------------	----------
	45 degree-parallel	section- 2 Simple beam part	0.662
truck crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	working-orthogonal	----------------------	----------
	working-parallel	----------------------	----------

Note) Bending moment is the sum of moment by fixed load, load, and impact.

2.3.2 Bending moment computation

Calculate in the load condition that induces bending moment maximum

1) load condition Truck load(Parallel)

2) design section - 2 Simple beam part

3) include Main girder in design section

No.	Main girder No.
1	G 2

4) Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

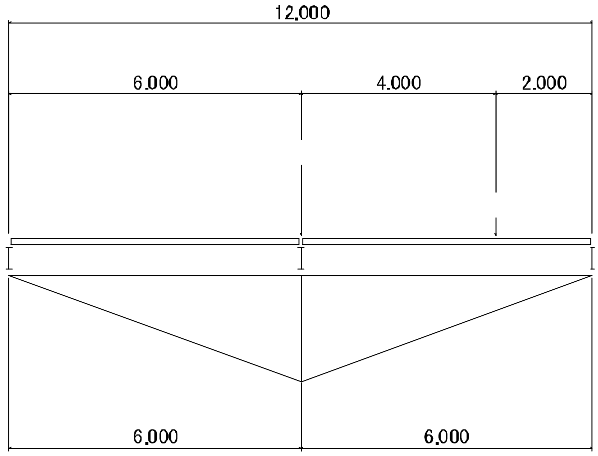
where

Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

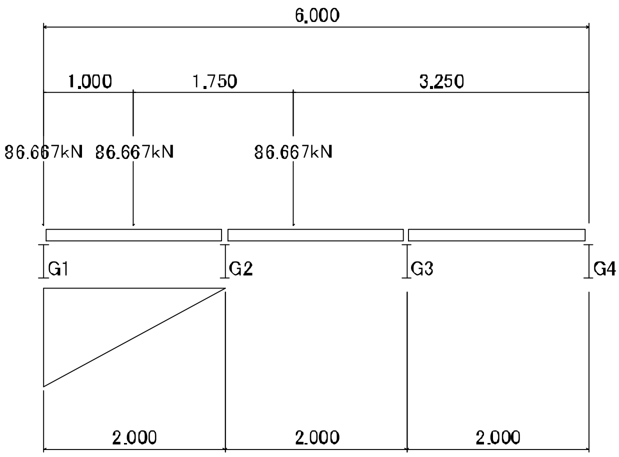
5) Main girder reaction force by truck load
in case that Beam seat of bending moment is at maximum, truck load position.



reaction force by train load
Rj = Sig. PJi * Etai = 86.667 (kN)

wheel No.	load PJi (kN)	influence value on reaction force Etai
1	80.000	1.000
2	20.000	0.333

in case that Beam seat of bending moment is at maximum, truck load position.



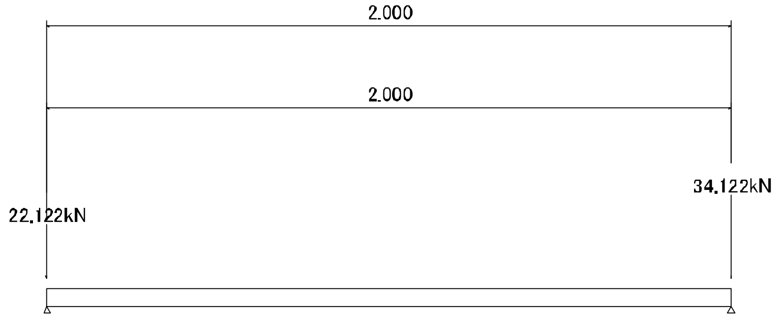
1 Main girder reaction force is maximum, then Beam seat bending moment is maximum
influence value of each beam

No.	Main girder No.	influence value
1	G 1	1.500
2	G 2	1.125
3	G 3	0.375
4	G 4	0.000

Rji = Rj * Ii

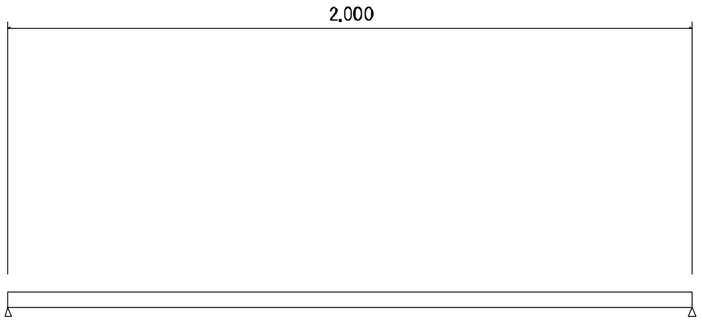
No.	Main girder No.	eachMain girder effect value Ii	Rji (kN)
1	G 1	1.500	130.000
2	G 2	1.125	97.500
3	G 3	0.375	32.500
4	G 4	0.000	0.000

6)calculate bending moment
Simple beam part
Bending moment by fixed load



Md = 0.662 (kN.m)
where
lmax : Mmax position(from left support point) = 2.000 (m)
wd : self-weight = 1.3240 (kN/m)
member used H-350x350x12x19

Bending moment by load



Mj = 0.000 (kN.m)
where
lmax : Mmax position (from left support point) = 0.000 (m)

7) sum of bending moment

fixed load			=	0.662	(kN.m)
load			=	0.000	(kN.m)
impact	=	0.000 * 0.300	=	0.000	(kN.m)
total			M =	0.662	(kN.m)

FORUM8

2.3.3 Sum up shear force for each load

load condition		section	shear force (kN)
truck load	orthogonal	---------------------	----------
	parallel	section- 2 Simple beam part	218.529
crawler crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	213.169
	0 degree-orthogonal	---------------------	----------
	0 degree-parallel	section- 2 Simple beam part	250.286
	90 degree-orthogonal	---------------------	----------
	90 degree-parallel	section- 2 Simple beam part	329.800
	45 degree-orthogonal	---------------------	----------
	45 degree-parallel	section- 2 Simple beam part	328.855
truck crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	155.335
	working-orthogonal	---------------------	----------
	working-parallel	---------------------	----------

Note) Shear force is the sum of shear force by fixed load, load, and impact.

2.3.4 Shear force computation

Calculate in the load condition that induces shear force maximum

1) load condition Crawler crane side hang(Parallel)
2) design section - 2 Simple beam part
3) include Main girder in design section

No.	Main girder No.
1	G 2

4) Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN/m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

where

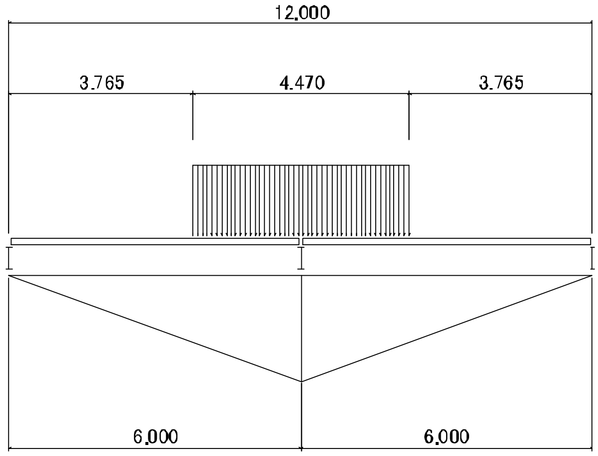
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force of crawler crane

Beam seat - Shear force is at maximum, crawler load condition



reaction force of crawler crane

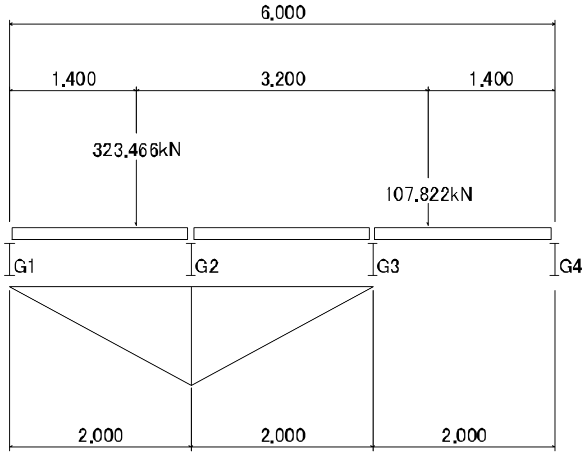
Rc1 = w1 * { b * (a + b/2.0) / l1
+ c * (d + c/2.0) / l2 } = 323.466 (kN)

Rc2 = w2 * { b * (a + b/2.0) / l1
+ c * (d + c/2.0) / l2 } = 107.822 (kN)

where

w1 :	crawler crane load intensity on operation side		
	w1 = (W+ T) / lb * 0.750	=	88.926 (kN/m)
w2 :	crawler crane load intensity on non-operation side		
	w2 = (W+ T) / lb * 0.250	=	29.642 (kN/m)
a :	unloading length in left span	=	3.765 (m)
b :	loading length in left span	=	2.235 (m)
c :	loading length in right span	=	2.235 (m)
d :	unloading length in right span	=	3.765 (m)
W :	crawler crane self-weight	=	480.000 (kN)
T :	lifting load	=	50.000 (kN)
lb :	crawler crane contact	=	4.470 (m)
l1 :	length of left span	=	6.000 (m)
l2 :	length of right span	=	6.000 (m)

Beam seat of Shear force is at maximum, crawler load condition

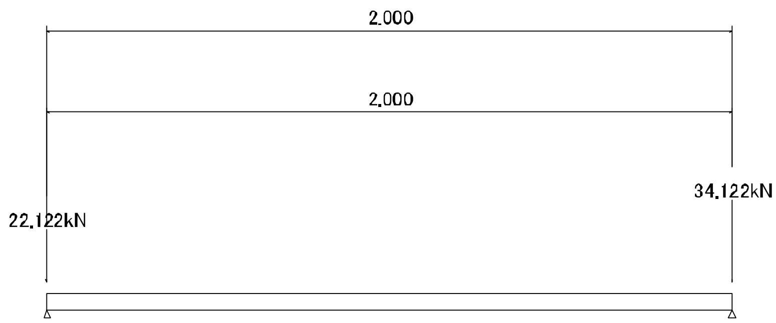


No.	Main girder No.	eachMain girder reaction force(kN)
1	G 1	97.040
2	G 2	226.426
3	G 3	75.475
4	G 4	32.347

6) calculate shear force

Simple beam part

Shear force by fixed load



Sd = 35.446 (kN)

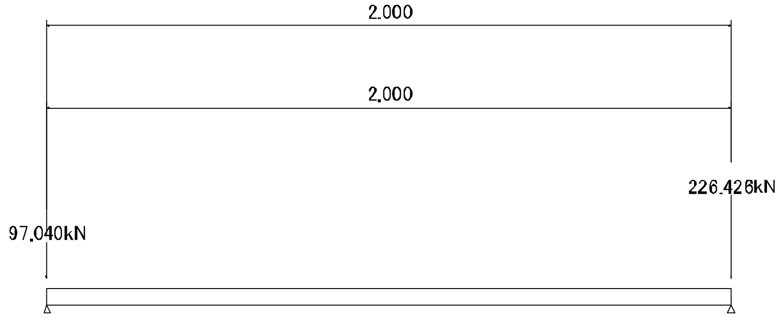
where

l : span length = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

shear force by load



Sj = 226.426 (kN)

7) sum of shear force

fixed load		=	35.446 (kN)
load		=	226.426 (kN)
impact	= 226.426 * 0.300	=	67.928 (kN)
total		S =	329.800 (kN)

2.3.5 Allowable stress calculation

steel material for structure SS400
using member H-350x350x12x19
allowable bending stress
Sig.ba = 205.629 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 200.000 (cm)
b : cross sectional area of compressive flange = 35.000 (cm)
l/b : = 5.714
allowable shear stress
Taua = 120.000

2.3.6 Beam seat stress calculation

using member H-350x350x12x19
bending stress
Sig. = M / Z = 0.290 (N/mm²) <= 205.629 (N/mm²)
where
M : design bending moment = 0.662 (kN.m)
(Truck load(Parallel))
Z : section modulus = 2280.000 (cm³)
shear stress
Tau = S / Aw = 88.088 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 329.800 (kN)
(Crawler crane side hang(Parallel))
Aw : web section area = 37.440 (cm²)

2.3.7 Deflection calculation

Calculate deflection when bending moment is maximum in a simple beam section

$$Del. = \frac{5Mmaxl^2}{48EI} * (1.0+i) + \frac{5Mdl^2}{48EI} = 0.000\ (cm) <= 0.500\ (cm)$$

where
Mmax: bending moment by load = 0.000 (kN.m)
(Truck load(Parallel))
Md : bending moment by dead load = 0.662 (kN.m)
i : impact coefficient = 0.300
l : span length = 200.000 (cm)
I : moment of inertia of area = 39800.000 (cm⁴)
E : Young's modulus = $2.0*10^5$(N/mm²)

2.4 Support pile Design

2.4.1 The axial force and horizontal force of Support pile for each load

		axial force at max		horizontal force (kN)
		Support pileNo.	axial force (kN)	
truck load	orthogonal	----	--------	--------
	parallel	2	257.972	69.333
crawler crane	moving-orthogonal	----	--------	--------
	moving-parallel	3	252.612	96.000
	0 degree-orthogonal	----	--------	--------
	0 degree-parallel	3	289.728	106.000
	90 degree-orthogonal	----	--------	--------
	90 degree-parallel	3	369.242	106.000
	45 degree-orthogonal	----	--------	--------
	45 degree-parallel	3	368.297	106.000
truck crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	194.778	36.889
	working-orthogonal	----	--------	--------
	working-parallel	----	--------	--------

2.4.2 Axial force calculation for member design

Calculate for the load condition when axial force is maximum

For pile stress and bearing capacity of Support pile,use maximum axial force multiplied by 1/1 .

1) Load condition Crawler crane side hang(Parallel)

2) Support pile Number 3

Checking Support pile left Simple beam part

Checking Support pile left section Number of Main girder = 1

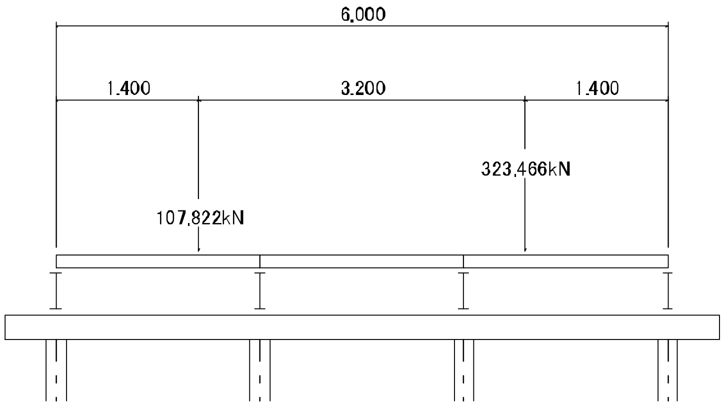
No.	Main girder No.
1	G 2

Checking Support pile right Simple beam part

Checking Support pile right section Number of Main girder = 1

No.	Main girder No.
1	G 3

3) calculate max axial force
simple beam + simple beam



axial force by fixed load
Nd = Ndl + Ndr + nd = 74.889 (kN)
where
Ndl : axial force by fixed load on simple beam (left)
Ndl = Sig.(Rdi * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rdi (kN)	lLi (m)
1	G 2	34.122	0.000

Ndr : axial force by fixed load on simple beam (right)
Ndr = Sig.(Rdj * lRj) / lk2 = 34.122 (kN)

No.	Main girder No.	Rdj (kN)	lRj (m)
1	G 3	34.122	2.000

nd : axial force by self-weight
Beam seat Self weight 1.324 * ((lk1 + lk2) / 2.0) = 2.648 (kN)
Hori. joint 0.182 * ls1 * 2 = 0.728 (kN)
Hori. brace 0.000 * ls2 = 0.000 (kN)
Vert. brace 0.146 * lv = 0.826 (kN)
Support pile Self weight 1.687 * lKUI = 36.564 (kN)
other load = 0.000 (kN)
----
total 40.767 (kN)
where
lk1 : left span length of simple beam = 2.000 (m)
lk2 : right span length of simple beam = 2.000 (m)
ls1 : Hori. joint Length = 2.000 (m)
ls1 = ((lk1+lk2) / 2.0) * 1
ls2 : Hori. brace Length = 0.000 (m)
lv : Vert. brace Length = 5.657 (m)
lv = Sig.lvn
$lv1 = \sqrt{lk1^2 + 2.000^2} + \sqrt{lk2^2 + 2.000^2}$ = 5.657 (m)
lKUI : Support pile Length = 21.674 (m)

axial force by load

Nj = Njl + Njr = 226.426 (kN)

where

Njl : axial force by load on simple beam(left)

Njl = Sig.(Rji * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rji (kN)	lLi (m)
1	G 2	75.475	0.000

Njr : axial force by load on simple beam(right)

Njr = Sig.(Rjj * lRj) / lk2 = 226.426 (kN)

No.	Main girder No.	Rjj (kN)	lRj (m)
1	G 3	226.426	2.000

member design axial force

fixed load = 74.889 (kN)

load = 226.426 (kN)

impact 226.426 * 0.300 = 67.928 (kN)

----

total N = 369.242 (kN)

member design axial force is 1/1 N * 1/1 = 369.242 (kN)

2.4.3 Horizontal force calculation

1) horizontal force by fixed load

Hd = (W1 + W2 + W3 + W4 + W5 + W6 + W7) * kh = 25.284 (kN)

W1 : weight of steel deck* nominal load

W1 = (Wf1 * Bf1 + Wf2 * Bf2) * (l + lside) / 2.0 = 72.000 (kN)

Wf1 : steel deck 2m+ nominal load = 2.000 (kN/m²)
Bf1 : steel deck 2m+ width direction = 6.000 (m)
Wf2 : steel deck 3m+ nominal load = 2.000 (kN/m²)
Bf2 : steel deck 3m+ width direction = 0.000 (m)
l : span length = 6.000 (m)
lside : adjacent span length = 6.000 (m)

W2 : dead load weight of wheel guard

W2 = (WL + WR) * (l + lside) / 2.0 = 0.000 (kN)

WL : dead load of left wheel guard = 0.000 (kN/m)
WR : dead load of right wheel guard = 0.000 (kN/m)

W3 : Main girder Weight

W3 = N * WN * (l + lside) / 2.0 = 40.488 (kN)

N : Main girder Members number = 4
WN : Main girder Self weight = 1.687 (kN/m)

W4 : Beam seat Weight

W4 = WH * lH = 9.268 (kN)

WH : Beam seat Self weight = 1.324 (kN/m)
lH : Beam seat length = 7.000 (m)

W5 : Hori. joint Weight

W5 = Ws1 * ls1 * 2 = 2.184 (kN)

Ws1 : Hori. joint Weight = 0.182 (kN/m)
ls1 : Hori. joint Length = 6.000 (m)

W6 : Hori. brace Weight

W6 = Ws2 * ls2 / 2.0 = 0.000 (kN)

Ws2 : Hori. brace Self weight = 0.000 (kN/m)
ls2 : Hori. brace Extension = 0.000 (m)

W7 : Vert. brace Weight

W7 = Wv * lv = 2.479 (kN)

Wv : Vert. brace Self weight = 0.146 (kN/m)
lv : Vert. brace Extension = 16.971 (m)

kh : coefficient for horizontal force estimate

kh = 0.200

2) horizontal load by horizontal force

Hj = R * kh = 106.000 (kN)

R : load case [Crawler crane font hang(Parallel)]

R = W + T = 530.000 (kN)

where

W: heaviest machine weight = 480.000 (kN)

In case truck load, reaction force by truck load on working platform is taken.

T : lifting load(zero when truck load) = 50.000 (kN)

kh : coefficient for horizontal force estimate

kh = 0.200

3) sum of horizontal force

```
fixed load                    =  25.284 (kN)
load                          = 106.000 (kN)
impact     106.000 * 0.300    =  31.800 (kN)
-----------------------------------------------
total                         = 163.084 (kN)
```

2.4.4 Bending moment by horizontal force(pile top fixed)

Calculate bending moment and displacement using Chang's equation assuming infinite pile.
Since top of support pile are connected with lateral beams, horizontal force at top of transmits to the bottom of lateral beams.
Use bigger value either constrained moment at pile top or max bending moment in subground.

horizontal force on Support pile

H = Sig.H / n = 40.771 (kN)

where

Sig.H : horizontal force acting on one frame plane = 163.084 (kN)

n : Support pileMembers number = 4

constrained moment at pile top

Mo = (1 + Betah) * H / 2Beta = 146.301 (kN.m)

max bending moment in subground

Mmax = - H / 2Beta * (1 + (Betah)^{2})$^{1/2}$ * exp (- Betalm) = 85.010 (kN.m)

depth at max bending moment in subground

lm = 1 / Beta * tan^{-1}(1 / Betah) = 0.548 (m)

horizontal displacement at pile top

Del. = ((1 + Betah)^{3}+ 2) * H / (12 EIBeta^{3}) = 2.885 (cm)

where

h : above ground length = 5.424 (m)

I : Support pilearea moment of inertia = 22400.000 (cm^{4})

E : Support pileYoung modulus = 2.000 * 10^{5}(N/mm^{2})

pile characteristic value

Beta = ^{4}ã(kh* D / (4EI)) = 0.00571 (1/cm)

where

D : Support pilewidth = 40.000 (cm)

subgrade reaction coefficient in lateral direction

kh = kho* (BH/30)$^{-3/4}$ = 47.470 (N/cm^{3})

kho = 1/30* Alp.* Eo = 102.667 (N/cm^{3})

BH = (D/Beta)$^{1/2}$ = 83.908 (cm)

where

BH : pile conversion width of load

Alp.* Eo: average Alp.* Eo in range of 1/Beta = 3080.000 (N/cm^{2})

2.4.5 Support pile buckling stability check

Because Support pile buckling possibly occur under axial direction force and bending moment, check the stability on buckling using next 2 equations.

Sig.c / Sig.caz + Sig.bcz / { Sig.bao * (1 - Sig.c / Sig.eaz) }
= 0.786 <= 1.0

Sig.c + Sig.bcz / (1 - Sig.c / Sig.eaz)
= 157.499 <= Sig.cal

where

Sig.c : compressive stress in axial direction = 16.884 (N/mm²)

Sig.bcz : moment compressive stress by bending moment around weak axis.
Sig.bcz = Mz / zz = 130.626 (N/mm²)

Sig.caz : allowable compressive stress in axial direction around weak axis = 144.740(N/mm²)
lk/r <= 18 --- Sig.caz = 210
18 < lk/r <= 92 --- Sig.caz = { 140 - 0.82 * (lk/r - 18) } * 1.50
92 < lk/r --- Sig.caz = 1200000 / { 6700 + (lk/r)²} * 1.50
lk/r = 717.673 / 10.100 = 71.057

Sig.bao : upper limit of allowable compressive stress without local buckling
= 210.000 (N/mm²)

Sig.cal : allowable stress of free extension plate under comp stress about local buckling
where b' <= 13.1t' = 210.000 (N/mm²)

Sig.eaz : Euler buckling strength around weak axis
Sig.eaz = 1200000 / (lk/rz)² = 237.668 (N/mm²)

N : Support pile acting axial force = 369.242 (kN)

Mz : bending moment around z axis = 146.301 (kN.m)

lk : buckling length = 717.673 (cm)

lLow: lowest design span, height at lowest is added 1/Beta(lk reference value, fixed value).
lLow = lLow' + 1/Beta = 542.400 + 175.273 = 717.673
where,
lLow' : height at lowest = 542.400 (cm)
Beta : characteristic value
Beta = ⁴ã(kh* D / (4EI)) = 0.00571 (1/cm)
where
I : Support pilearea moment of inertia = 22400.000 (cm⁴)
E : Support pileYoung modulus = 2.000 * 10^5(N/mm²)
D : Support pilewidth = 40.000 (cm)
kh : lateral subgrade reaction = 47.470 (N/cm³)

use steel member, H-400x400x13x2(Weak)
A : cross sectional area of steel material = 218.700 (cm²)
zz : section modulus around z axis = 1120.000 (cm³)
ry : radius of gyration of area around y axis = 17.500 (cm)
rz : radius of gyration of area around z axis = 10.100 (cm)

Shear stress

horizontal force acting on weak axis of post.
Tau = H / (2 * Af) = 2.427 <= 120.000 (N/mm²)
H : Support pileworking horizontal force = 40.771 (kN)
Af : Support pileFlange area = 84.000 (cm²)

FORUM8

2.4.6 Support pile bearing capacity examination

allowable bearing capacity

Ra = { qd* A + uSig.lifi }/ 2.0 = 473.600 (kN)

(construction method: driving)

where

qd: ultimate bearing capacity at tip ground = 2900.00

qd = 200Alp.N

N : Support pileN value of soil layer at tip= 14.50

N = (N1 + N2) / 2

upper limit is 40.

N1: Support pileN value at tip position = 16.00

N2: Support pile in the range of 2m above from tip

average N-value = 13.00

A : Support piletip area = 0.16 (m²)

u : Support pilePerimeter = 1.600 (m)

li: thickness to be considered circumference friction

fi: maximum skin friction in the layer considered friction

fi=2BetaNs(sand)

Ns upper limit is 50.

fi=10BetaNc(Nc:N-value) , fi=BetaNc(Nc:cohesion)(clay)

where, Nc(N-value 10* Nc) upper limit is 150.

Sig.lifi: circumference friction = 302.000

li(m)	Ns	Nc	fi(kN/m²)	li* fi
5.000	11.0	------	22.000	110.000
4.000	11.0	------	22.000	88.000
4.000	8.0	------	16.000	64.000
1.250	16.0	------	32.000	40.000

Alp. : coefficient of tip bearing capacity for construction method = 1.0

Beta : coefficient of skin friction for construction method = 1.0

max axial force acting on Support pile Crawler crane side hang(Parallel)

N max = 369.242 (kN) <= 473.600 (kN)

2.5 Hori. joint Design

2.5.1 Hori. joint checking

Design Hori. joint as a member receiving compression force.
load condition   Crawler crane font hang(Parallel)
compression force acting on Hori. joint
share the horizontal force receiving on a frame plane by single Hori. joint.
Set both sides of Support pile
N = H / 2 = 81.542 (kN)
Sig.c = N / A = 34.391 (N/mm^2) <= Sig.ca = 123.770 (N/mm^2)
where
H : compressive force acting on a frame plane = 163.084 (kN)
Sig.c : axial direction compressive stress
Sig.ca : allowable axial direction compressive stress = 123.770 (N/mm^2)
l/r <= 18 --- Sig.ca = 210
18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r - 18) } * 1.50
92 < l/r --- Sig.ca = 1200000 / {6700 + $(l/r)^2$} * 1.50
l/r = 88.106
Use steel material [-150x75x6.5x10
A : cross sectional area of steel material = 23.710(cm^2)
l : buckling length = 2.000(m)
r : radius of gyration of area around weak axis = 2.270(cm)

2.5.2 Connection part checking

compression force acting on Hori. joint
T = 81.542 (kN)
required length for welding part
l = T / (0.7rho* s) = 38.829 (cm)
rho : allowable stress of welding joint = 100.000 (N/mm^2)
s : foot length = 0.300 (cm)

2.6 Vert. brace Design

2.6.1 Vert. brace checking

design Vert. brace as a member receiving Compressive force
load condition   Crawler crane font hang(Parallel)
horizontal force shared by Vert. brace
share the horizontal force receiving on a frame plane by number of Vert. brace
Hv = H / n = 54.361 (kN)
force Vert. brace acting on Compressive
T = Hv / cos(Theta) = 76.878 (kN)
cos(Theta) = l / $(l^2 + h^2)^{1/2}$ = 0.707
where
l : Support pileThe most shortest spacing(length) = 2.000 (m)
h : Hori. jointlongest spacing = 2.000 (m)
Compressive stress
Sig.c = T / A = 40.462 (N/mm^2) <= Sig.ca = 64.891 (N/mm^2)
where
Sig.ca : allowable axial direction compressive stress = 64.891 (N/mm^2)
l/r <= 18 --- Sig.ca = 210
18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r - 18) } * 1.50
92 < l/r --- Sig.ca = 1200000 / {6700 + $(l/r)^2$} * 1.50
l/r = 145.048
Use steel material L-100x100x10
A : effective cross sectional area of steel material = 19.000 (cm^2)
l : buckling length = 2.828 (m)
r : radius of gyration of area = 1.950 (cm)

2.6.2 Connection part checking

force Compressive acting on a brace member

T = 76.878 (kN)

required length for welding part

l = T / (0.7rho* s) = 36.609 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.7 Summary export

2.7.1 Steel deck summary report

steel deck : steel deck type2

1) check regarding to bending moment

load condition	Truck load(Parallel)			
name of steel deck	Steel deck type 2 (1000*2000)			
bending moment due to fixed load	Md =	1.000 (kN.m)		
bending moment due to load	Mmax =	58.332 (kN.m)		
design bending moment	M =	23.533 (kN.m)		
bending stress	Sig. =	75.426 <=	210.000	(N/mm²)

2) check regarding to shear force

load condition	Truck load(Parallel)			
name of steel deck	Steel deck type 2 (1000*2000)			
shear force due to fixed load	Sd =	2.000 (kN)		
shear force due to load	Smax =	140.000 (kN)		
design shear force	S =	56.400 (kN)		
shear stress	Tau =	69.630 <=	120.000	(N/mm²)

2.7.2 Main girder Summary report

1) calculate bending moment
load condition Crawler crane diagonal hang(Parallel)
design object Main girder number 2 of

fixed load		=	25.592(kN.m)
load		=	287.922(kN.m)
impact	287.922 * 0.300	=	86.377(kN.m)
total		=	399.891(kN.m)

2)calculate shear force
load condition Crawler crane diagonal hang(Parallel)
design object Main girder number 2

fixed load		=	17.061(kN)
load		=	201.657(kN)
impact	201.657 * 0.300	=	60.497(kN)
total		=	279.215(kN)

3)checking stress
using member H-400x400x13x21

web section area	Aw =	46.540 cm²
section modulus	Z =	3330.000 cm³

bending stress	Sig. = M / Z	= 120.087 (N/mm²)
allowable bending stress	Sig.ba	= 172.200 (N/mm²)
shear stress	Tau = S / Aw	= 59.995 (N/mm²)
allowable shear stress	fs	= 120.000 (N/mm²)

4)deformation
Calculate deformation when bending moment is maximum in a load condition

deformation	Del. =	1.1258 (cm)
allowable deformation	Del.a =	1.5000 (cm)

2.7.3 Beam seat Summary report

1)Calculate bending moment
load condition Truck load(Parallel)
design section 2 Simple beam part

fixed load		=	0.662(kN.m)
load		=	0.000(kN.m)
impact	0.000 * 0.300	=	0.000(kN.m)
--			
tototal		=	0.662(kN.m)

2)Calculate shear force
load condition Crawler crane side hang(Parallel)
design section 2 Simple beam part

fixed load		=	35.446(kN)
load		=	226.426(kN)
impact	226.426 * 0.300	=	67.928(kN)
--			
total		=	329.800(kN)

3)checking stresses
material H-350x350x12x19
web section area Aw = 37.440 cm²
section modulus Z = 2280.000 cm³

bending stress Sig. = M / Z = 0.290 (N/mm²)
allowable bending stress Sig.ba = 205.629 (N/mm²)
shear stress Tau = S / Aw = 88.088 (N/mm²)
allowable shear stress Taua = 120.000 (N/mm²)

4)deflection
Calculate deflection when bending moment by live load is at max..
deflection Del. = 0.0003 (cm)
allowable deflection Del.a = 0.5000 (cm)

2.7.4 Support pile Summary report

1)load condition that weight on working platform is max. Crawler crane side hang(Parallel)
(axial force for member design)

2)Support pile number 3

3)calculation of axial force

fixed load			=	74.889 (kN)
load			=	226.426 (kN)
impact	226.426 *	0.300	=	67.928 (kN)
total	369.242 *	1/1	=	369.242 (kN)

4)calculation of horizontal force

fixed load			=	25.284 (kN)
load			=	106.000 (kN)
impact	106.000 *	0.300	=	31.800 (kN)
total				163.084 (kN)

5)bending moment by horizontal force

Support pile horizontal force acting on single member = 40.771 (kN)
maximum bending moment = 146.301 (kN.m)

6)Support pile strength check

material used H-400x400x13x2(Weak)

cross sectional area	A	=	218.700 cm^2
section modulus	Z	=	1120.000 cm^3
radius of gyration of area around y axis	Ry	=	17.500 cm
radius of gyration of area around z axis	Rz	=	10.100 cm
flange width	B	=	40.000 cm
web section area	Aw	=	84.000 cm^2

Sig.c/Sig.caz + Sig.bcz/{Sig.bao * (1-Sig.c/Sig.eaz)} = 0.786 <= 1.000
Sig.c + Sig.bcz/(1-Sig.c/Sig.eaz) = 157.499 <= 210.000

7) check bearing capacity Support pile

max axial force on Support pile Crawler crane side hang(Parallel)
Nmax = 369.242 <= 473.600 (kN)

2.8 List table

2.8.1 Steel deck List

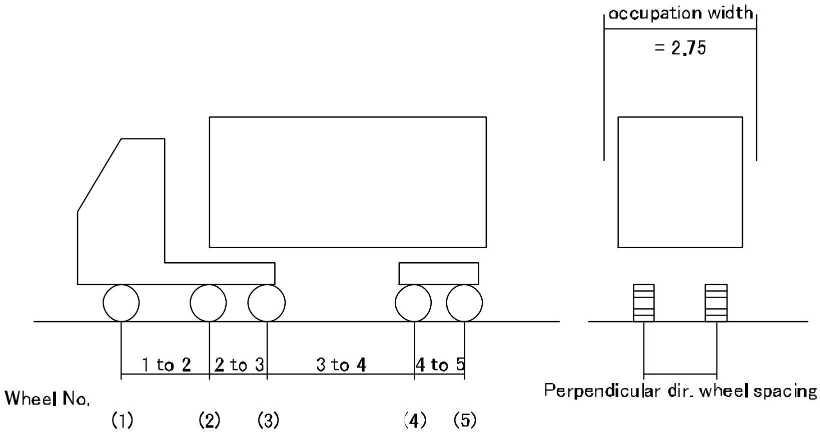
steel deck	name	Steel deck type 2 (1000*2000)
	bending moment max Mmax Sig.	Truck load(Parallel) 58.332 (kN m) 75.426 <= 210.000 (N/mm²)
	shear force max Smax Tau	Truck load(Parallel) 140.000 (kN) 69.630 <= 120.000 (N/mm²)

2.8.2 Member list table

Main girder	use	H-400x400x13x21
	bending moment max Mmax Sig.	Crawler crane diagonal hang(Parallel) 399.891 (kN.m) 120.087 <= 172.200 (N/mm²)
	shear force max Smax Tau	Crawler crane diagonal hang(Parallel) 279.215 (kN) 59.995 <= 120.000 (N/mm²)
	deflection Del.	Crawler crane diagonal hang(Parallel) 1.126 <= 1.500 (cm)
Beam seat (Support pile)	use	H-350x350x12x19
	bending moment max Mmax Sig.	Truck load(Parallel) 0.662 (kN.m) 0.290 <= 205.629 (N/mm²)
	shear force max Smax Tau	Crawler crane side hang(Parallel) 329.800 (kN) 88.088 <= 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.000 <= 0.500 (cm)
Support pile	use	H-400x400x13x2(Weak)
	load(section) load(bearing capacity)	Crawler crane side hang(Parallel) Crawler crane side hang(Parallel)
	force	N = 369.242 (kN) M = 146.301 (kN.m) S = 40.771 (kN) Sig.c = 16.884 Sig.b = 130.626 (N/mm²) Tau = 2.427 <= Taua = 120.000 (N/mm²)
	check buckling	eq-1 ------- 0.786 <= 1.000 eq-2 ------- 157.499 <= 210.000 (N/mm²)
	bearing capacity	369.242 <= 473.600 (kN)
Hori. joint	use	[-150x75x6.5x10
	cmpr stress Sig.c	34.391 <= 123.770 (N/mm²) (N= 81.542kN)
Hori. jointJoint part	required welding length	38.829 (cm)
Vert. brace	use	L-100x100x10
	cmpr stress Sig.c	40.462 <= 64.891 (N/mm²) (T= 76.878kN)
Vert. braceJoint part	required welding length	36.609 (cm)

3 Registered load data export

3.1 Truck load



1	name : TT43		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	30.000	3.250
	2	65.000	7.800
	3	60.000	1.550
	4	60.000	------------------------------------

2	name : T25		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	4.000
	2	100.000	------------------------------------

3	name : T20		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.000
	2	80.000	------------------------------------

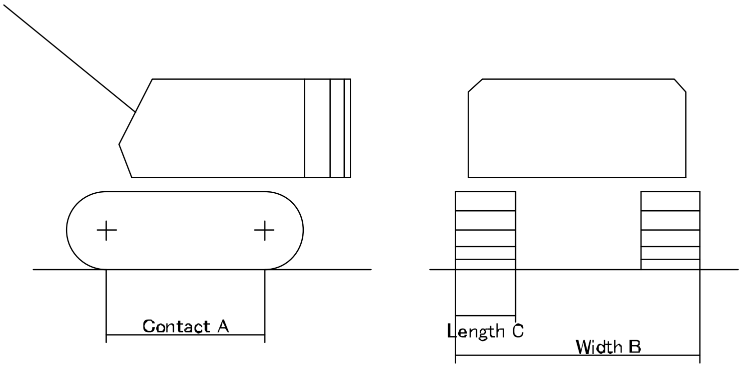
4	name : T14		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	14.000	4.000
	2	56.000	------------------------------------

5	name : Ready mixed concrete Truck(3 cubic meters)		
	wheel distance in perpendicular direction = 1.08 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.200
	2	54.000	------------------------------------

6	name : Ready mixed concrete Truck(5 cubic meters)		
	wheel distance in perpendicular direction = 1.88 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	3.160
	2	55.000	1.880
	3	30.000	------------------------------------

7	name : Surplus soil Truck	
	wheel distance in perpendicular direction = 1.90 (m)	
	load intsty(1 side)(kN)	wheel distance in moving direction(m)
1	34.000	4.000
2	63.000	------------------------------------

3.2 Crawler crane



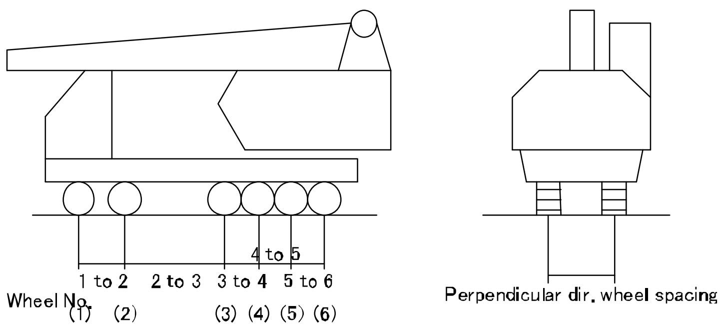
1	name : D408S			
	self weight =	480.000(kN)	90 degree distribution ratio =	0.800
	lifting load =	50.000(kN)	0 degree distribution ratio =	0.600
	contact length A =	4.470(m)	45 degree distribution ratio =	0.700
	width B =	4.000(m)	45 degree contact ratio =	0.900
	contact width C =	0.800(m)		

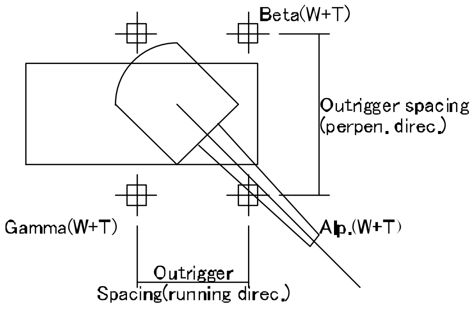
2	name : P&H440S			
	self weight =	400.000(kN)	90 degree distribution ratio =	0.800
	lifting load =	50.000(kN)	0 degree distribution ratio =	0.600
	contact length A =	4.380(m)	45 degree distribution ratio =	0.700
	width B =	3.960(m)	45 degree contact ratio =	0.900
	contact width C =	0.760(m)		

3	name : P&H335AS			
	self weight =	350.000(kN)	90 degree distribution ratio =	0.800
	lifting load =	30.000(kN)	0 degree distribution ratio =	0.600
	contact length A =	4.280(m)	45 degree distribution ratio =	0.700
	width B =	3.790(m)	45 degree contact ratio =	0.900
	contact width C =	0.590(m)		

4	name : P&H325			
	self weight =	280.000(kN)	90 degree distribution ratio =	0.800
	lifting load =	30.000(kN)	0 degree distribution ratio =	0.600
	contact length A =	3.950(m)	45 degree distribution ratio =	0.700
	width B =	3.030(m)	45 degree contact ratio =	0.900
	contact width C =	0.590(m)		

3.3 Truck crane





1	name : NK-300		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	32.000	3.850
	2	64.000	1.350
	3	64.000	--
	self weight W= 320.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.750(m) outrigger distance(perpendicular) = 5.600(m) outrigger width = 0.500(m)

2	name : NK-200		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.980
	2	40.000	1.240
	3	40.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.450(m) outrigger distance(perpendicular) = 4.800(m) outrigger width = 0.400(m)

3	name : Rough terrain crane 20tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.000
	2	80.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 5.700(m) outrigger distance(perpendicular) = 5.700(m) outrigger width = 0.400(m)

4	name : Rough terrain crane 25tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	25.000	3.500
	2	100.000	--
	self weight W= 250.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 6.300(m) outrigger distance(perpendicular) = 6.200(m) outrigger width = 0.400(m)

No.	name : Rough terrain crane 40tons	
	wheel distance in perpendicular direction = 2.10 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
5	1 35.000	4.250
	2 140.000	--
	self weight W= 350.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 7.300(m) outrigger distance(perpendicular) = 6.500(m) outrigger width = 0.500(m)

No.	name : KA-900	
	wheel distance in perpendicular direction = 2.30 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
6	1 38.850	1.650
	2 38.850	2.400
	3 27.250	1.650
	4 27.250	--
	self weight W= 264.400(kN) lifting load T= 800.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 8.700(m) outrigger distance(perpendicular) = 7.400(m) outrigger width = 0.500(m)

4 Registered member data export

4.1 Main girder Registered data

No.	name : H-300x300x10x15	
1	unit weight = 912.0 (N/m) web section area Aw = 27.00(cm²) moment of inertia I = 20200.0(cm⁴) beam height h = 30.0(cm) web thickness t1 = 1.00(cm)	flange section area Af = 45.00(cm²) section modulus Z = 1350.0(cm³) lateral buckling radius i = 8.23(cm) compressive flange width b = 30.0(cm) compressive flange thickness t2 = 1.50(cm)

No.	name : H-350x350x12x19	
2	unit weight = 1324.0 (N/m) web section area Aw = 37.44(cm²) moment of inertia I = 39800.0(cm⁴) beam height h = 35.0(cm) web thickness t1 = 1.20(cm)	flange section area Af = 66.50(cm²) section modulus Z = 2280.0(cm³) lateral buckling radius i = 9.65(cm) compressive flange width b = 35.0(cm) compressive flange thickness t2 = 1.90(cm)

No.	name : H-400x400x13x21	
3	unit weight = 1687.0 (N/m) web section area Aw = 46.54(cm²) moment of inertia I = 66600.0(cm⁴) beam height h = 40.0(cm) web thickness t1 = 1.30(cm)	flange section area Af = 84.00(cm²) section modulus Z = 3330.0(cm³) lateral buckling radius i = 11.00(cm) compressive flange width b = 40.0(cm) compressive flange thickness t2 = 2.10(cm)

No.	name : H-594x302x14x23	
4	unit weight = 1667.0 (N/m) web section area Aw = 76.72(cm²) moment of inertia I = 134000.0(cm⁴) beam height h = 59.4(cm) web thickness t1 = 1.40(cm)	flange section area Af = 69.46(cm²) section modulus Z = 4500.0(cm³) lateral buckling radius i = 7.96(cm) compressive flange width b = 30.2(cm) compressive flange thickness t2 = 2.30(cm)

No.	name : H-900x300x16x28	
5	unit weight = 2354.0 (N/m) web section area Aw = 135.04(cm²) moment of inertia I = 404000.0(cm⁴) beam height h = 90.0(cm) web thickness t1 = 1.60(cm)	flange section area Af = 84.00(cm²) section modulus Z = 8990.0(cm³) lateral buckling radius i = 7.68(cm) compressive flange width b = 30.0(cm) compressive flange thickness t2 = 2.80(cm)

No.						
6	name : H 912x302x18x34					
	unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm^2)
	web section area	Aw =	151.92(cm^2)	section modulus	Z =	10800.0(cm^3)
	moment of inertia	I =	491000.0(cm^4)	lateral buckling radius	i =	7.84(cm)
	beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)

No.						
7	name : H 250x250x9x14					
	unit weight	=	718.0 (N/m)	flange section area	Af =	35.00(cm^2)
	web section area	Aw =	19.98(cm^2)	section modulus	Z =	860.0(cm^3)
	moment of inertia	I =	10700.0(cm^4)	lateral buckling radius	i =	6.91(cm)
	beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4.2 Beam seat H-Beam registered data

No.						
1	name : H 300x300x10x15					
	unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm^2)
	web section area	Aw =	27.00(cm^2)	section modulus	Z =	1350.0(cm^3)
	moment of inertia	I =	20200.0(cm^4)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)

No.						
2	name : H 350x350x12x19					
	unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm^2)
	web section area	Aw =	37.44(cm^2)	section modulus	Z =	2280.0(cm^3)
	moment of inertia	I =	39800.0(cm^4)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)

No.						
3	name : H 400x400x13x21					
	unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm^2)
	web section area	Aw =	46.54(cm^2)	section modulus	Z =	3330.0(cm^3)
	moment of inertia	I =	66600.0(cm^4)	lateral buckling radius	i =	11.00(cm)
	beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)

No.						
4	name : H 594x302x14x23					
	unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm^2)
	web section area	Aw =	76.72(cm^2)	section modulus	Z =	4500.0(cm^3)
	moment of inertia	I =	134000.0(cm^4)	lateral buckling radius	i =	7.96(cm)
	beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)

No.						
5	name : H 900x300x16x28					
	unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm^2)
	web section area	Aw =	135.04(cm^2)	section modulus	Z =	8990.0(cm^3)
	moment of inertia	I =	404000.0(cm^4)	lateral buckling radius	i =	7.68(cm)
	beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)

No.						
6	name : H 912x302x18x34					
	unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm^2)
	web section area	Aw =	151.92(cm^2)	section modulus	Z =	10800.0(cm^3)
	moment of inertia	I =	491000.0(cm^4)	lateral buckling radius	i =	7.84(cm)
	beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)

No.						
7	name : H 250x250x9x14					
	unit weight	=	704.0 (N/m)	flange section area	Af =	35.00(cm^2)
	web section area	Aw =	19.98(cm^2)	section modulus	Z =	860.0(cm^3)
	moment of inertia	I =	10700.0(cm^4)	lateral buckling radius	i =	6.91(cm)
	beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4.3 Beam seat one side U steel

No.						
	name : [-250x90x9x13					
1	unit weight	=	339.0(N/m)	section area	Af =	44.07(cm²)
	web section area	Aw =	20.16(cm²)	section modulus	Z =	335.0(cm³)
	moment of inertia	I =	4180.0(cm⁴)	area gyration radius	i =	2.58(cm)
	web height	h =	25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)
	name : [-300x90x9x13					
2	unit weight	=	374.0(N/m)	section area	Af =	48.57(cm²)
	web section area	Aw =	24.66(cm²)	section modulus	Z =	429.0(cm³)
	moment of inertia	I =	6440.0(cm⁴)	area gyration radius	i =	2.52(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)
	name : [-300x90x10x15.5					
3	unit weight	=	430.0(N/m)	section area	Af =	55.74(cm²)
	web section area	Aw =	26.90(cm²)	section modulus	Z =	494.0(cm³)
	moment of inertia	I =	7410.0(cm⁴)	area gyration radius	i =	2.54(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.55(cm)
	name : [-380x100x10.5x16					
4	unit weight	=	534.0(N/m)	section area	Af =	69.39(cm²)
	web section area	Aw =	36.54(cm²)	section modulus	Z =	763.0(cm³)
	moment of inertia	I =	14500.0(cm⁴)	area gyration radius	i =	2.78(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.05(cm)	compressive flange thickness	t2 =	1.60(cm)
	name : [-380x100x13x20					
5	unit weight	=	660.0(N/m)	section area	Af =	85.71(cm²)
	web section area	Aw =	44.20(cm²)	section modulus	Z =	926.0(cm³)
	moment of inertia	I =	17600.0(cm⁴)	area gyration radius	i =	2.76(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.00(cm)

4.4 Beam seat L section steel Registered data

No.						
	name : L-65x65x6					
1	unit weight	=	58.0(N/m)	section area	A =	7.527(cm²)
	area gyration radius	iy =	1.98(cm)			
	angle edge width	B =	6.5(cm)	thickness	t =	0.60(cm)
	name : L-75x75x6					
2	unit weight	=	67.2(N/m)	section area	A =	8.727(cm²)
	area gyration radius	iy =	2.30(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.60(cm)
	name : L-75x75x9					
3	unit weight	=	97.7(N/m)	section area	A =	12.690(cm²)
	area gyration radius	iy =	2.25(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.90(cm)
	name : L-90x90x10					
4	unit weight	=	130.4(N/m)	section area	A =	17.000(cm²)
	area gyration radius	iy =	2.71(cm)			
	angle edge width	B =	9.0(cm)	thickness	t =	1.00(cm)
	name : L-100x100x10					
5	unit weight	=	146.1(N/m)	section area	A =	19.000(cm²)
	area gyration radius	iy =	3.04(cm)			
	angle edge width	B =	10.0(cm)	thickness	t =	1.00(cm)

4.5 Support pile Registered data

No.	name : H-300x300x10x15(Weak)			
1	unit weight =	912.0 (N/m)	section area A =	118.40(cm^2)
	flange section area Af =	45.00(cm^2)	web section area Aw =	27.00(cm^2)
	action direction =	weak	area gyration radius iy =	13.10(cm)
	area gyration radius iz =	7.55(cm)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
	section modulus Z =	450.0(cm^3)	moment of inertia I =	6750.0(cm^4)
	pile tip area =	900.0(cm^2)	pile circumference =	120.0(cm)
	pile diameter =	30.0(cm)	pile unit weight =	912.0(N/m)

No.	name : H-300x300x10x15(Strong)			
2	unit weight =	912.0 (N/m)	section area A =	118.40(cm^2)
	flange section area Af =	45.00(cm^2)	web section area Aw =	27.00(cm^2)
	action direction =	strong	area gyration radius iy =	13.10(cm)
	area gyration radius iz =	7.55(cm)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
	section modulus Z =	1350.0(cm^3)	moment of inertia I =	20200.0(cm^4)
	pile tip area =	900.0(cm^2)	pile circumference =	120.0(cm)
	pile diameter =	30.0(cm)	pile unit weight =	912.0(N/m)

No.	name : H-350x350x12x19･Weak)			
3	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	weak	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	776.0(cm^3)	moment of inertia I =	13600.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

No.	name : H-350x350x12x19(Strong)			
4	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	strong	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	2280.0(cm^3)	moment of inertia I =	39800.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

No.	name : H-400x400x13x2(Weak)			
5	unit weight =	1687.0 (N/m)	section area A =	218.70(cm^2)
	flange section area Af =	84.00(cm^2)	web section area Aw =	46.54(cm^2)
	action direction =	weak	area gyration radius iy =	17.50(cm)
	area gyration radius iz =	10.10(cm)	lateral buckling radius i =	11.00(cm)
	beam height h =	40.0(cm)	compressive flange width b =	40.0(cm)
	web thickness t1 =	1.30(cm)	compressive flange thickness t2 =	2.10(cm)
	section modulus Z =	1120.0(cm^3)	moment of inertia I =	22400.0(cm^4)
	pile tip area =	1600.0(cm^2)	pile circumference =	160.0(cm)
	pile diameter =	40.0(cm)	pile unit weight =	1686.8(N/m)

4.6 Hori. joint Registered data

No.	name : [-150x75x6.5x10			
1	unit weight =	182.0(N/m)	section area A =	23.71(cm^2)
	area gyration radius iy =	2.27(cm)		
	web height h =	15.0(cm)	compressive flange width b =	7.5(cm)
	web thickness t1 =	0.65(cm)	compressive flange thickness t2 =	1.00(cm)

No.	name : [-200x90x8x13.5			
2	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

3	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area A =	44.07(cm²)
	area gyration radius iy =	2.64(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

4.7 Vert. brace Registered data

1	name : L-65x65x6			
	unit weight =	58.00(N/m)	section area A =	7.527(cm²)
	area gyration radius iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm²)
	area gyration radius iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm²)
	area gyration radius iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

4	name : L-90x90x10			
	unit weight =	130.40(N/m)	section area A =	17.000(cm²)
	area gyration radius iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

5	name : L-100x100x10			
	unit weight =	146.10(N/m)	section area A =	19.000(cm²)
	area gyration radius iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.8 Hori. brace Registered data

1	name : L-65x65x6			
	unit weight =	58.00(N/m)	section area A =	7.527(cm²)
	moment of inertia iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm²)
	moment of inertia iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm²)
	moment of inertia iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

4	name : L-90x90x10			
	unit weight =	130.40(N/m)	section area A =	17.000(cm²)
	moment of inertia iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

5	name : L-100x100x10			
	unit weight =	146.10(N/m)	section area A =	19.000(cm²)
	moment of inertia iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.9 Lateral joint member 1 side U steel Registered data

1	name : [-200x90x8x13.5			
	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

2	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area A =	44.07(cm^2)
	area gyration radius iy =	2.58(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

3	name : [-300x90x9x13			
	unit weight =	374.0(N/m)	section area A =	48.57(cm^2)
	area gyration radius iy =	2.52(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

4	name : [-300x90x10x15.5			
	unit weight =	430.0(N/m)	section area A =	55.74(cm^2)
	area gyration radius iy =	2.54(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.55(cm)

4.10 Lateral joint member L section steel Registered data

1	name : L-65x65x6			
	unit weight =	58.0(N/m)	section area A =	7.527(cm^2)
	area gyration radius iy =	1.98(cm)		
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.2(N/m)	section area A =	8.727(cm^2)
	area gyration radius iy =	2.30(cm)		
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.7(N/m)	section area A =	12.690(cm^2)
	area gyration radius iy =	2.25(cm)		
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

4	name : L-90x90x10			
	unit weight =	130.4(N/m)	section area A =	17.000(cm^2)
	area gyration radius iy =	2.71(cm)		
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

5	name : L-100x100x10			
	unit weight =	146.1(N/m)	section area A =	19.000(cm^2)
	area gyration radius iy =	3.04(cm)		
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.11 Retaining wall Steel sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m^2)	A (cm^2/m)	I (cm^4/m)	Z (cm^3/m)
1	II	400	100	48.0	153.00	8740	874
2	III	400	125	60.0	191.00	16800	1340
3	III	400	130	60.0	191.00	17400	1340
4	IV	400	170	76.1	242.50	38600	2270
5	VL	500	200	105.0	267.60	63000	3150
6	IIw	600	130	61.8	131.20	13000	1000
7	IIIw	600	180	81.6	173.20	32400	1800
8	IVw	600	210	106.0	225.50	56700	2700

4.12 Retaining wall soldier lateral sheet pile Registered data

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
1	H-100x100x 6x 8	100	100	6.0	8	21.59	16.9	378	76
2	H-125x125x 6x 9	125	125	6.5	9	30.00	23.6	839	134
3	H-150x150x 7x10	150	150	7.0	10	39.65	31.1	1620	216
4	H-175x175x 7x11	175	175	7.5	11	51.42	40.4	2900	331
5	H-200x200x 8x12	200	200	8.0	12	63.53	49.9	4720	472
6	H-250x250x 9x14	250	250	9.0	14	91.43	71.8	10700	860
7	H-300x300x10x15	300	300	10.0	15	118.40	93.0	20200	1350
8	H-350x350x12x19	350	350	12.0	19	171.90	135.0	39800	2280
9	H-400x400x13x21	400	400	13.0	21	218.70	172.0	66600	3330
10	H-400x400x18x28	414	405	18.0	28	295.40	232.0	92800	4480
11	H-400x400x20x35	428	407	20.0	35	360.70	283.0	119000	5570
12	H-400x400x30x50	458	417	30.0	50	528.60	415.0	187000	8170
13	H-400x400x45x70	498	432	45.0	70	770.10	605.0	298000	12000

4.13 Retaining wall Lightweight sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	TypeA	250	36	14.8	75.40	107	60
2	TypeB	333	51	17.9	68.28	510	144
3	TypeC	333	85	19.3	73.80	2000	272
4	TypeD	333	74	21.6	82.53	636	171
5	TypeE	500	160	33.6	85.70	3620	452

Cover

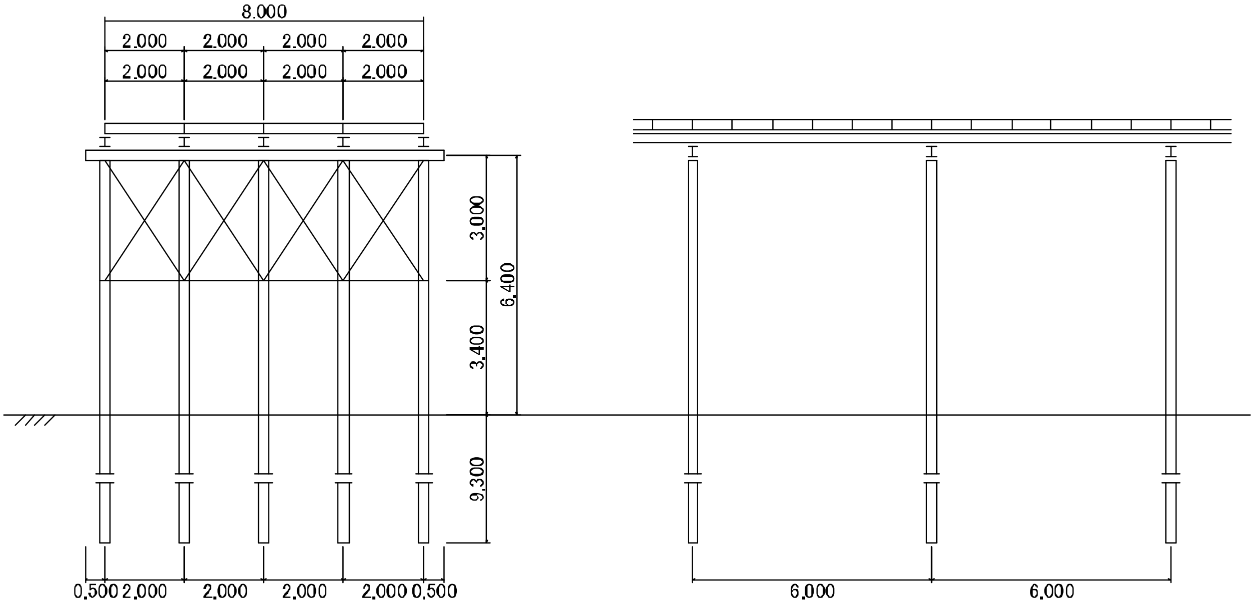
Contents

1 Input data export

1.1 Title

file : Bahr Yusef 70-8mDE.F8K
title: Dairout Bahr Yusef 70-8mD

1.2 Shape data



1. 4 Design condition

basic condition

Applied standard	C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
type of working platform	Type i(widthMain girder orthogonal)
adjacent span	Yes
Support pile Foundation type	Support pile

steel deck, coefficient

type of steel deck		Steel deck type 2(Old Metro-deck)
At Steel deck designMain girder treatment		Not consider
impact coefficient steel deck		0.300
other than steel deck		0.300
Horizontal coefficient	fixed load	0.200
load	truck	= 0.200
	heavy equipment	= 0.200

Use horizontal coefficient when truck crane is moving.

impact when horizontal load is calculated	not include impact
impact when deflection is calculated	not include impact

1.4 Member design condition

Beam seatSteel specification	H-Beam
Beam seatCheck share stress	Checking
Beam seat, Support piledesign guideline	Main girder load distribution is considered.
allowable deflection	length of a span/ 400.000
maximum deflection	2.500 (cm)
dead load when deflection is calculated	Not consider
Eq of deflection for single live load	Calculation equation for 1 member
Support piledesign	Examine
Support pileDesign time axial force	maximum axial force / 1
Support pileself weight treatment	Total length
other vertical load	0.000 (kN/ a member)
Support pileHorizontal force load status	Use vertical load when horizontal force is max.
Hori. jointhorizontal force	1 memberHori. jointshare(by before member)
Hori. joint	both sides install
Beam seatunderneathHori. jointinstall:	Not do
Hori. jointJoint part	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)
Hori. joint,brace horizontal force calculation method	Use vertical load when horizontal force is max.
brace member	Design as compressive member
brace connection	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)

1. 4 Design condition

live load

increment of live load movement of live load when member section is calculated for live load Del.L 0.010 (m)

crawler crane load Linear load

Support piledesign

Incase of Penetration length is not satisfied with Beta L >= 2.50 :design as limited length pile

increase rate pile top free bending moment		1.00
	displacement	1.25
pile top fixed bending moment		1.10
	displacement	1.20

1.6 Live load for steel deck design

	Main girder orthogonal to		Main girder parallel to	
	1000* 2000	1000* 3000	1000* 2000	1000* 3000
truck load	NG	NG	OK	NG
crawler crane moving	NG	NG	OK	NG
crawler crane 0 degree	NG	NG	OK	NG
crawler crane 90 degree	NG	NG	OK	NG
crawler crane 45 degree	NG	NG	OK	NG
truck crane moving	NG	NG	OK	NG
truck crane working	NG	NG	NG	NG
reinforcing beam	NG		NG	

OK : design NG : not design

1.7 Live loads for member design

	Main girder orthogonal to	Main girder parallel to
truck load	NG	OK
crawler crane moving	NG	OK
crawler crane 0 degree	NG	OK
crawler crane 90 degree	NG	OK
crawler crane 45 degree	NG	OK
truck crane moving	NG	OK
truck crane working	NG	NG

OK : design NG : not design

1.8 working platform data

Span* adjacent span data

item	symbol	unit	value
main span length	--	m	6.000
adjacent span length	--	m	6.000

Main girder spacing data

No. N	Main girder spacing(m)
1	2.000
2	2.000
3	2.000
4	2.000

steel deck layout data

No. F	steel deck size (m)
1	2
2	2
3	2
4	2

Support pile spacing

No. S	Support pile spacing(m)
1	2.000
2	2.000
3	2.000
4	2.000

width, overhang

item	symbol	unit	value
road width	--	m	8.000
gap	--	m	0.000
left overhang length	LL	m	0.500
right overhang length	LR	m	0.500

1.9 frame data

with or without Hori. brace [none]
with or without Vert. brace [Yes]
elevation

No. h	frame spacing (m)
1	3.000
2	3.400

item	symbol	unit	value
Support pilepenetration length	hL	m	9.300
ground level G.L.	--	m	41.000

1.10 Support piledesign condition

Sand layer with N-value more than 30 or delluvial clay with more than 10
embedded more than 3m in the bearing layer Not allow
Pile construction method (not embedded by written above) Striking construction method
Directly input Alp.* Beta No
Pile moment using vertical brace
Calculation method Chang equation
Specify upper limit of N-value in pile tip ground Based on the design strength
Direct input N-value at pile tip ground No
embedment length 9.30 (m)
Young's modulus of pile * 10^5 2.00 (N/mm²)
Modulus of subgrade lateral reaction 0.00 (kN/m³)
Assume sound layer when pile tip bearing capacity is calculated
Lower limit of N-value 20.000
Factor of Safey when allowable bearing capacity is calculated 2.0

1.11 Strata data

No.	layer type	layer thickness	average N-value	coh soil unc cmpr strg(kN/m²)	Alp.* Eo (kN/m²)	cohesion (kN/m²)
1	Sandy soil	1.000	4.000	100.000	11200.00	50.000
2	Sandy soil	1.000	8.000	100.000	22400.00	50.000
3	Sandy soil	1.000	19.000	200.000	53200.00	100.000
4	Sandy soil	1.000	16.000	200.000	44800.00	100.000
5	Sandy soil	1.000	26.000	300.000	72800.00	150.000
6	Sandy soil	1.000	19.000	200.000	53200.00	100.000
7	Sandy soil	1.000	25.000	300.000	70000.00	150.000
8	Sandy soil	1.000	25.000	300.000	70000.00	150.000
9	Sandy soil	1.000	52.000	300.000	145600.00	150.000
10	Sandy soil	1.000	45.000	300.000	126000.00	150.000
11	Sandy soil	1.000	31.000	300.000	86800.00	150.000
12	Sandy soil	1.000	40.000	300.000	112000.00	150.000
13	Sandy soil	1.000	46.000	300.000	128800.00	150.000
14	Sandy soil	1.000	38.000	300.000	106400.00	150.000
15	Sandy soil	1.000	38.000	300.000	106400.00	150.000
16	Sandy soil	1.000	46.000	300.000	128800.00	150.000
17	Sandy soil	1.000	78.000	300.000	218400.00	150.000

1.12 steel deck load distribution ratio specification

* truck load distribution ratio

	Main girder orthogonal to	Main girder parallel to
truck	0.40	0.40

* Crawler crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
0 degree	0.25	0.20
45 degree	0.25	0.20
60 degree	0.25	0.20

Note) use the value of front hang when moving.

* Truck crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
moving working	0.40 0.40	0.40 0.40

1.13 Steel deck material data

height of steel deck 200(mm)

* in case of 1000* 2000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm²)
3) Z 312.0 (cm³)

* in case of 1000* 3000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm²)
3) Z 312.0 (cm³)

Note: Web section area, section modulus are input data per one H steel.

1.14 Reinforcement girder material data

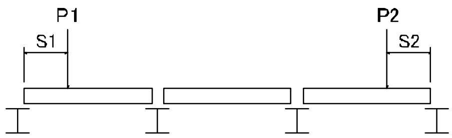
1) name of using material
2) Aw 54.00 (cm²)
3) Z 2720.0 (cm³)
4) self-weight 1880.0 (N/m)
5) span length 2.0 (m)
6) comment (description)

1.15 Beam seat Joint part bolt data

Support pile part

bolt is not designed.

1.16 Bridge face(dead) load



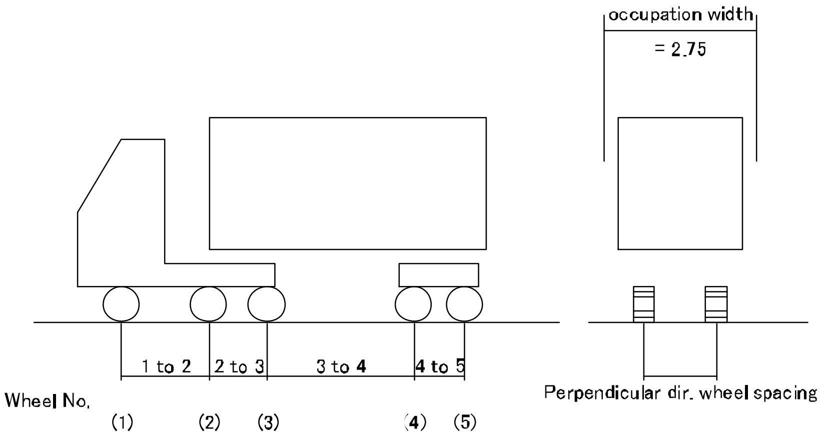
1) left loading position 0.000 (m)
2) right loading position 0.000 (m)
3) left load intensity 0.000 (kN/m)
4) right load intensity 0.000 (kN/m)

1.17 Steel deck/Nominal load

1) steel deck self-weight	1000	*	2000	2.000 (kN/m²)
	1000	*	3000	2.000 (kN/m²)
other				2.000 (kN/m²)
2) nominal load				0.000 (kN/m²)
3) attachment unit				0.100

1.18 Select truck load

* bridge axis direction



1) load selection — Input load
2) registration name — T20
3) axis spacing in perpendicular direction — 1.75 (m)
4) number of wheels — 2
5) axis spacing in moving direction (m)

1 - 2	4.000

6) load intensity (one side) (kN)

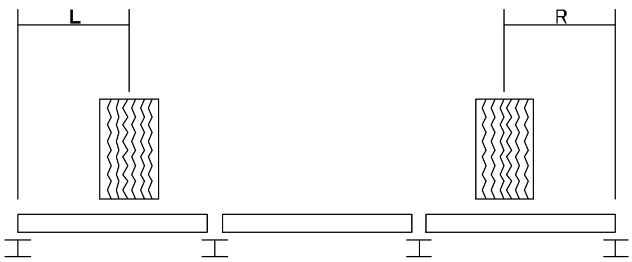
1	20.000
2	80.000

* perpendicular to bridge axis direction
1) load selection Input load
2) load type
P1 T20
P2 T20
P3 T20

1.19 Truck load condition setting

* bridge axis direction
1) train load is considered — No
2) Number in perpendicular direction — 2

1.20 Width of truck load setting



1) load on one side — Consider
2) non-width of load (left) — 0.000 (m)
3) non-width of load (right) — 0.000 (m)

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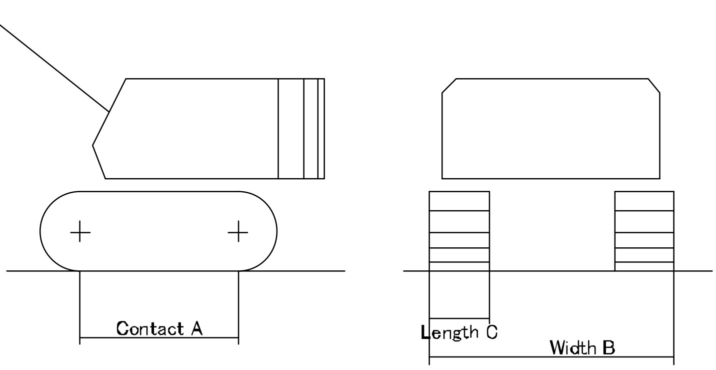
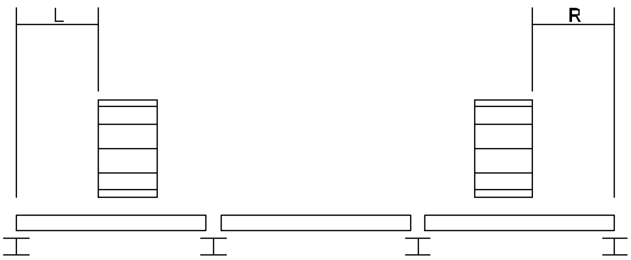
1.21 Crawler crane load selection

1)registration name D408S



2)self-weight	480.000 (kN)
3)hoisting self-weight	50.000 (kN)
4)contact A	4.470 (m)
5)width B	4.000 (m)
6)contact width C	0.800 (m)
7)apportionment on lateral operation side	0.750
8)contact when hoisting forward	0.750
9)apportionment on operation side in orthogonal direction	0.700
10)contact on operation side in orthogonal direction	0.900

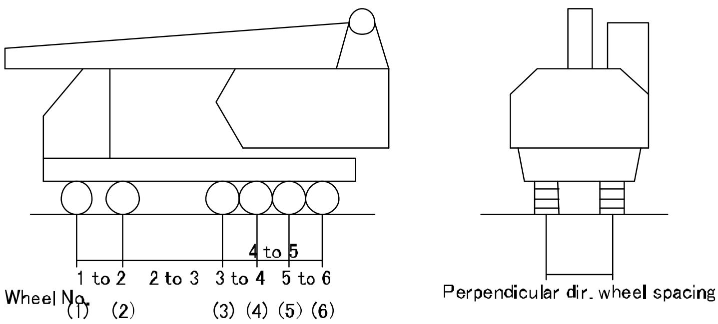
1.22 Width of Crawler crane non-load setting



1)load on one side	Not consider
2)non-width of load (left)	1.000 (m)
3)non-width of load (right)	1.000 (m)
4)location of heavy equipment in bridge axis direction	not specify

1.23 Truck crane load selection

* at moving



1)registration name	KA-900
2)wheel spacing in perpendicular direction	2.30 (m)
3)number of wheels	4

4)wheel spacing in moving direction (m)

1 - 2	1.650

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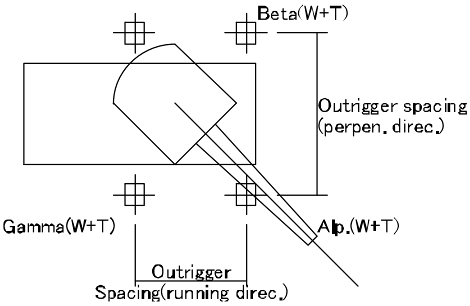
2 - 3	2.400
3 - 4	1.650

5)load intensity(one side) (kN)

1	38.850
2	38.850
3	27.250
4	27.250

* at operating



1)self-weight	W	264.400 (kN)
2)hoisting self-weight	T	800.000 (kN)
3)outrigger spacing (moving)		8.700 (m)
4)outrigger spacing (perpendicular)		7.400 (m)
5)load distribution ratio	Alp.	0.700
6)load distribution ratio	Beta	0.150
7)load distribution ratio	Gam	0.150
8)outrigger width		0.500 (m)

1.24 Width of Truck crane non-load setting

truck crane load is not considered.

1.25 Dead load arbitrary position

Dead load at any location is not input.

1.26 Specify allowable stress

steel type name SS400
load factor of allowable stress 1.50
allowable stress

	direct input of allowable stress			
	bend cmpr (N/mm²)	ax cmpr (N/mm²)	ax tns (N/mm²)	shear (N/mm²)
steel deck	Auto calc	----	----	Auto calc
Main girder	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)H-Beam	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)U shape steel	210.00	----	----	Auto calc
Support pile	Auto calc	Auto calc	----	Auto calc
Hori. joint	----	Auto calc	----	----
brace	----	Auto calc	Auto calc	----

allowable stress automatic calculation(calculate from fixed number in the middle of a member)

	fixed number of middle		member length	
	distance flange fixed	effective buckling length	distance fixed (cm)	effective buckling length(cm)
steel deck	----	----	----	----
Main girder	0	----	0.00	----
Beam seat(Support pilepart)H-Beam	0	----	0.00	----
Beam seat(Support pilepart)U shape steel	0	----	0.00	----
Support pile	0	0	0.00	0.00
Hori. joint	----	0	----	0.00
brace	----	----	----	----

1.27 Borehole log of strata

Depth(m)	Soil mark	N value 0 10 20 30 40 50
40.00		
45.00		
49.00		
57.00		

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1.28 Initial input

1)applied standard C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
2)abutment type Type i
3)adjacent span Yes
4)Support pile Foundation type bearing pile embedment length 9.300(m)
5)shape data
* width 8.000(m)
* left overhang 0.500(m)
* right overhang 0.500(m)
* span 6.000(m)
* working platform height 6.400(m)
* steel deck size 2.000(m)
* Support pileBasic spacing 2.000(m)
* frame basic spacing 3.000(m)

6)Design Support pile
* Foundation data
  1.pile construction method driven casting
* Soil data

No.	type	thickness (m)	ave N value	coh soil cmpr strg (kN/m²)	Alp.* Eo (kN/m²)	cohension (kN/m²)
1	Sandy soil	1.000	4.000	100.000	11200.00	50.000
2	Sandy soil	1.000	8.000	100.000	22400.00	50.000
3	Sandy soil	1.000	19.000	200.000	53200.00	100.000
4	Sandy soil	1.000	16.000	200.000	44800.00	100.000
5	Sandy soil	1.000	26.000	300.000	72800.00	150.000
6	Sandy soil	1.000	19.000	200.000	53200.00	100.000
7	Sandy soil	1.000	25.000	300.000	70000.00	150.000
8	Sandy soil	1.000	25.000	300.000	70000.00	150.000
9	Sandy soil	1.000	52.000	300.000	145600.00	150.000
10	Sandy soil	1.000	45.000	300.000	126000.00	150.000
11	Sandy soil	1.000	31.000	300.000	86800.00	150.000
12	Sandy soil	1.000	40.000	300.000	112000.00	150.000
13	Sandy soil	1.000	46.000	300.000	128800.00	150.000
14	Sandy soil	1.000	38.000	300.000	106400.00	150.000
15	Sandy soil	1.000	38.000	300.000	106400.00	150.000
16	Sandy soil	1.000	46.000	300.000	128800.00	150.000
17	Sandy soil	1.000	78.000	300.000	218400.00	150.000

2 Calculation result export

2.2 Main girder Design

2.2.1 bending moment sum up for each load

load status		Main girder No.	bending moment (kN.m)
truck load	orthogonal	--------	------------
	parallel	G 2	279.092
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	319.261
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	429.912
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	511.981
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	560.304
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	146.068
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.2 bending moment calculation

Calculate load condition when bending moment is maximum

1)load condition Crawler crane diagonal hang(Parallel)

2)design Main girder number 2

3)stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

Main girder Self weight = 1.687

----

total wd = 5.687 (kN/m)

using Main girder H-400x400x13x21

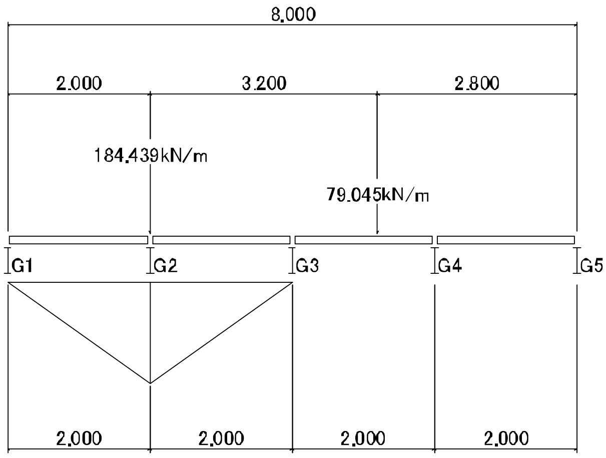
* stresses by fixed load

bending moment

$Md = wd * l^2/8 + Mo = 5.687 * 6.000^2/8 + 0.000 = 25.592$(kN.m)

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side
  triangular distribution front side   p1 = (W + T) * 0.700
                                        /(0.900 * lb * 1/2) = 184.439 (kN/m)
  triangular distribution front side   p1'   =   0.000 (kN/m)

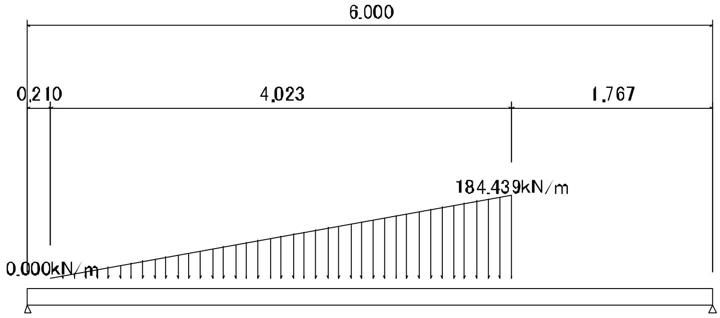
crawler crane load intensity on non-operation side
  triangular distribution front side   p2 = (W + T) * 0.300
                                        /(0.900 * lb * 1/2) = 79.045 (kN/m)
  triangular distribution front side   p2'   =   0.000 (kN/m)

load intensity on focus Main girder
  triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2 = 184.439 (kN/m)
  triangular distribution front side   q1'   =   0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	1.00000
Eta2	: crawler influence value on non-operation side	=	0.00000

* crawler crane (slant hoisting) bending moment



crawler crane bending moment
Mmax = 411.318 (kN m)
where
lmax : Mmax location = 3.105 (m)

* crawler crane bending moment

fixed load			=	25.592(kN m)
crawler crane load			=	411.318(kN m)
impact	411.318 * 0.300		=	123.395(kN m)
total		M	=	560.304(kN m)

2.2.3 Shear force sum up for each load

load status		Main girder No.	Shear force (kN)
truck load	orthogonal	--------	------------
	parallel	G 2	200.144
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	212.841
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	297.028
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	341.322
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	391.567
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	117.466
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.4 Shear force calculation

Calculate load condition when Shear force is maximum

1) load condition   Crawler crane diagonal hang(Parallel)

2) design Main girder number   2

3) stresses by fixed load

Equations to calculate stresses by fixed load   2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load   2.000 *   2.000 /   2.000 =   2.000

steel deck self-weight* nominal load   2.000 *   2.000 /   2.000 =   2.000

Main girder Self weight   =   1.687

----

total   wd =   5.687 (kN/m)

using Main girder   H-400x400x13x21

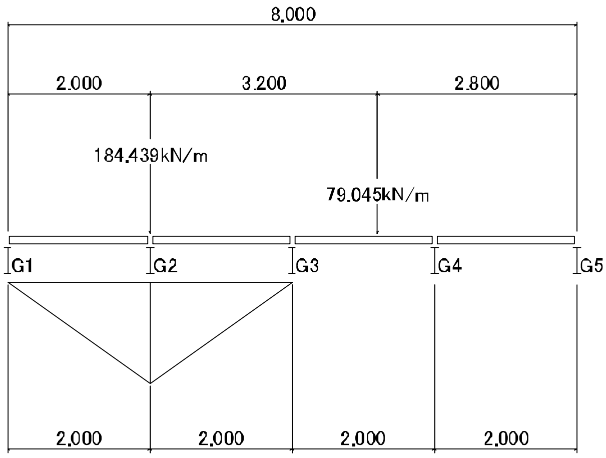
* stresses by fixed load

Shear force

Sd = wd * l / 2 + So =   5.687 *   6.000 / 2 + 0.000 = 17.061(kN)

Calculate stresses of crawler crane (slant hoisting)　　2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side

triangular distribution front side　p1 = (W + T) * 0.700
/(0.900 * lb * 1/2) = 184.439 (kN/m)

triangular distribution front side　p1' = 0.000 (kN/m)

crawler crane load intensity on non-operation side

triangular distribution front side　p2 = (W + T) * 0.300
/(0.900 * lb * 1/2) = 79.045 (kN/m)

triangular distribution front side　p2' = 0.000 (kN/m)

load intensity on focus Main girder

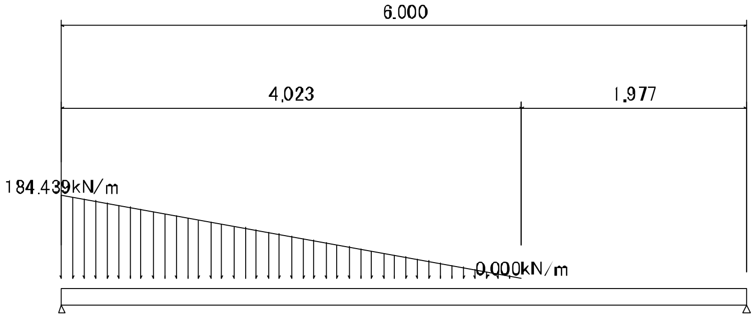
triangular distribution front side　q1 = p1 * Eta1 + p2 * Eta2 = 184.439 (kN/m)

triangular distribution front side　q1' = 0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	1.00000
Eta2	: crawler influence value on non-operation side	=	0.00000

* crawler crane (slant hoisting) Shear force



crawler crane Shear force
Smax = 288.081 (kN)

* crawler crane Shear force

fixed load		=	17.061(kN)
crawler crane load		=	288.081(kN)
impact	288.081 * 0.300	=	86.424(kN)
total	S	=	391.567(kN)

2.2.5 Allowable stress calculation

steel material for structure SS400
using member H-400x400x13x21
allowable bending stress
Sig.ba = 172.200 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 600.000 (cm)
b : cross sectional area of compressive flange = 40.000 (cm)
l/b : = 15.000
allowable shear stress
Taua = 120.000

2.2.6 Main girder stress calculation

using member H-400x400x13x21
bending stress
Sig. = M/ Z = 168.260 (N/mm²) <= 172.200 (N/mm²)
where
M: design bending moment = 560.304 (kN.m)
(Crawler crane diagonal hang(Parallel))
Z : section modulus = 3330.000 (cm³)
shear stress
Tau = S / Aw = 84.136 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 391.567 (kN)
(Crawler crane diagonal hang(Parallel))
Aw : web section area = 46.540 (cm²)

2.2.7 Deflection calculation

Calculate deflection when bending moment is maximum

$$\text{Del.} = \frac{5 M_{max} l^2}{48EI} = 1.158\ (\text{cm}) \le 1.500\ (\text{cm})$$

where
Mmax: bending moment by load = 411.318 (kN.m)
(Crawler crane diagonal hang(Parallel))
l : span length = 600.000 (cm)
I : moment of inertia of area = 66600.000 (cm⁴)
E : Young's modulus = 2.0* 10^5(N/mm²)

2.3 Beam seat Design

2.3.1 Sum up bending moment for each load

load condition		section	bending moment (kN m)
truck load	orthogonal	----------------------	----------
	parallel	section- 2 Simple beam part	0.662
crawler crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	0 degree-orthogonal	----------------------	----------
	0 degree-parallel	section- 2 Simple beam part	0.662
	90 degree-orthogonal	----------------------	----------
	90 degree-parallel	section- 2 Simple beam part	0.662
	45 degree-orthogonal	----------------------	----------
	45 degree-parallel	section- 2 Simple beam part	0.662
truck crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	working-orthogonal	----------------------	----------
	working-parallel	----------------------	----------

Note) Bending moment is the sum of moment by fixed load, load, and impact.

2.3.2 Bending moment computation

Calculate in the load condition that induces bending moment maximum

1)load condition Truck load(Parallel)

2)design section - 2 Simple beam part

3)include Main girder in design section

No.	Main girder No.
1	G 2

4)Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	5.687	0.000	34.122
5	G 5	3.687	0.000	22.122

where

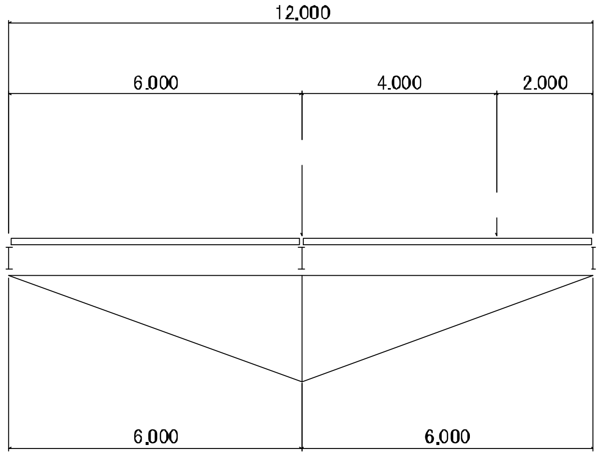
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force by truck load

in case that Beam seat of bending moment is at maximum, truck load position.

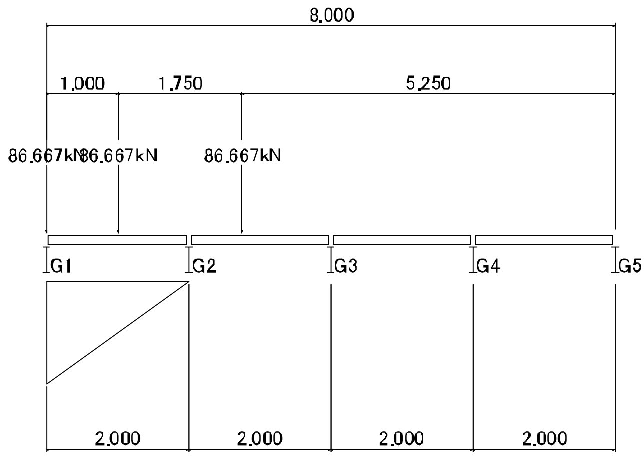


reaction force by train load

Rj = Sig. PJi * Etai = 86.667 (kN)

wheel No.	load PJi (kN)	influence value on reaction force Etai
1	80.000	1.000
2	20.000	0.333

in case that Beam seat of bending moment is at maximum, truck load position.



1 Main girder reaction force is maximum, then Beam seat bending moment is maximum

influence value of each beam

No.	Main girder No.	influence value
1	G 1	1.500
2	G 2	1.125
3	G 3	0.375
4	G 4	0.000
5	G 5	0.000

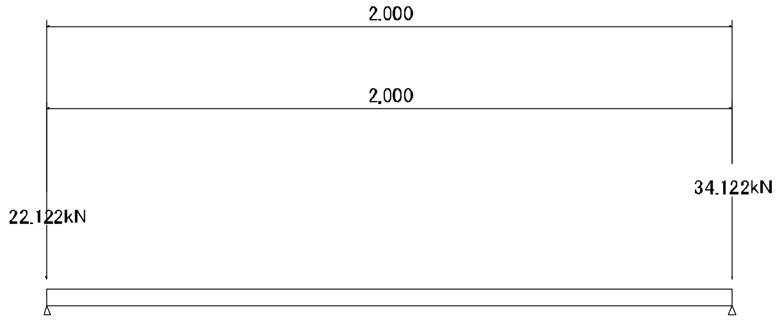
Rji = Rj * Ii

No.	Main girder No.	eachMain girder effect value Ii	Rji (kN)
1	G 1	1.500	130.000
2	G 2	1.125	97.500
3	G 3	0.375	32.500
4	G 4	0.000	0.000
5	G 5	0.000	0.000

6) calculate bending moment

Simple beam part

Bending moment by fixed load



Md = 0.662 (kN.m)

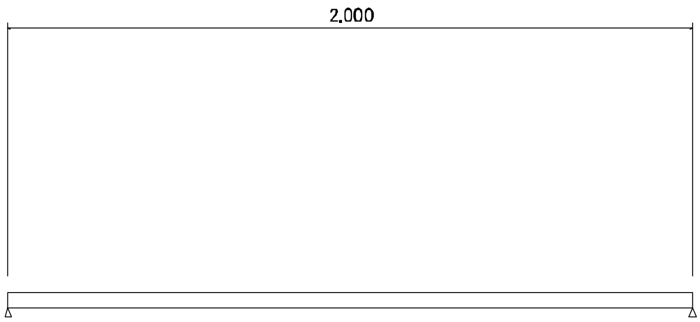
where

lmax : Mmax position(from left support point) = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

Bending moment by load



Ml = 0.000 (kN.m)

where

lmax : Mmax position (from left support point) = 0.000 (m)

7) sum of bending moment

fixed load		=	0.662 (kN m)
load		=	0.000 (kN m)
impact	= 0.000 * 0.300	=	0.000 (kN m)
total		M =	0.662 (kN m)

2.3.3 Sum up shear force for each load

load condition		section	shear force (kN)
truck load	orthogonal	---------------------	----------
	parallel	section- 2 Simple beam part	218.529
crawler crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	289.336
	0 degree-orthogonal	---------------------	----------
	0 degree-parallel	section- 2 Simple beam part	342.360
	90 degree-orthogonal	---------------------	----------
	90 degree-parallel	section- 2 Simple beam part	455.951
	45 degree-orthogonal	---------------------	----------
	45 degree-parallel	section- 2 Simple beam part	454.602
truck crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	155.335
	working-orthogonal	---------------------	----------
	working-parallel	---------------------	----------

Note) Shear force is the sum of shear force by fixed load, load, and impact.

2.3.4 Shear force computation

Calculate in the load condition that induces shear force maximum

1)load condition   Crawler crane side hang(Parallel)

2)design section - 2   Simple beam part

3)include Main girder in design section

No.	Main girder No.
1	G 2

4)Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN/m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	5.687	0.000	34.122
5	G 5	3.687	0.000	22.122

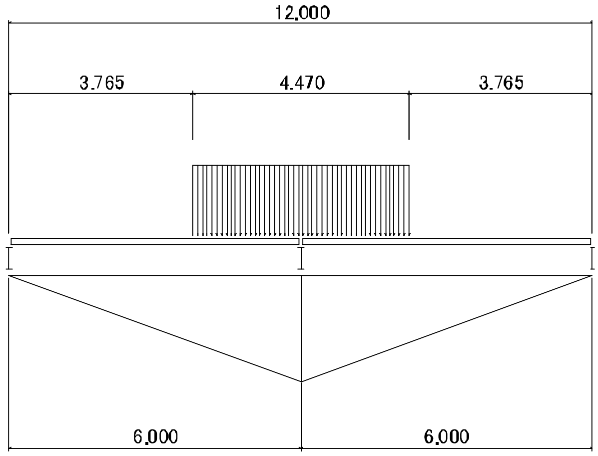
where

Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

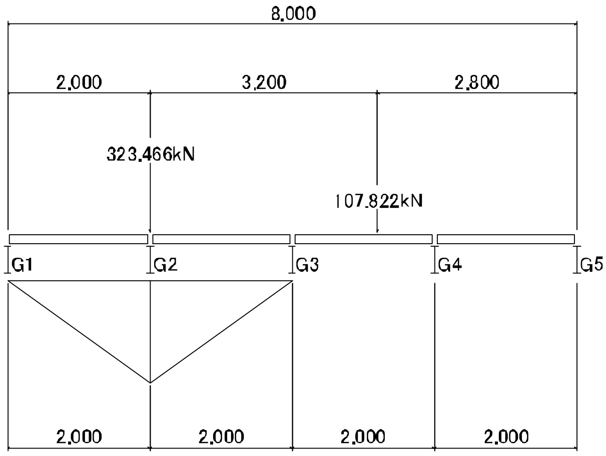
5) Main girder reaction force of crawler crane
Beam seat - Shear force is at maximum, crawler load condition



reaction force of crawler crane

```
        Rc1 = w1 *  { b *  ( a + b/2.0 ) / l1
                    + c *  ( d + c/2.0 ) / l2 }          =   323.466 (kN)
        Rc2 = w2 *  { b *  ( a + b/2.0 ) / l1
                    + c *  ( d + c/2.0 ) / l2 }          =   107.822 (kN)
        where
              w1 : crawler crane load intensity on operation side
                    w1 = (W+ T) / lb *  0.750         =   88.926 (kN/m)
              w2 :  crawler crane load intensity on non-operation side
                    w2 = (W+ T) / lb *  0.250         =   29.642 (kN/m)
               a : unloading length in left span       =     3.765 (m)
               b : loading length in left span         =     2.235 (m)
               c : loading length in right span        =     2.235 (m)
               d : unloading length in right span      =     3.765 (m)
               W : crawler crane self-weight           =   480.000 (kN)
               T : lifting load                        =    50.000 (kN)
              lb : crawler crane contact               =     4.470 (m)
              l1 : length of left span                 =     6.000 (m)
              l2 : length of right span                =     6.000 (m)
```

Beam seat of Shear force is at maximum, crawler load condition

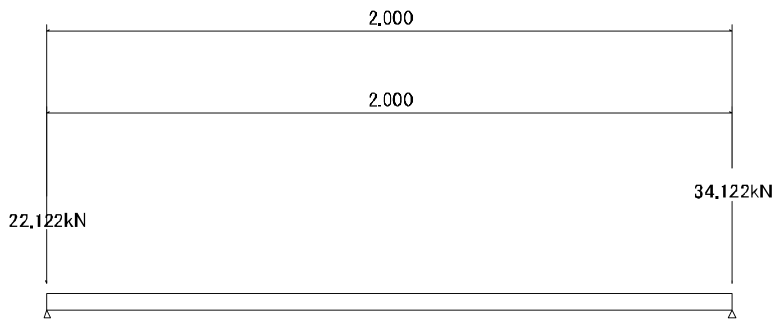


No.	Main girder No.	eachMain girder reaction force(kN)
1	G 1	0.000
2	G 2	323.466
3	G 3	43.129
4	G 4	64.693
5	G 5	0.000

6)calculate shear force

Simple beam part

Shear force by fixed load



Sd = 35.446 (kN)

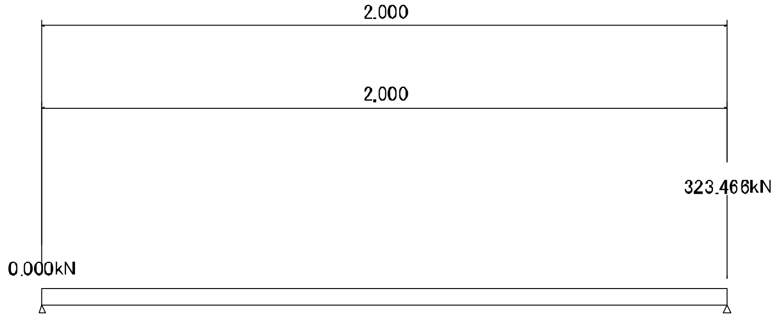
where

l : span length = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

shear force by load



Sj = 323.466 (kN)

7) sum of shear force

fixed load		=	35.446 (kN)
load		=	323.466 (kN)
impact	= 323.466 * 0.300	=	97.040 (kN)
total		S =	455.951 (kN)

2.3.5 Allowable stress calculation

steel material for structure SS400
using member H-350x350x12x19
allowable bending stress
Sig.ba = 205.629 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 200.000 (cm)
b : cross sectional area of compressive flange = 35.000 (cm)
l/b : = 5.714
allowable shear stress
Taua = 120.000

2.3.6 Beam seat stress calculation

using member H-350x350x12x19
bending stress
Sig. = M / Z = 0.290 (N/mm²) <= 205.629 (N/mm²)
where
M : design bending moment = 0.662 (kN.m)
(Truck load(Parallel))
Z : section modulus = 2280.000 (cm³)
shear stress
Tau = S / Aw = 121.782 (N/mm²) > 120.000 (N/mm²)
where
S : design shear force = 455.951 (kN)
(Crawler crane side hang(Parallel))
Aw : web section area = 37.440 (cm²)

2.3.7 Deflection calculation

Calculate deflection when bending moment is maximum in a simple beam section

$$Del. = \frac{5Mmax l^2}{48EI} = 0.000 \text{ (cm)} <= 0.500 \text{ (cm)}$$

where
Mmax: bending moment by load = 0.000 (kN.m)
(Truck load(Parallel))
l : span length = 200.000 (cm)
I : moment of inertia of area = 39800.000 (cm⁴)
E : Young's modulus = $2.0 * 10^5$ (N/mm²)

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2.4 Support pile Design

2.4.1 The axial force and horizontal force of Support pile for each load

		axial force at max		horizontal force (kN)
		Support pileNo.	axial force (kN)	
truck load	orthogonal	----	--------	--------
	parallel	2	242.422	69.333
crawler crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	313.228	96.000
	0 degree-orthogonal	----	--------	--------
	0 degree-parallel	2	366.252	106.000
	90 degree-orthogonal	----	--------	--------
	90 degree-parallel	2	479.844	106.000
	45 degree-orthogonal	----	--------	--------
	45 degree-parallel	2	478.494	106.000
truck crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	179.228	36.889
	working-orthogonal	----	--------	--------
	working-parallel	----	--------	--------

2.4.2 Axial force calculation for member design

Calculate for the load condition when axial force is maximum

For pile stress and bearing capacity of Support pile, use maximum axial force multiplied by 1/1 .

1) Load condition Crawler crane side hang(Parallel)

2) Support pile Number 2

Checking Support pile left Simple beam part

Checking Support pile left section Number of Main girder = 1

No.	Main girder No.
1	G 1

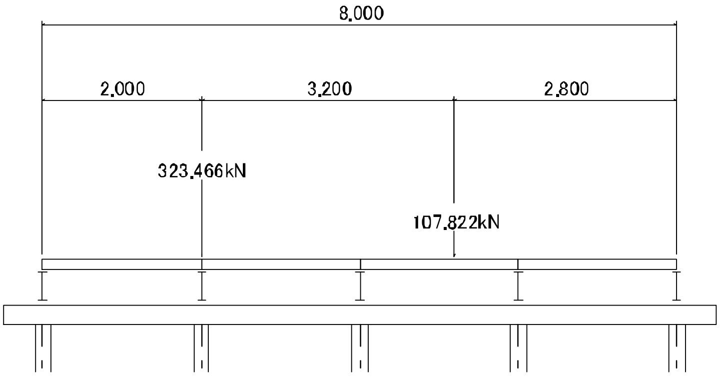
Checking Support pile right Simple beam part

Checking Support pile right section Number of Main girder = 1

No.	Main girder No.
1	G 2

3) calculate max axial force

simple beam + simple beam



axial force by fixed load

Nd = Ndl + Ndr + nd = 59.338 (kN)

where

Ndl : axial force by fixed load on simple beam(left)

Ndl = Sig.(Rdi * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rdi (kN)	lLi (m)
1	G 1	22.122	0.000

Ndr : axial force by fixed load on simple beam(right)

Ndr = Sig.(Rdj * lRj) / lk2 = 34.122 (kN)

No.	Main girder No.	Rdj (kN)	lRj (m)
1	G 2	34.122	2.000

nd : axial force by self-weight

Beam seat Self weight 1.324 * ((lk1 + lk2) / 2.0) = 2.648 (kN)

Hori. joint 0.182 * ls1 * 2 = 0.728 (kN)

Hori. brace 0.000 * ls2 = 0.000 (kN)

Vert. brace 0.146 * lv = 1.054 (kN)

Support pile Self weight 1.324 * lKUI = 20.787 (kN)

other load = 0.000 (kN)

----

total 25.216 (kN)

where

lk1 : left span length of simple beam = 2.000 (m)

lk2 : right span length of simple beam = 2.000 (m)

ls1 : Hori. joint Length = 2.000 (m)

ls1 = ((lk1+lk2) / 2.0) * 1

ls2 : Hori. brace Length = 0.000 (m)

lv : Vert. brace Length = 7.211 (m)

lv = Sig.lvn

lv1 = $\sqrt{lk1^2 + 3.000^2} + \sqrt{lk2^2 + 3.000^2}$ = 7.211 (m)

lKUI : Support pile Length = 15.700 (m)

axial force by load

Nj = Njl + Njr = 323.466 (kN)

where

Njl : axial force by load on simple beam(left)

Njl = Sig.(Rji * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rji (kN)	lLi (m)
1	G 1	0.000	0.000

Njr : axial force by load on simple beam(right)

Njr = Sig.(Rjj * lRj) / lk2 = 323.466 (kN)

No.	Main girder No.	Rjj (kN)	lRj (m)
1	G 2	323.466	2.000

member design axial force

fixed load = 59.338 (kN)

load = 323.466 (kN)

impact 323.466 * 0.300 = 97.040 (kN)

----

total N = 479.844 (kN)

member design axial force is 1/1 N * 1/1 = 479.844 (kN)

2.4.3 Horizontal force calculation

1) horizontal force by fixed load

Hd = (W1 + W2 + W3 + W4 + W5 + W6 + W7) * kh = 33.130 (kN)

W1 : weight of steel deck* nominal load

W1 = (Wf1 * Bf1 + Wf2 * Bf2) * (l + lside) / 2.0 = 96.000 (kN)

Wf1 :	steel deck 2m+ nominal load	=	2.000 (kN/m²)
Bf1 :	steel deck 2m+ width direction	=	8.000 (m)
Wf2 :	steel deck 3m+ nominal load	=	2.000 (kN/m²)
Bf2 :	steel deck 3m+ width direction	=	0.000 (m)
l :	span length	=	6.000 (m)
lside :	adjacent span length	=	6.000 (m)

W2 : dead load weight of wheel guard

W2 = (WL + WR) * (l + lside) / 2.0 = 0.000 (kN)

WL :	dead load of left wheel guard	=	0.000 (kN/m)
WR :	dead load of right wheel guard	=	0.000 (kN/m)

W3 : Main girder Weight

W3 = N * WN * (l + lside) / 2.0 = 50.610 (kN)

N :	Main girder Members number	=	5
WN :	Main girder Self weight	=	1.687 (kN/m)

W4 : Beam seat Weight

W4 = WH * lH = 11.916 (kN)

WH :	Beam seat Self weight	=	1.324 (kN/m)
lH :	Beam seat length	=	9.000 (m)

W5 : Hori. joint Weight

W5 = Ws1 * ls1 * 2 = 2.912 (kN)

Ws1 :	Hori. joint Weight	=	0.182 (kN/m)
ls1 :	Hori. joint Length	=	8.000 (m)

W6 : Hori. brace Weight

W6 = Ws2 * ls2 / 2.0 = 0.000 (kN)

Ws2 :	Hori. brace Self weight	=	0.000 (kN/m)
ls2 :	Hori. brace Extension	=	0.000 (m)

W7 : Vert. brace Weight

W7 = Wv * lv = 4.214 (kN)

Wv :	Vert. brace Self weight	=	0.146 (kN/m)
lv :	Vert. brace Extension	=	28.844 (m)

kh : coefficient for horizontal force estimate

kh = 0.200

FORUM8

2) horizontal load by horizontal force

Hj = R * kh = 106.000 (kN)

R : load case [Crawler crane font hang(Parallel)]

R = W + T = 530.000 (kN)

where

W: heaviest machine weight = 480.000 (kN)

In case truck load, reaction force by truck load on working platform is taken.

T : lifting load(zero when truck load) = 50.000 (kN)

kh : coefficient for horizontal force estimate

kh = 0.200

3) sum of horizontal force

fixed load	=	33.130 (kN)
load	=	106.000 (kN)
total	=	139.130 (kN)

2.4.4 Bending moment by horizontal force(pile top fixed)

Calculate bending moment and displacement using Chang's equation assuming infinite pile.
Since top of support pile are connected with lateral beams, horizontal force at top of transmits to the bottom of lateral beams.
Use bigger value either constrained moment at pile top or max bending moment in subground.

horizontal force on Support pile
H = Sig.H / n = 27.826 (kN)
where
Sig.H : horizontal force acting on one frame plane = 139.130 (kN)
n : Support pileMembers number = 5

constrained moment at pile top
Mo = (1 + Betah) * H / 2Beta = 73.177 (kN.m)
max bending moment in subground
Mmax = - H / 2Beta * (1 + (Betah)^2)$^{1/2}$ * exp (- Betalm) = 32.687 (kN.m)
depth at max bending moment in subground
lm = 1 / Beta * tan^{-1}(1 /Betah) = 0.931 (m)
horizontal displacement at pile top
Del. = ((1 + Betah)^3+ 2) * H / (12 EIBeta^3) = 1.350 (cm)
where
h : above ground length = 3.400 (m)
I : Support pilearea moment of inertia = 13600.000 (cm^4)
E : Support pileYoung modulus = 2.000 * 10^5(N/mm^2)

pile characteristic value
Beta = ^{4} ã(kh* D / (4EI)) = 0.00538 (1/cm)
where
D : Support pilewidth = 35.000 (cm)

subgrade reaction coefficient in lateral direction
kh = kho* (BH/30)$^{-3/4}$ = 25.996 (N/cm^3)
kho = 1/30* Alp.* Eo = 54.486 (N/cm^3)
BH = (D/Beta)$^{1/2}$ = 80.467 (cm)
where
BH : pile conversion width of load
Alp.* Eo: average Alp.* Eo in range of 1/Beta = 1634.595 (N/cm^2)

2.4.5 Support pile buckling stability check

Because Support pile buckling possibly occur under axial direction force and bending moment, check the stability on buckling using next 2 equations.

Sig.c / Sig.caz + Sig.bcz / { Sig.bao * (1 - Sig.c / Sig.eaz) }
= 0.664 <= 1.0

Sig.c + Sig.bcz / (1 - Sig.c / Sig.eaz)
= 130.572 <= Sig.cal

where

Sig.c : compressive stress in axial direction = 27.914 (N/mm²)

Sig.bcz : moment compressive stress by bending moment around weak axis.

Sig.bcz = Mz / zz = 94.300 (N/mm²)

Sig.caz : allowable compressive stress in axial direction around weak axis = 159.370(N/mm²)

lk/r <= 18 --- Sig.caz = 210

18 < lk/r <= 92 --- Sig.caz = { 140 - 0.82 * (lk/r - 18) } * 1.50

92 < lk/r --- Sig.caz = 1200000 / { 6700 + (lk/r)²} * 1.50

lk/r = 525.957 / 8.890 = 59.163

Sig.bao : upper limit of allowable compressive stress without local buckling
= 210.000 (N/mm²)

Sig.cal : allowable stress of free extension plate under comp stress about local buckling
where b' <= 13.1t' = 210.000 (N/mm²)

Sig.eaz : Euler buckling strength around weak axis
Sig.eaz = 1200000 / (lk/rz)² = 342.835 (N/mm²)

N : Support pile acting axial force = 479.844 (kN)

Mz : bending moment around z axis = 73.177 (kN.m)

lk : buckling length = 525.957 (cm)

lLow: lowest design span, height at lowest is added 1/Beta(lk reference value, fixed value).

lLow = lLow' + 1/Beta = 340.000 + 185.957 = 525.957

where,

lLow' : height at lowest = 340.000 (cm)

Beta : characteristic value

Beta = ⁴√(kh* D / (4EI)) = 0.00538 (1/cm)

where

I : Support pilearea moment of inertia = 13600.000 (cm⁴)

E : Support pileYoung modulus = 2.000 * 10⁵(N/mm²)

D : Support pilewidth = 35.000 (cm)

kh : lateral subgrade reaction = 25.996 (N/cm³)

use steel member, H-350x350x12x19・Weak)

A : cross sectional area of steel material = 171.900 (cm²)

zz : section modulus around z axis = 776.000 (cm³)

ry : radius of gyration of area around y axis = 15.200 (cm)

rz : radius of gyration of area around z axis = 8.890 (cm)

Shear stress

horizontal force acting on weak axis of post.

Tau = H / (2 * Af) = 2.092 <= 120.000 (N/mm²)

H : Support pileworking horizontal force = 27.826 (kN)

Af : Support pileFlange area = 66.500 (cm²)

2.4.6 Support pile bearing capacity examination

allowable bearing capacity

Ra = { qd* A + uSig.lifi }/ 2.0 = 667.450 (kN)

(construction method: driving)

where

qd: ultimate bearing capacity at tip ground = 6200.00

qd = 200Alp.N

N : Support pileN value of soil layer at tip= 31.00

Support pile because less than 2m thickness of sound layer from pile tip

N-value in lower ground is N-value of tip ground Support pile.

upper limit is 40.

A : Support piletip area = 0.12 (m²)

u : Support pilePerimeter = 1.400 (m)

li: thickness to be considered circumference friction

fi: maximum skin friction in the layer considered friction

fi=2BetaNs(sand)

Ns upper limit is 50.

fi=10BetaNc(Nc:N-value) , fi=BetaNc(Nc:cohesion)(clay)

where, Nc(N-value 10* Nc) upper limit is 150.

Sig.lifi: circumference friction = 411.000

li(m)	Ns	Nc	fi(kN/m²)	li* fi
1.000	4.0	------	8.000	8.000
1.000	8.0	------	16.000	16.000
1.000	19.0	------	38.000	38.000
1.000	16.0	------	32.000	32.000
1.000	26.0	------	52.000	52.000
1.000	19.0	------	38.000	38.000
1.000	25.0	------	50.000	50.000
1.000	25.0	------	50.000	50.000
1.000	50.0	------	100.000	100.000
0.300	45.0	------	90.000	27.000

Alp. : coefficient of tip bearing capacity for construction method = 1.0

Beta : coefficient of skin friction for construction method = 1.0

max axial force acting on Support pile Crawler crane side hang(Parallel)

N max = 479.844 (kN) <= 667.450 (kN)

2.5 Hori. joint Design

2.5.1 Hori. joint checking

Design Hori. joint as a member receiving compression force.

load condition   Crawler crane font hang(Parallel)

compression force acting on Hori. joint

share the horizontal force receiving on a frame plane by single Hori. joint.

Set both sides of Support pile

N = H / 2 = 69.565 (kN)

Sig.c = N / A = 29.340 (N/mm²) <= Sig.ca = 123.770 (N/mm²)

where

H : compressive force acting on a frame plane = 139.130 (kN)

Sig.c : axial direction compressive stress

Sig.ca : allowable axial direction compressive stress = 123.770 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50

l/r = 88.106

Use steel material [-150x75x6.5x10

A : cross sectional area of steel material = 23.710(cm²)

l : buckling length = 2.000(m)

r : radius of gyration of area around weak axis = 2.270(cm)

2.5.2 Connection part checking

compression force acting on Hori. joint

T = 69.565 (kN)

required length for welding part

l = T / (0.7rho* s) = 33.126 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.6 Vert. brace Design

2.6.1 Vert. brace checking

design Vert. brace as a member receiving Compressive force

load condition   Crawler crane font hang(Parallel)

horizontal force shared by Vert. brace

share the horizontal force receiving on a frame plane by number of Vert. brace

Hv = H / n = 34.783 (kN)

force Vert. brace acting on Compressive

T = Hv / cos(Theta) = 62.705 (kN)

cos(Theta) = $l / (l^2 + h^2)^{1/2}$ = 0.555

where

l : Support pileThe most shortest spacing(length) = 2.000 (m)

h : Hori. jointlongest spacing = 3.000 (m)

Compressive stress

Sig.c = T / A = 33.003 (N/mm²) <= Sig.ca = 44.023 (N/mm²)

where

Sig.ca : allowable axial direction compressive stress = 44.023 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50

l/r = 184.900

Use steel material L-100x100x10

A : effective cross sectional area of steel material = 19.000 (cm²)

l : buckling length = 3.606 (m)

r : radius of gyration of area = 1.950 (cm)

2.6.2 Connection part checking

force Compressive acting on a brace member

T = 62.705 (kN)

required length for welding part

l = T / (0.7rho* s) = 29.860 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm^2)

s : foot length = 0.300 (cm)

2.7 Summary export

2.7.2 Main girder Summary report

1) calculate bending moment

load condition Crawler crane diagonal hang(Parallel)

design object Main girder number 2 of

fixed load		=	25.592(kN.m)
load		=	411.318(kN.m)
impact	411.318 * 0.300	=	123.395(kN.m)
total		=	560.304(kN.m)

2) calculate shear force

load condition Crawler crane diagonal hang(Parallel)

design object Main girder number 2

fixed load		=	17.061(kN)
load		=	288.081(kN)
impact	288.081 * 0.300	=	86.424(kN)
total		=	391.567(kN)

3) checking stress

using member H-400x400x13x21

web section area	Aw =	46.540 cm^2
section modulus	Z =	3330.000 cm^3

bending stress	Sig. = M / Z	= 168.260 (N/mm^2)
allowable bending stress	Sig.ba	= 172.200 (N/mm^2)
shear stress	Tau = S / Aw	= 84.136 (N/mm^2)
allowable shear stress	fs	= 120.000 (N/mm^2)

4) deformation

Calculate deformation when bending moment is maximum in a load condition

deformation	Del. =	1.1580 (cm)
allowable deformation	Del.a =	1.5000 (cm)

2.7.3 Beam seat Summary report

```
 1)Calculate bending moment
     load condition  Truck load(Parallel)
     design section   2  Simple beam part
       fixed load                               =    0.662(kN.m)
       load                                     =    0.000(kN.m)
       impact                   0.000 *  0.300  =    0.000(kN.m)
       ---------------------------------------------------------
       tototal                                  =    0.662(kN.m)

 2)Calculate shear force
     load condition  Crawler crane side hang(Parallel)
     design section   2  Simple beam part
       fixed load                               =   35.446(kN)
       load                                     =  323.466(kN)
       impact                 323.466 *  0.300  =   97.040(kN)
       ---------------------------------------------------------
       total                                    =  455.951(kN)

 3)checking stresses
     material       H-350x350x12x19
     web section area  Aw =    37.440 cm2
     section modulus   Z  =  2280.000 cm3

     bending stress      Sig. =  M / Z   =   0.290 (N/mm2)
       allowable bending stress Sig.ba   = 205.629 (N/mm2)
     shear stress        Tau =  S / Aw   = 121.782 (N/mm2)
       allowable shear stress      Taua  = 120.000 (N/mm2)

 4)deflection
     Calculate deflection when bending moment by live load is at max..
     deflection                 Del.  =     0.0000 (cm)
     allowable deflection       Del.a =     0.5000 (cm)
```

2.7.4 Support pile Summary report

1)load condition that weight on working platform is max. Crawler crane side hang(Parallel)
(axial force for member design)

2)Support pile number 2

3)calculation of axial force

```
    fixed load                                 =    59.338 (kN)
    load                                       =   323.466 (kN)
    impact             323.466 *      0.300    =    97.040 (kN)
    -----------------------------------------------------------
    total                     479.844 *  1/1 =   479.844 (kN)
```

4)calculation of horizontal force

```
    fixed load                                 =    33.130 (kN)
    load                                       =   106.000 (kN)
    ----------------------------------------------------
    total                                          139.130 (kN)
```

5)bending moment by horizontal force

```
    Support pile horizontal force acting on single member  =    27.826 (kN)
    maximum bending moment                          =    73.177 (kN.m)
```

6)Support pile strength check

```
    material used  H-350x350x12x19･Weak)
    cross sectional area                               A  =   171.900 cm2
    section modulus                                    Z  =   776.000 cm3
    radius of gyration of area around y axis           Ry =    15.200 cm
    radius of gyration of area around z axis           Rz =     8.890 cm
    flange width                                       B  =    35.000 cm
    web section area                                   Aw =    66.500 cm2

      Sig.c/Sig.caz + Sig.bcz/{Sig.bao * ( 1-Sig.c/Sig.eaz )}  =    0.664 <=    1.000
      Sig.c + Sig.bcz/( 1-Sig.c/Sig.eaz )                      =  130.572 <=  210.000
```

7) check bearing capacity Support pile

```
    max axial force on Support pile   Crawler crane side hang(Parallel)
      Nmax =   479.844 <=   667.450 (kN)
```

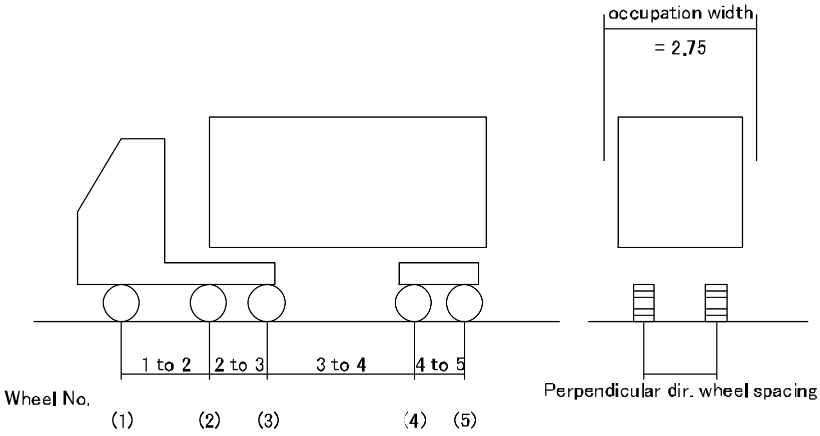
2.8 List table

2.8.2 Member list table

Main girder	use	H-400x400x13x21
	bending moment max Mmax Sig.	Crawler crane diagonal hang(Parallel) 560.304 (kN.m) 168.260 <= 172.200 (N/mm²)
	shear force max Smax Tau	Crawler crane diagonal hang(Parallel) 391.567 (kN) 84.136 <= 120.000 (N/mm²)
	deflection Del.	Crawler crane diagonal hang(Parallel) 1.158 <= 1.500 (cm)
Beam seat (Support pile)	use	H-350x350x12x19
	bending moment max Mmax Sig.	Truck load(Parallel) 0.662 (kN.m) 0.290 <= 205.629 (N/mm²)
	shear force max Smax Tau	Crawler crane side hang(Parallel) 455.951 (kN) 121.782 > 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.000 <= 0.500 (cm)
Support pile	use	H-350x350x12x19･Weak)
	load(section) load(bearing capacity)	Crawler crane side hang(Parallel) Crawler crane side hang(Parallel)
	force	N = 479.844 (kN) M = 73.177 (kN.m) S = 27.826 (kN) Sig.c = 27.914 Sig.b = 94.300 (N/mm²) Tau = 2.092 <= Taua = 120.000 (N/mm²)
	check buckling	eq- 1 ------- 0.664 <= 1.000 eq- 2 ------- 130.572 <= 210.000 (N/mm²)
	bearing capacity	479.844 <= 667.450 (kN)
Hori. joint	use	[-150x75x6.5x10
	cmpr stress Sig.c	29.340 <= 123.770 (N/mm²) (N= 69.565kN)
Hori. jointJoint part	required welding length	33.126 (cm)
Vert. brace	use	L-100x100x10
	cmpr stress Sig.c	33.003 <= 44.023 (N/mm²) (T= 62.705kN)
Vert. braceJoint part	required welding length	29.860 (cm)

3 Registered load data export

3.1 Truck load



1	name : TT43		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	30.000	3.250
	2	65.000	7.800
	3	60.000	1.550
	4	60.000	------------------------------------

2	name : T25		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	4.000
	2	100.000	------------------------------------

3	name : T20		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.000
	2	80.000	------------------------------------

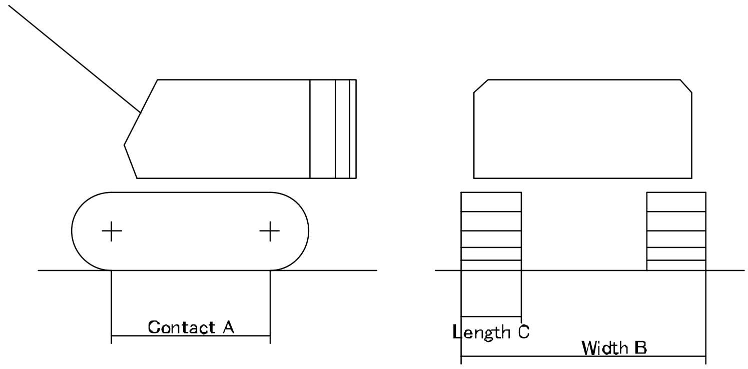
4	name : T14		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	14.000	4.000
	2	56.000	------------------------------------

5	name : Ready mixed concrete Truck(3 cubic meters)		
	wheel distance in perpendicular direction = 1.08 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.200
	2	54.000	------------------------------------

6	name : Ready mixed concrete Truck(5 cubic meters)		
	wheel distance in perpendicular direction = 1.88 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	3.160
	2	55.000	1.880
	3	30.000	------------------------------------

7	name : Surplus soil Truck		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	34.000	4.000
	2	63.000	------------------------------------

3.2 Crawler crane



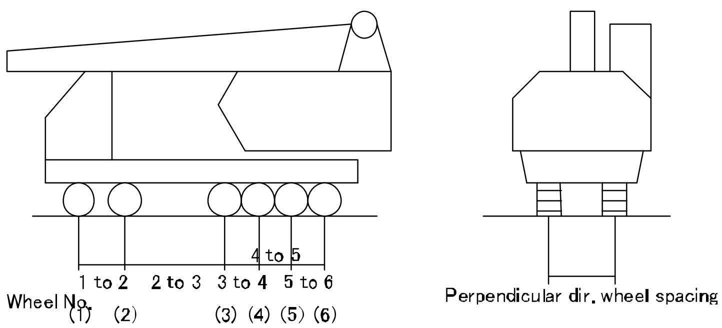
1	name : D408S	
	self weight = 480.000(kN) lifting load = 50.000(kN) contact length A = 4.470(m) width B = 4.000(m) contact width C = 0.800(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

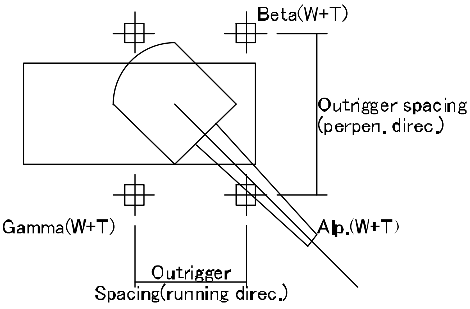
2	name : P&H440S	
	self weight = 400.000(kN) lifting load = 50.000(kN) contact length A = 4.380(m) width B = 3.960(m) contact width C = 0.760(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

3	name : P&H335AS	
	self weight = 350.000(kN) lifting load = 30.000(kN) contact length A = 4.280(m) width B = 3.790(m) contact width C = 0.590(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

4	name : P&H325	
	self weight = 280.000(kN) lifting load = 30.000(kN) contact length A = 3.950(m) width B = 3.030(m) contact width C = 0.590(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

3.3 Truck crane





1	name : NK-300	
	wheel distance in perpendicular direction = 2.10 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
1	32.000	3.850
2	64.000	1.350
3	64.000	--
	self weight W= 320.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 4.750(m) outrigger distance(perpendicular) = 5.600(m) outrigger width = 0.500(m)

2	name : NK-200	
	wheel distance in perpendicular direction = 1.90 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
1	20.000	3.980
2	40.000	1.240
3	40.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 4.450(m) outrigger distance(perpendicular) = 4.800(m) outrigger width = 0.400(m)

3	name : Rough terrain crane 20tons	
	wheel distance in perpendicular direction = 2.10 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
1	20.000	3.000
2	80.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 5.700(m) outrigger distance(perpendicular) = 5.700(m) outrigger width = 0.400(m)

4	name : Rough terrain crane 25tons	
	wheel distance in perpendicular direction = 2.10 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
1	25.000	3.500
2	100.000	--
	self weight W= 250.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 6.300(m) outrigger distance(perpendicular) = 6.200(m) outrigger width = 0.400(m)

	name : Rough terrain crane 40tons	
	wheel distance in perpendicular direction = 2.10 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
5 1	35.000	4.250
2	140.000	

self weight W= 350.000(kN) outrigger distance(moving) = 7.300(m)
lifting load T= 30.000(kN) outrigger distance(perpendicular) = 6.500(m)
load distribution ratio Alp.= 0.700 outrigger width = 0.500(m)
load distribution ratio Beta= 0.150
load distribution ratio Gam= 0.150

	name : KA-900	
	wheel distance in perpendicular direction = 2.30 (m)	
	load intensity (1 side)(kN)	wheel distance in moving direction (m)
6 1	38.850	1.650
2	38.850	2.400
3	27.250	1.650
4	27.250	

self weight W= 264.400(kN) outrigger distance(moving) = 8.700(m)
lifting load T= 800.000(kN) outrigger distance(perpendicular) = 7.400(m)
load distribution ratio Alp.= 0.700 outrigger width = 0.500(m)
load distribution ratio Beta= 0.150
load distribution ratio Gam= 0.150

4 Registered member data export

4.1 Main girder Registered data

1 name : H-300x300x10x15

unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm²)
web section area	Aw =	27.00(cm²)	section modulus	Z =	1350.0(cm³)
moment of inertia	I =	20200.0(cm⁴)	lateral buckling radius	i =	8.23(cm)
beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)

2 name : H-350x350x12x19

unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm²)
web section area	Aw =	37.44(cm²)	section modulus	Z =	2280.0(cm³)
moment of inertia	I =	39800.0(cm⁴)	lateral buckling radius	i =	9.65(cm)
beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)

3 name : H-400x400x13x21

unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm²)
web section area	Aw =	46.54(cm²)	section modulus	Z =	3330.0(cm³)
moment of inertia	I =	66600.0(cm⁴)	lateral buckling radius	i =	11.00(cm)
beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)

4 name : H-594x302x14x23

unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm²)
web section area	Aw =	76.72(cm²)	section modulus	Z =	4500.0(cm³)
moment of inertia	I =	134000.0(cm⁴)	lateral buckling radius	i =	7.96(cm)
beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)

5 name : H-900x300x16x28

unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm²)
web section area	Aw =	135.04(cm²)	section modulus	Z =	8990.0(cm³)
moment of inertia	I =	404000.0(cm⁴)	lateral buckling radius	i =	7.68(cm)
beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)

6 name : H-912x302x18x34

unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm^2)
web section area	Aw =	151.92(cm^2)	section modulus	Z =	10800.0(cm^3)
moment of inertia	I =	491000.0(cm^4)	lateral buckling radius	i =	7.84(cm)
beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)

7 name : H-250x250x9x14

unit weight	=	718.0 (N/m)	flange section area	Af =	35.00(cm^2)
web section area	Aw =	19.98(cm^2)	section modulus	Z =	860.0(cm^3)
moment of inertia	I =	10700.0(cm^4)	lateral buckling radius	i =	6.91(cm)
beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4.2 Beam seat H-Beam registered data

1 name : H-300x300x10x15

unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm^2)
web section area	Aw =	27.00(cm^2)	section modulus	Z =	1350.0(cm^3)
moment of inertia	I =	20200.0(cm^4)	lateral buckling radius	i =	8.23(cm)
beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)

2 name : H-350x350x12x19

unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm^2)
web section area	Aw =	37.44(cm^2)	section modulus	Z =	2280.0(cm^3)
moment of inertia	I =	39800.0(cm^4)	lateral buckling radius	i =	9.65(cm)
beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)

3 name : H-400x400x13x21

unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm^2)
web section area	Aw =	46.54(cm^2)	section modulus	Z =	3330.0(cm^3)
moment of inertia	I =	66600.0(cm^4)	lateral buckling radius	i =	11.00(cm)
beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)

4 name : H-594x302x14x23

unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm^2)
web section area	Aw =	76.72(cm^2)	section modulus	Z =	4500.0(cm^3)
moment of inertia	I =	134000.0(cm^4)	lateral buckling radius	i =	7.96(cm)
beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)

5 name : H-900x300x16x28

unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm^2)
web section area	Aw =	135.04(cm^2)	section modulus	Z =	8990.0(cm^3)
moment of inertia	I =	404000.0(cm^4)	lateral buckling radius	i =	7.68(cm)
beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)

6 name : H-912x302x18x34

unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm^2)
web section area	Aw =	151.92(cm^2)	section modulus	Z =	10800.0(cm^3)
moment of inertia	I =	491000.0(cm^4)	lateral buckling radius	i =	7.84(cm)
beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)

7 name : H-250x250x9x14

unit weight	=	704.0 (N/m)	flange section area	Af =	35.00(cm^2)
web section area	Aw =	19.98(cm^2)	section modulus	Z =	860.0(cm^3)
moment of inertia	I =	10700.0(cm^4)	lateral buckling radius	i =	6.91(cm)
beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4.3 Beam seat one side U steel

No.						
	name : [-250x90x9x13					
1	unit weight	=	339.0(N/m)	section area	Af =	44.07(cm^2)
	web section area	Aw =	20.16(cm^2)	section modulus	Z =	335.0(cm^3)
	moment of inertia	I =	4180.0(cm^4)	area gyration radius	i =	2.58(cm)
	web height	h =	25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

No.						
	name : [-300x90x9x13					
2	unit weight	=	374.0(N/m)	section area	Af =	48.57(cm^2)
	web section area	Aw =	24.66(cm^2)	section modulus	Z =	429.0(cm^3)
	moment of inertia	I =	6440.0(cm^4)	area gyration radius	i =	2.52(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

No.						
	name : [-300x90x10x15.5					
3	unit weight	=	430.0(N/m)	section area	Af =	55.74(cm^2)
	web section area	Aw =	26.90(cm^2)	section modulus	Z =	494.0(cm^3)
	moment of inertia	I =	7410.0(cm^4)	area gyration radius	i =	2.54(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.55(cm)

No.						
	name : [-380x100x10.5x16					
4	unit weight	=	534.0(N/m)	section area	Af =	69.39(cm^2)
	web section area	Aw =	36.54(cm^2)	section modulus	Z =	763.0(cm^3)
	moment of inertia	I =	14500.0(cm^4)	area gyration radius	i =	2.78(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.05(cm)	compressive flange thickness	t2 =	1.60(cm)

No.						
	name : [-380x100x13x20					
5	unit weight	=	660.0(N/m)	section area	Af =	85.71(cm^2)
	web section area	Aw =	44.20(cm^2)	section modulus	Z =	926.0(cm^3)
	moment of inertia	I =	17600.0(cm^4)	area gyration radius	i =	2.76(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.00(cm)

4.4 Beam seat L section steel Registered data

No.						
	name : L-65x65x6					
1	unit weight	=	58.0(N/m)	section area	A =	7.527(cm^2)
	area gyration radius	iy =	1.98(cm)			
	angle edge width	B =	6.5(cm)	thickness	t =	0.60(cm)

No.						
	name : L-75x75x6					
2	unit weight	=	67.2(N/m)	section area	A =	8.727(cm^2)
	area gyration radius	iy =	2.30(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.60(cm)

No.						
	name : L-75x75x9					
3	unit weight	=	97.7(N/m)	section area	A =	12.690(cm^2)
	area gyration radius	iy =	2.25(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.90(cm)

No.						
	name : L-90x90x10					
4	unit weight	=	130.4(N/m)	section area	A =	17.000(cm^2)
	area gyration radius	iy =	2.71(cm)			
	angle edge width	B =	9.0(cm)	thickness	t =	1.00(cm)

No.						
	name : L-100x100x10					
5	unit weight	=	146.1(N/m)	section area	A =	19.000(cm^2)
	area gyration radius	iy =	3.04(cm)			
	angle edge width	B =	10.0(cm)	thickness	t =	1.00(cm)

4.5 Support pile Registered data

No.	name : H-300x300x10x15(Weak)				
1	unit weight	= 912.0 (N/m)	section area	A =	118.40(cm^2)
	flange section area Af	= 45.00(cm^2)	web section area	Aw =	27.00(cm^2)
	action direction	= weak	area gyration radius	iy =	13.10(cm)
	area gyration radius iz	= 7.55(cm)	lateral buckling radius	i =	8.23(cm)
	beam height h	= 30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness t1	= 1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
	section modulus Z	= 450.0(cm^3)	moment of inertia	I =	6750.0(cm^4)
	pile tip area	= 900.0(cm^2)	pile circumference	=	120.0(cm)
	pile diameter	= 30.0(cm)	pile unit weight	=	912.0(N/m)

No.	name : H-300x300x10x15(Strong)				
2	unit weight	= 912.0 (N/m)	section area	A =	118.40(cm^2)
	flange section area Af	= 45.00(cm^2)	web section area	Aw =	27.00(cm^2)
	action direction	= strong	area gyration radius	iy =	13.10(cm)
	area gyration radius iz	= 7.55(cm)	lateral buckling radius	i =	8.23(cm)
	beam height h	= 30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness t1	= 1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
	section modulus Z	= 1350.0(cm^3)	moment of inertia	I =	20200.0(cm^4)
	pile tip area	= 900.0(cm^2)	pile circumference	=	120.0(cm)
	pile diameter	= 30.0(cm)	pile unit weight	=	912.0(N/m)

No.	name : H-350x350x12x19·Weak)				
3	unit weight	= 1324.0 (N/m)	section area	A =	171.90(cm^2)
	flange section area Af	= 66.50(cm^2)	web section area	Aw =	37.44(cm^2)
	action direction	= weak	area gyration radius	iy =	15.20(cm)
	area gyration radius iz	= 8.89(cm)	lateral buckling radius	i =	9.65(cm)
	beam height h	= 35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness t1	= 1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
	section modulus Z	= 776.0(cm^3)	moment of inertia	I =	13600.0(cm^4)
	pile tip area	= 1225.0(cm^2)	pile circumference	=	140.0(cm)
	pile diameter	= 35.0(cm)	pile unit weight	=	1323.9(N/m)

No.	name : H-350x350x12x19(Strong)				
4	unit weight	= 1324.0 (N/m)	section area	A =	171.90(cm^2)
	flange section area Af	= 66.50(cm^2)	web section area	Aw =	37.44(cm^2)
	action direction	= strong	area gyration radius	iy =	15.20(cm)
	area gyration radius iz	= 8.89(cm)	lateral buckling radius	i =	9.65(cm)
	beam height h	= 35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness t1	= 1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
	section modulus Z	= 2280.0(cm^3)	moment of inertia	I =	39800.0(cm^4)
	pile tip area	= 1225.0(cm^2)	pile circumference	=	140.0(cm)
	pile diameter	= 35.0(cm)	pile unit weight	=	1323.9(N/m)

4.6 Hori. joint Registered data

No.	name : [-150x75x6.5x10				
1	unit weight	= 182.0(N/m)	section area	A =	23.71(cm^2)
	area gyration radius iy	= 2.27(cm)			
	web height h	= 15.0(cm)	compressive flange width	b =	7.5(cm)
	web thickness t1	= 0.65(cm)	compressive flange thickness	t2 =	1.00(cm)

No.	name : [-200x90x8x13.5				
2	unit weight	= 297.0(N/m)	section area	A =	38.65(cm^2)
	area gyration radius iy	= 2.68(cm)			
	web height h	= 20.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1	= 0.80(cm)	compressive flange thickness	t2 =	1.35(cm)

No.	name : [-250x90x9x13				
3	unit weight	= 339.0(N/m)	section area	A =	44.07(cm^2)
	area gyration radius iy	= 2.64(cm)			
	web height h	= 25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1	= 0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

4.7 Vert. brace Registered data

No.	name : L-65x65x6				
1	unit weight	= 58.00(N/m)	section area	A =	7.527(cm^2)
	area gyration radius iy	= 1.98(cm)	min area gyration radius	iv =	1.27(cm)
	angle edge width B	= 6.5(cm)	thickness	t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm^2)
	area gyration radius iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm^2)
	area gyration radius iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

4	name : L-90x90x10			
	unit weight =	130.40(N/m)	section area A =	17.000(cm^2)
	area gyration radius iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

5	name : L-100x100x10			
	unit weight =	146.10(N/m)	section area A =	19.000(cm^2)
	area gyration radius iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.8 Hori. brace Registered data

1	name : L-65x65x6			
	unit weight =	58.00(N/m)	section area A =	7.527(cm^2)
	moment of inertia iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm^2)
	moment of inertia iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm^2)
	moment of inertia iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

4	name : L-90x90x10			
	unit weight =	130.40(N/m)	section area A =	17.000(cm^2)
	moment of inertia iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

5	name : L-100x100x10			
	unit weight =	146.10(N/m)	section area A =	19.000(cm^2)
	moment of inertia iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.9 Lateral joint member 1 side U steel Registered data

1	name : [-200x90x8x13.5			
	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

2	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area A =	44.07(cm^2)
	area gyration radius iy =	2.58(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

	name : [-300x90x9x13				
3	unit weight	= 374.0(N/m)	section area	A =	48.57(cm²)
	area gyration radius iy	= 2.52(cm)			
	web height h	= 30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1	= 0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

	name : [-300x90x10x15.5				
4	unit weight	= 430.0(N/m)	section area	A =	55.74(cm²)
	area gyration radius iy	= 2.54(cm)			
	web height h	= 30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1	= 1.00(cm)	compressive flange thickness	t2 =	1.55(cm)

4.10 Lateral joint member L section steel Registered data

	name : L-65x65x6				
1	unit weight	= 58.0(N/m)	section area	A =	7.527(cm²)
	area gyration radius iy	= 1.98(cm)			
	angle edge width B	= 6.5(cm)	thickness	t =	0.60(cm)

	name : L-75x75x6				
2	unit weight	= 67.2(N/m)	section area	A =	8.727(cm²)
	area gyration radius iy	= 2.30(cm)			
	angle edge width B	= 7.5(cm)	thickness	t =	0.60(cm)

	name : L-75x75x9				
3	unit weight	= 97.7(N/m)	section area	A =	12.690(cm²)
	area gyration radius iy	= 2.25(cm)			
	angle edge width B	= 7.5(cm)	thickness	t =	0.90(cm)

	name : L-90x90x10				
4	unit weight	= 130.4(N/m)	section area	A =	17.000(cm²)
	area gyration radius iy	= 2.71(cm)			
	angle edge width B	= 9.0(cm)	thickness	t =	1.00(cm)

	name : L-100x100x10				
5	unit weight	= 146.1(N/m)	section area	A =	19.000(cm²)
	area gyration radius iy	= 3.04(cm)			
	angle edge width B	= 10.0(cm)	thickness	t =	1.00(cm)

4.11 Retaining wall Steel sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	II	400	100	48.0	153.00	8740	874
2	III	400	125	60.0	191.00	16800	1340
3	III	400	130	60.0	191.00	17400	1340
4	IV	400	170	76.1	242.50	38600	2270
5	VL	500	200	105.0	267.60	63000	3150
6	IIw	600	130	61.8	131.20	13000	1000
7	IIIw	600	180	81.6	173.20	32400	1800
8	IVw	600	210	106.0	225.50	56700	2700

4.12 Retaining wall soldier lateral sheet pile Registered data

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
1	H-100x100x 6x 8	100	100	6.0	8	21.59	16.9	378	76
2	H-125x125x 6.5x 9	125	125	6.5	9	30.00	23.6	839	134
3	H-150x150x 7x10	150	150	7.0	10	39.65	31.1	1620	216
4	H-175x175x 7.5x11	175	175	7.5	11	51.42	40.4	2900	331
5	H-200x200x 8x12	200	200	8.0	12	63.53	49.9	4720	472
6	H-250x250x 9x14	250	250	9.0	14	91.43	71.8	10700	860
7	H-300x300x10x15	300	300	10.0	15	118.40	93.0	20200	1350
8	H-350x350x12x19	350	350	12.0	19	171.90	135.0	39800	2280
9	H-400x400x13x21	400	400	13.0	21	218.70	172.0	66600	3330
10	H-400x400x18x28	414	405	18.0	28	295.40	232.0	92800	4480
11	H-400x400x20x35	428	407	20.0	35	360.70	283.0	119000	5570
12	H-400x400x30x50	458	417	30.0	50	528.60	415.0	187000	8170

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
13	H-400x400x45x70	498	432	45.0	70	770.10	605.0	298000	12000

4.13 Retaining wall Lightweight sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	TypeA	250	36	14.8	75.40	107	60
2	TypeB	333	51	17.9	68.28	510	144
3	TypeC	333	85	19.3	73.80	2000	272
4	TypeD	333	74	21.6	82.53	636	171
5	TypeE	500	160	33.6	85.70	3620	452

Cover

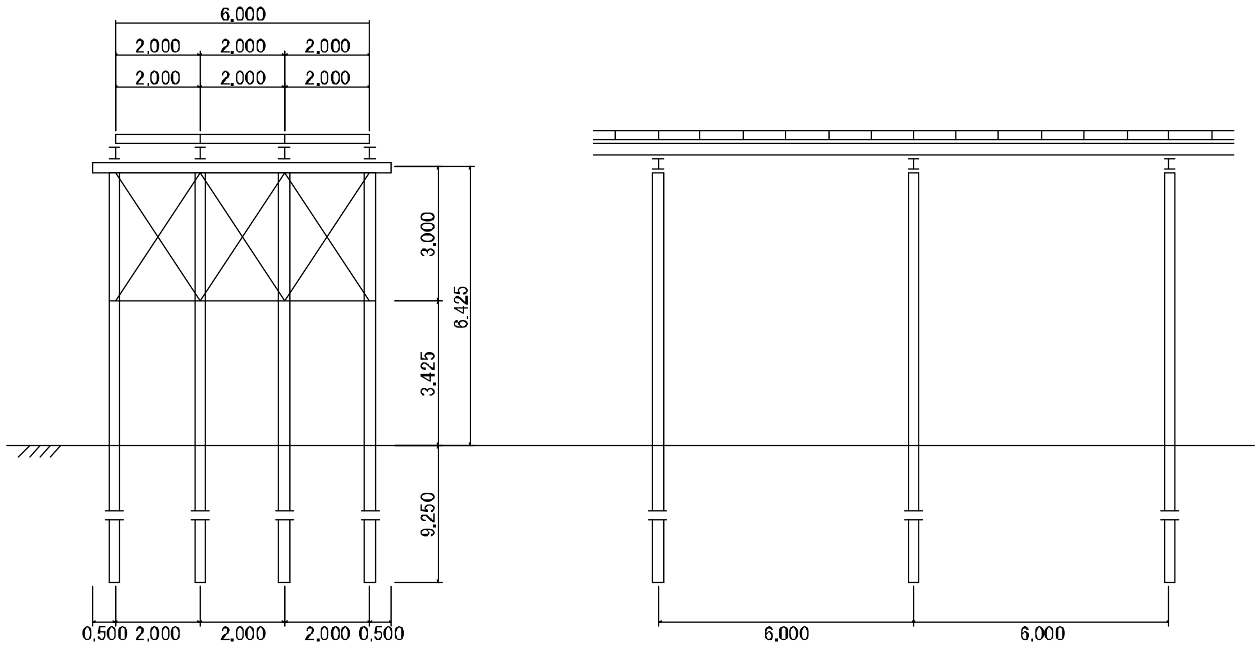
Contents

1 Input data export

1.1 Title

file : Bahr Yusef 60-6mDE.F8K
title: Dairout Bahr Yusef 60-6mD

1.2 Shape data



FORUM8

1. 4 Design condition

basic condition

Applied standard	C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
type of working platform	Type i(widthMain girder orthogonal)
adjacent span	Yes
Support pile Foundation type	Support pile

steel deck, coefficient

type of steel deck	Steel deck type 2(Old Metro-deck)
At Steel deck designMain girder treatment	Not consider
impact coefficient steel deck	0.300
other than steel deck	0.300
Horizontal coefficient fixed load	0.200
load truck	= 0.200
heavy equipment	= 0.200

Use horizontal coefficient when truck crane is moving.

impact when horizontal load is calculated	not include impact
impact when deflection is calculated	not include impact

1.4 Member design condition

Beam seatSteel specification	H Beam
Beam seatCheck share stress	Checking
Beam seat, Support piledesign guideline	Main girder load distribution is considered.
allowable deflection	length of a span/ 400.000
maximum deflection	2.500 (cm)
dead load when deflection is calculated	Not consider
Eq of deflection for single live load	Calculation equation for 1 member
Support piledesign	Examine
Support pileDesign time axial force	maximum axial force / 1
Support pileself weight treatment	Total length
other vertical load	0.000 (kN/ a member)
Support pileHorizontal force load status	Use vertical load when horizontal force is max.
Hori. jointhorizontal force	1 memberHori. jointshare(by before member)
Hori. joint	both sides install
Beam seatunderneathHori. jointinstall:	Not do
Hori. jointJoint part	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)
Hori. joint,brace horizontal force calculation method	Use vertical load when horizontal force is max.
brace member	Design as compressive member
brace connection	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)

1. 4 Design condition

live load

increment of live load movement of live load when member section is calculated for live load Del.L 0.010 (m)

crawler crane load Linear load

Support piledesign

Incase of Penetration length is not satisfied with Beta L >= 2.50 :design as limited length pile

increase rate pile top free	bending moment	1.00
	displacement	1.25
pile top fixed	bending moment	1.10
	displacement	1.20

1.6 Live load for steel deck design

	Main girder orthogonal to		Main girder parallel to	
	1000* 2000	1000* 3000	1000* 2000	1000* 3000
truck load	NG	NG	OK	NG
crawler crane moving	NG	NG	OK	NG
crawler crane 0 degree	NG	NG	OK	NG
crawler crane 90 degree	NG	NG	OK	NG
crawler crane 45 degree	NG	NG	OK	NG
truck crane moving	NG	NG	OK	NG
truck crane working	NG	NG	NG	NG
reinforcing beam	NG		NG	

OK : design NG : not design

1.7 Live loads for member design

	Main girder orthogonal to	Main girder parallel to
truck load	NG	OK
crawler crane moving	NG	OK
crawler crane 0 degree	NG	OK
crawler crane 90 degree	NG	OK
crawler crane 45 degree	NG	OK
truck crane moving	NG	OK
truck crane working	NG	NG

OK : design NG : not design

1.8 working platform data

Span* adjacent span data

item	symbol	unit	value
main span length	--	m	6.000
adjacent span length	--	m	6.000

Main girder spacing data

No. N	Main girder spacing(m)
1	2.000
2	2.000
3	2.000

steel deck layout data

No. F	steel deck size (m)
1	2
2	2
3	2

Support pile spacing

No. S	Support pile spacing(m)
1	2.000
2	2.000
3	2.000

width, overhang

item	symbol	unit	value
road width	--	m	6.000
gap	--	m	0.000
left overhang length	LL	m	0.500
right overhang length	LR	m	0.500

1.9 frame data

with or without Hori. brace [none]
with or without Vert. brace [Yes]
elevation

No. h	frame spacing (m)
1 2	3.000 3.425

item	symbol	unit	value
Support pilepenetration length	hL	m	9.250
ground level G.L.	--	m	41.000

1.10 Support piledesign condition

Sand layer with N-value more than 30 or delluvial clay with more than 10
embedded more than 3min the bearing layer Not allow
Pile construction method (not embedded by written above) Striking construction method
Directly input Alp.* Beta No
Pile moment using vertical brace
Calculation method Chang equation
Specify upper limit of N-value in pile tip ground Based on the design strength
Direct input N-value at pile tip ground No
embedment length 9.25 (m)
Young's modulus of pile * 10^5 2.00 (N/mm²)
Modulus of subgrade lateral reaction 0.00 (kN/m³)
Assume sound layer when pile tip bearing capacity is calculated
Lower limit of N-value 20.000
Factor of Safey when allowable bearing capacity is calculated 2.0

1.11 Strata data

No.	layer type	layer thickness	average N-value	coh soil unc cmpr strg(kN/m²)	Alp.* Eo (kN/m²)	cohesion (kN/m²)
1	Sandy soil	1.000	4.000	100.000	11200.00	50.000
2	Sandy soil	1.000	8.000	100.000	22400.00	50.000
3	Sandy soil	1.000	19.000	200.000	53200.00	100.000
4	Sandy soil	1.000	16.000	200.000	44800.00	100.000
5	Sandy soil	1.000	26.000	300.000	72800.00	150.000
6	Sandy soil	1.000	19.000	200.000	53200.00	100.000
7	Sandy soil	1.000	25.000	300.000	70000.00	150.000
8	Sandy soil	1.000	25.000	300.000	70000.00	150.000
9	Sandy soil	1.000	52.000	300.000	145600.00	150.000
10	Sandy soil	1.000	45.000	300.000	126000.00	150.000
11	Sandy soil	1.000	31.000	300.000	86800.00	150.000
12	Sandy soil	1.000	40.000	300.000	112000.00	150.000
13	Sandy soil	1.000	46.000	300.000	128800.00	150.000
14	Sandy soil	1.000	38.000	300.000	106400.00	150.000
15	Sandy soil	1.000	38.000	300.000	106400.00	150.000
16	Sandy soil	1.000	46.000	300.000	128800.00	150.000
17	Sandy soil	1.000	78.000	300.000	218400.00	150.000

1.12 steel deck load distribution ratio specification

* truck load distribution ratio

	Main girder orthogonal to	Main girder parallel to
truck	0.40	0.40

* Crawler crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
0 degree	0.25	0.20
45 degree	0.25	0.20
60 degree	0.25	0.20

Note)use the value of front hang when moving.

* Truck crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
moving working	0.40 0.40	0.40 0.40

1.13 Steel deck material data

height of steel deck 200(mm)

* in case of 1000* 2000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm²)
3) Z 312.0 (cm³)

* in case of 1000* 3000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm²)
3) Z 312.0 (cm³)

Note: Web section area, section modulus are input data per one H steel.

1.14 Reinforcement girder material data

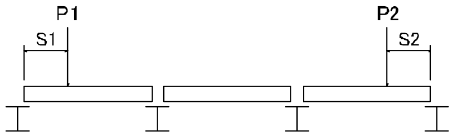
1) name of using material
2) Aw 54.00 (cm²)
3) Z 2720.0 (cm³)
4) self-weight 1880.0 (N/m)
5) span length 2.0 (m)
6) comment (description)

1.15 Beam seat Joint part bolt data

Support pile part

bolt is not designed.

1.16 Bridge face(dead) load



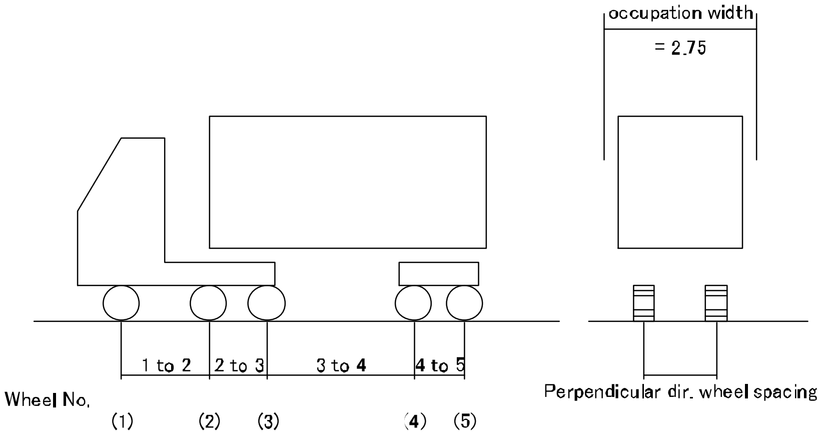
1) left loading position 0.000 (m)
2) right loading position 0.000 (m)
3) left load intensity 0.000 (kN/m)
4) right load intensity 0.000 (kN/m)

1.17 Steel deck/Nominal load

1) steel deck self-weight 1000 * 2000 2.000 (kN/m²)
   1000 * 3000 2.000 (kN/m²)
   other 2.000 (kN/m²)
2) nominal load 0.000 (kN/m²)
3) attachment unit 0.100

1.18 Select truck load

* bridge axis direction



1) load selection　Input load
2) registration name　T20
3) axis spacing in perpendicular direction　1.75 (m)
4) number of wheels　2
5) axis spacing in moving direction (m)

1 - 2	4.000

6) load intensity (one side) (kN)

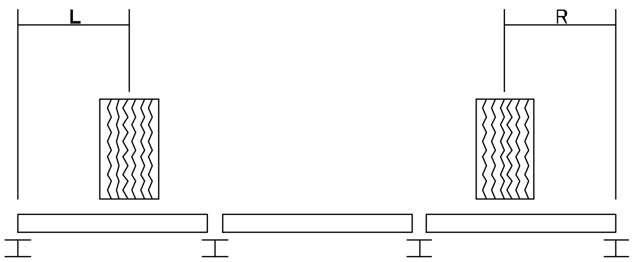
1	20.000
2	80.000

* perpendicular to bridge axis direction
1) load selection　Input load
2) load type
P1　T20
P2　T20
P3　T20

1.19 Truck load condition setting

* bridge axis direction
1) train load is considered　No
2) Number in perpendicular direction　2

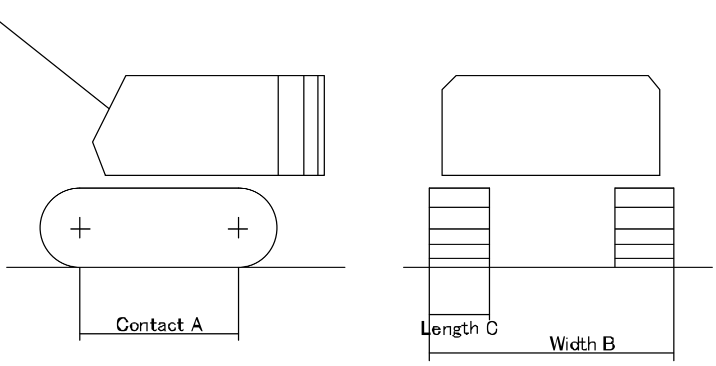
1.20 Width of truck load setting



1) load on one side　Consider
2) non-width of load (left)　0.000 (m)
3) non-width of load (right)　0.000 (m)

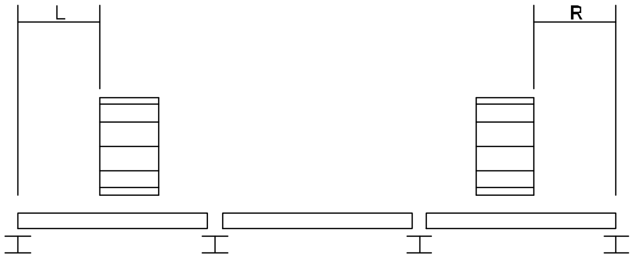
1.21 Crawler crane load selection

1)registration name D408S



2)self-weight 480.000 (kN)
3)hoisting self-weight 50.000 (kN)
4)contact A 4.470 (m)
5)width B 4.000 (m)
6)contact width C 0.800 (m)
7)apportionment on lateral operation side 0.750
8)contact when hoisting forward 0.750
9)apportionment on operation side in orthogonal direction 0.700
10)contact on operation side in orthogonal direction 0.900

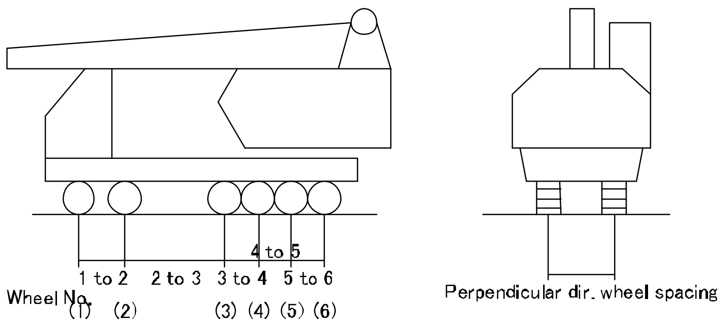
1.22 Width of Crawler crane non-load setting



1)load on one side Not consider
2)non-width of load (left) 1.000 (m)
3)non-width of load (right) 1.000 (m)
4)location of heavy equipment in bridge axis direction not specify

1.23 Truck crane load selection

* at moving



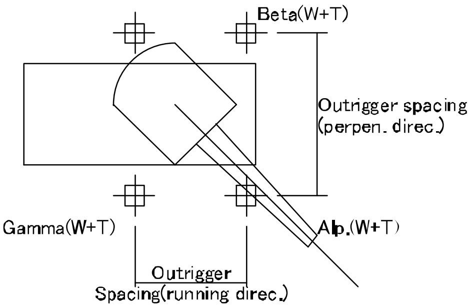
1)registration name Rough terrain crane 25tons
2)wheel spacing in perpendicular direction 2.10 (m)
3)number of wheels 2
4)wheel spacing in moving direction (m)

1 - 2	3.500

5) load intensity(one side) (kN)

1	25.000
2	100.000

* at operating



1) self-weight W 250.000 (kN)
2) hoisting self-weight T 30.000 (kN)
3) outrigger spacing (moving) 6.300 (m)
4) outrigger spacing (perpendicular) 6.200 (m)
5) load distribution ratio Alp. 0.700
6) load distribution ratio Beta 0.150
7) load distribution ratio Gam 0.150
8) outrigger width 0.400 (m)

1.24 Width of Truck crane non-load setting

truck crane load is not considered.

1.25 Dead load arbitrary position

Dead load at any location is not input.

1.26 Specify allowable stress

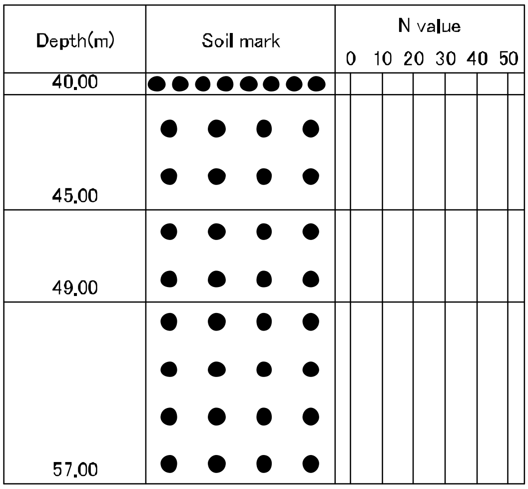
steel type name SS400
load factor of allowable stress 1.50
allowable stress

	direct input of allowable stress			
	bend cmpr (N/mm²)	ax cmpr (N/mm²)	ax tns (N/mm²)	shear (N/mm²)
steel deck	Auto calc	----	----	Auto calc
Main girder	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)H-Beam	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)U shape steel	210.00	----	----	Auto calc
Support pile	Auto calc	Auto calc	----	Auto calc
Hori. joint	----	Auto calc	----	----
brace	----	Auto calc	Auto calc	----

allowable stress automatic calculation(calculate from fixed number in the middle of a member)

	fixed number of middle		member length	
	distance flange fixed	effective buckling length	distance fixed (cm)	effective buckling length(cm)
steel deck	----	----	----	----
Main girder	0	----	0.00	----
Beam seat(Support pilepart)H-Beam	0	----	0.00	----
Beam seat(Support pilepart)U shape steel	0	----	0.00	----
Support pile	0	0	0.00	0.00
Hori. joint	----	0	----	0.00
brace	----	----	----	----

1.27 Borehole log of strata



1.28 Initial input

1)applied standard — C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
2)abutment type — Type i
3)adjacent span — Yes
4)Support pile Foundation type — bearing pile embedment length 9.250(m)
5)shape data
* width — 6.000(m)
* left overhang — 0.500(m)
* right overhang — 0.500(m)
* span — 6.000(m)
* working platform height — 6.425(m)
* steel deck size — 2.000(m)
* Support pileBasic spacing — 2.000(m)
* frame basic spacing — 3.000(m)
6)Design Support pile
* Foundation data
  1.pile construction method — driven casting
* Soil data

No.	type	thickness (m)	ave N value	coh soil cmpr strg (kN/m²)	Alp.* Eo (kN/m²)	cohension (kN/m²)
1	Sandy soil	1.000	4.000	100.000	11200.00	50.000
2	Sandy soil	1.000	8.000	100.000	22400.00	50.000
3	Sandy soil	1.000	19.000	200.000	53200.00	100.000
4	Sandy soil	1.000	16.000	200.000	44800.00	100.000
5	Sandy soil	1.000	26.000	300.000	72800.00	150.000
6	Sandy soil	1.000	19.000	200.000	53200.00	100.000
7	Sandy soil	1.000	25.000	300.000	70000.00	150.000
8	Sandy soil	1.000	25.000	300.000	70000.00	150.000
9	Sandy soil	1.000	52.000	300.000	145600.00	150.000
10	Sandy soil	1.000	45.000	300.000	126000.00	150.000
11	Sandy soil	1.000	31.000	300.000	86800.00	150.000
12	Sandy soil	1.000	40.000	300.000	112000.00	150.000
13	Sandy soil	1.000	46.000	300.000	128800.00	150.000
14	Sandy soil	1.000	38.000	300.000	106400.00	150.000
15	Sandy soil	1.000	38.000	300.000	106400.00	150.000
16	Sandy soil	1.000	46.000	300.000	128800.00	150.000
17	Sandy soil	1.000	78.000	300.000	218400.00	150.000

2 Calculation result export

2.1 Steel deck type 2 design (Old Metro-deck)

2.1.1 Sum up bending stress for each load

load status			Bending stress 1000 * 2000 (N/mm²)
truck load		parallel	70.084
		orthogonal	----------
crawler crane	moving	parallel	18.538
		orthogonal	----------
	working 0 degree	parallel	45.479
		orthogonal	----------
	working 90 degree	parallel	30.283
		orthogonal	----------
	working 45 degree	parallel	54.480
		orthogonal	----------
truck crane	moving	parallel	73.558
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			210.000

2.1.2 bending stress calculation

calculate stresses when the load condition induces bending stress maximum

1) load condition Truck crane when moving (Parallel)

2) steel deck Steel deck type 2 (1000*2000)

3) bending moment by fixed load (per a steel deck)

$$Md = w * l^2 / 8 = 1.000 \ (kN.m)$$

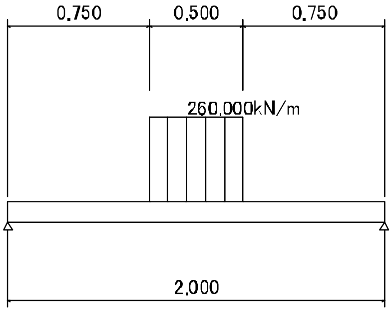
where

w : fixed load intensity applied on a steel deck

(self-weight of a steel deck + nominal load)* (width of a steel deck) = 2.000 (kN/m)

l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4) Truck crane when moving(Parallel) of bending moment



Mmax = 56.875 (kN m)

where
w : load intensity
w_1 = 260.000 (kN/m)

5) in case of Truck crane when moving(Parallel), bending moment per single steel sheet
steel deck type2 1000 * 2000
Sig.M = Mmax * 0.400 + Ml * 20/100 = 22.950 (kN m)

6) stresses in a steel deck
Sig. = Sig.M / Z = 73.558 (N/mm²)
where
Z: section modulus = 312.000 (cm³)

2.1.3 Sum up shear stress for each load

load status			shear stress 1000 * 2000 (N/mm²)
truck load		parallel	64.691
		orthogonal	----------
crawler crane	moving	parallel	14.281
		orthogonal	----------
	working 0 degree	parallel	35.035
		orthogonal	----------
	working 90 degree	parallel	23.329
		orthogonal	----------
	working 45 degree	parallel	41.970
		orthogonal	----------
truck crane	moving	parallel	56.667
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			120.000

2.1.4 Shear stress calculation

calculate stresses when the load condition induces Shear stress maximum

1)load condition Truck load(Parallel)

2)steel deck Steel deck type 2 (1000*2000)

3)Shear force by fixed load (per a steel deck)

$Sd = w * l / 2 =$ 2.000 (kN)

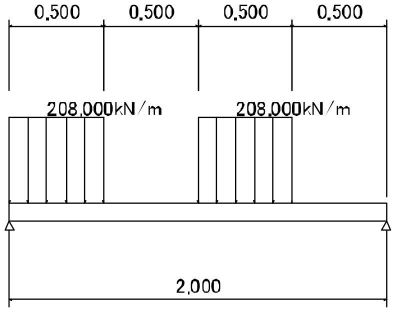
where

w : fixed load intensity applied on a steel deck

(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)

l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4)Truck load(Parallel) of Shear force



Smax = 130.000 (kN)

where

w : load intensity

w_1 = 208.000 (kN/m)

w_2 = 208.000 (kN/m)

5) in case of Truck load(Parallel), Shear force per single steel sheet
steel deck type2 1000 * 2000
Sig.S = Smax * 0.400 + Sd * 20/100 = 52.400 (kN)

6) stresses in a steel deck
Tau = Sig.S / A = 64.691 (N/mm²)
where
A: cross sectional area = 8.100 (cm²)

2.2 Main girder Design

2.2.1 bending moment sum up for each load

load status		Main girder No.	bending moment (kN.m)
truck load	orthogonal	--------	------------
	parallel	G 2	279.092
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	231.160
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	308.616
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	366.064
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	399.891
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	220.591
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.2 bending moment calculation

Calculate load condition when bending moment is maximum

1) load condition Crawler crane diagonal hang(Parallel)

2) design Main girder number 2

3) stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

Main girder Self weight = 1.687

----

total wd = 5.687 (kN/m)

using Main girder H-400x400x13x21

* stresses by fixed load

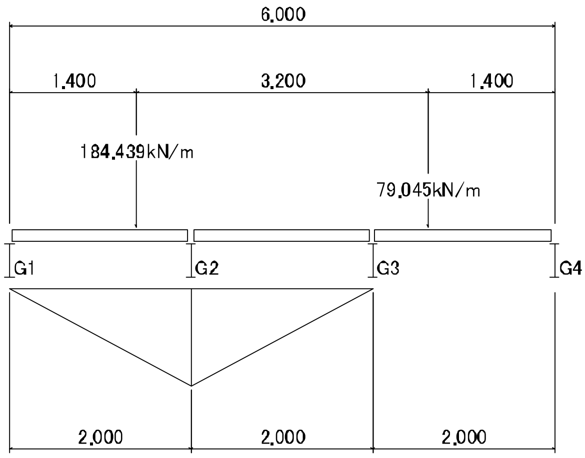
bending moment

$Md = wd * l^2 / 8 + Mo = 5.687 * 6.000^2 / 8 + 0.000 = 25.592$ (kN.m)

FORUM8

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side

triangular distribution front side p1 = (W+ T) * 0.700 /(0.900 * lb * 1/2) = 184.439 (kN/m)

triangular distribution front side p1' = 0.000 (kN/m)

crawler crane load intensity on non-operation side

triangular distribution front side p2 = (W+ T) * 0.300 /(0.900 * lb * 1/2) = 79.045 (kN/m)

triangular distribution front side p2' = 0.000 (kN/m)

load intensity on focus Main girder

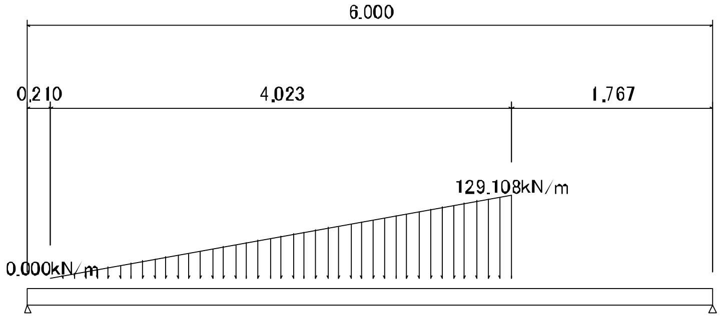
triangular distribution front side q1 = p1 * Eta1 + p2 * Eta2 = 129.108 (kN/m)

triangular distribution front side q1' = 0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	0.70000
Eta2	: crawler influence value on non-operation side	=	0.00000

* crawler crane (slant hoisting) bending moment



crawler crane bending moment
Mmax = 287.922 (kN m)
where
lmax : Mmax location = 3.105 (m)

* crawler crane bending moment

fixed load			=	25.592(kN m)
crawler crane load			=	287.922(kN m)
impact	287.922 * 0.300		=	86.377(kN m)
total		M	=	399.891(kN m)

FORUM8

2.2.3 Shear force sum up for each load

load status		Main girder No.	Shear force (kN)
truck load	orthogonal	--------	------------
	parallel	G 2	200.144
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	154.107
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	213.038
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	244.043
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	279.215
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	160.603
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.4 Shear force calculation

Calculate load condition when Shear force is maximum

1) load condition   Crawler crane diagonal hang(Parallel)

2) design Main girder number   2

3) stresses by fixed load

Equations to calculate stresses by fixed load   2 of Main girder

* fixed load intensity

```
steel deck self-weight* nominal load    2.000 *    2.000 /    2.000 =    2.000
steel deck self-weight* nominal load    2.000 *    2.000 /    2.000 =    2.000
Main girder Self weight                                              =    1.687
--------------------------------------------------------------------------------
total                                                   wd   =    5.687 (kN/m)
      using Main girder        H-400x400x13x21
```

* stresses by fixed load

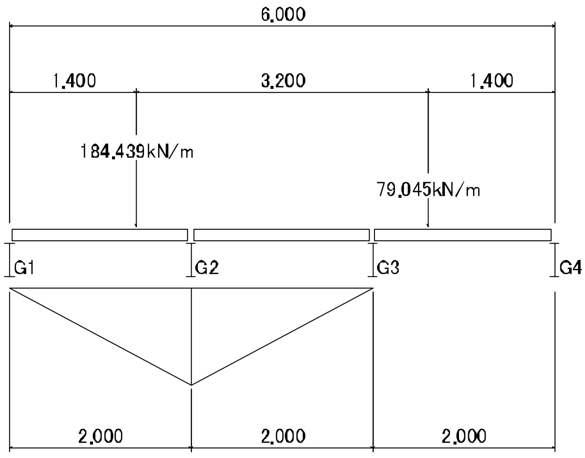
Shear force

$Sd = wd * l / 2 + So = 5.687 * 6.000 / 2 + 0.000 = 17.061$ (kN)

FORUM8

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



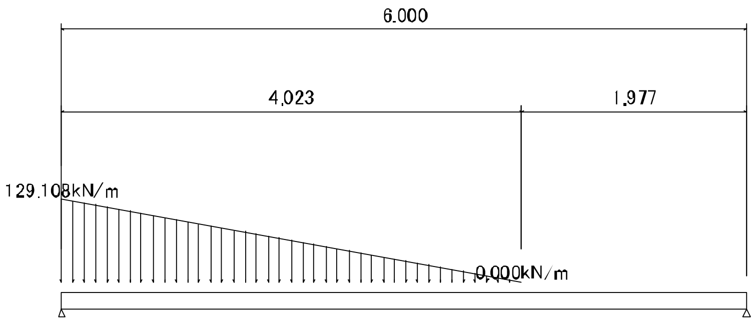
crawler crane load intensity on operation side
  triangular distribution front side   p1 = (W+ T) * 0.700
                                        /(0.900 * lb * 1/2) = 184.439 (kN/m)
  triangular distribution front side   p1'   =   0.000 (kN/m)

crawler crane load intensity on non-operation side
  triangular distribution front side   p2 = (W+ T) * 0.300
                                        /(0.900 * lb * 1/2) =   79.045 (kN/m)
  triangular distribution front side   p2'   =   0.000 (kN/m)

load intensity on focus Main girder
  triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2   = 129.108 (kN/m)
  triangular distribution front side   q1'   =   0.000 (kN/m)

where
  W : crawler crane self-weight   = 480.000 (kN)
  T : lifting load   =   50.000 (kN)
  lb : crawler crane contact   =   4.470 (m)
  Eta1: crawler influence value on operation side   = 0.70000
  Eta2: crawler influence value on non-operation side = 0.00000

* crawler crane (slant hoisting) Shear force



crawler crane Shear force
Smax = 201.657 (kN)

* crawler crane Shear force

fixed load		=	17.061(kN)
crawler crane load		=	201.657(kN)
impact	201.657 * 0.300	=	60.497(kN)
total	S	=	279.215(kN)

FORUM8

2.2.5 Allowable stress calculation

steel material for structure SS400
using member H-400x400x13x21
allowable bending stress
Sig.ba = 172.200 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 600.000 (cm)
b : cross sectional area of compressive flange = 40.000 (cm)
l/b : = 15.000
allowable shear stress
Taua = 120.000

2.2.6 Main girder stress calculation

using member H-400x400x13x21
bending stress
Sig. = M/ Z = 120.087 (N/mm²) <= 172.200 (N/mm²)
where
M: design bending moment = 399.891 (kN.m)
(Crawler crane diagonal hang(Parallel))
Z : section modulus = 3330.000 (cm³)
shear stress
Tau = S / Aw = 59.995 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 279.215 (kN)
(Crawler crane diagonal hang(Parallel))
Aw : web section area = 46.540 (cm²)

2.2.7 Deflection calculation

Calculate deflection when bending moment is maximum

$$Del. = \frac{5Mmaxl^2}{48EI} = 0.811 \text{ (cm)} \le 1.500 \text{ (cm)}$$

where
Mmax: bending moment by load = 287.922 (kN.m)
(Crawler crane diagonal hang(Parallel))
l : span length = 600.000 (cm)
I : moment of inertia of area = 66600.000 (cm⁴)
E : Young's modulus = $2.0 * 10^5$ (N/mm²)

2.3 Beam seat Design

2.3.1 Sum up bending moment for each load

load condition		section	bending moment (kN m)
truck load	orthogonal	---------------------	----------
	parallel	section- 2 Simple beam part	0.662
crawler crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	0 degree-orthogonal	---------------------	----------
	0 degree-parallel	section- 2 Simple beam part	0.662
	90 degree-orthogonal	---------------------	----------
	90 degree-parallel	section- 2 Simple beam part	0.662
	45 degree-orthogonal	---------------------	----------
	45 degree-parallel	section- 2 Simple beam part	0.662
truck crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	working-orthogonal	---------------------	----------
	working-parallel	---------------------	----------

Note) Bending moment is the sum of moment by fixed load, load, and impact.

2.3.2 Bending moment computation

Calculate in the load condition that induces bending moment maximum

1) load condition Truck load(Parallel)

2) design section - 2 Simple beam part

3) include Main girder in design section

No.	Main girder No.
1	G 2

4) Main girder reaction force by fixed load

Rdi = wdi * (l+lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

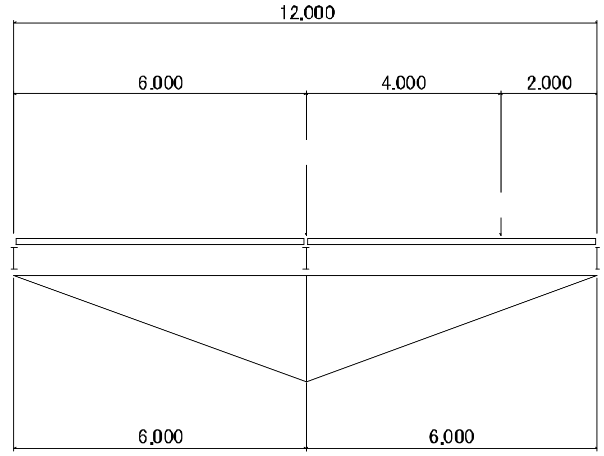
where

Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

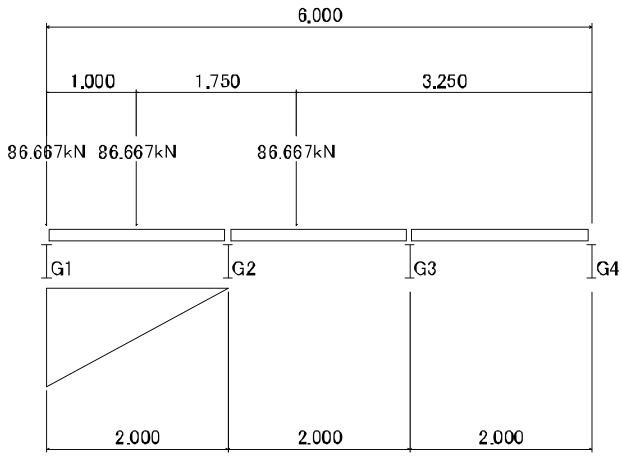
5) Main girder reaction force by truck load
in case that Beam seat of bending moment is at maximum, truck load position.



reaction force by train load
Rj = Sig. PJi * Etai = 86.667 (kN)

wheel No.	load PJi (kN)	influence value on reaction force Etai
1	80.000	1.000
2	20.000	0.333

in case that Beam seat of bending moment is at maximum, truck load position.



1 Main girder reaction force is maximum, then Beam seat bending moment is maximum
influence value of each beam

No.	Main girder No.	influence value
1	G 1	1.500
2	G 2	1.125
3	G 3	0.375
4	G 4	0.000

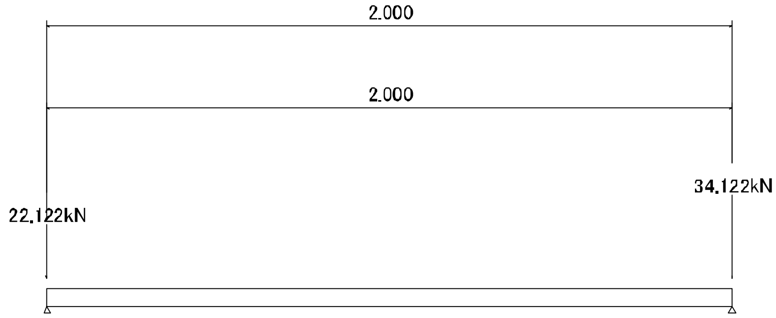
Rji = Rj * Ii

No.	Main girder No.	eachMain girder effect value Ii	Rji (kN)
1	G 1	1.500	130.000
2	G 2	1.125	97.500
3	G 3	0.375	32.500
4	G 4	0.000	0.000

6) calculate bending moment

Simple beam part

Bending moment by fixed load



Md = 0.662 (kN.m)

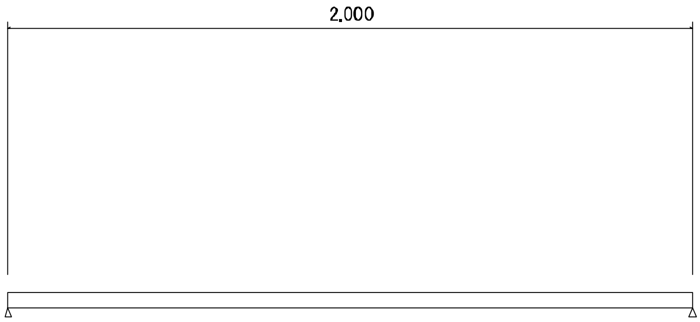
where

lmax : Mmax position(from left support point) = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

Bending moment by load



Mj = 0.000 (kN.m)

where

lmax : Mmax position (from left support point) = 0.000 (m)

7) sum of bending moment

fixed load				=	0.662	(kN.m)
load				=	0.000	(kN.m)
impact	=	0.000 *	0.300	=	0.000	(kN.m)
----------						
total				M =	0.662	(kN.m)

2.3.3 Sum up shear force for each load

load condition		section	shear force (kN)
truck load	orthogonal	----------------------	----------
	parallel	section- 2 Simple beam part	218.529
crawler crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	213.169
	0 degree-orthogonal	----------------------	----------
	0 degree-parallel	section- 2 Simple beam part	250.286
	90 degree-orthogonal	----------------------	----------
	90 degree-parallel	section- 2 Simple beam part	329.800
	45 degree-orthogonal	----------------------	----------
	45 degree-parallel	section- 2 Simple beam part	328.855
truck crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	178.988
	working-orthogonal	----------------------	----------
	working-parallel	----------------------	----------

Note) Shear force is the sum of shear force by fixed load, load, and impact.

2.3.4 Shear force computation

Calculate in the load condition that induces shear force maximum

1)load condition Crawler crane side hang(Parallel)

2)design section - 2 Simple beam part

3)include Main girder in design section

No.	Main girder No.
1	G 2

4)Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN/m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

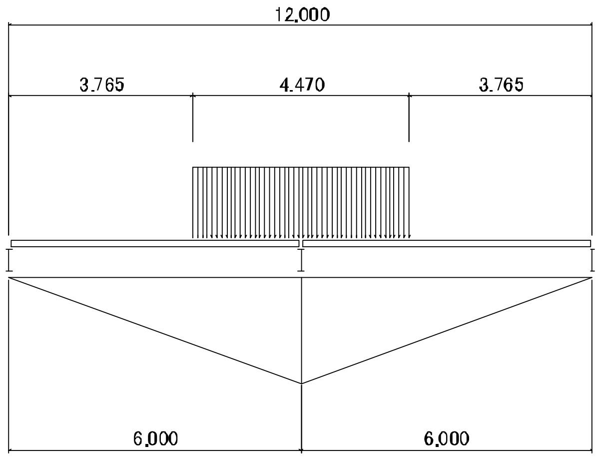
where

Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

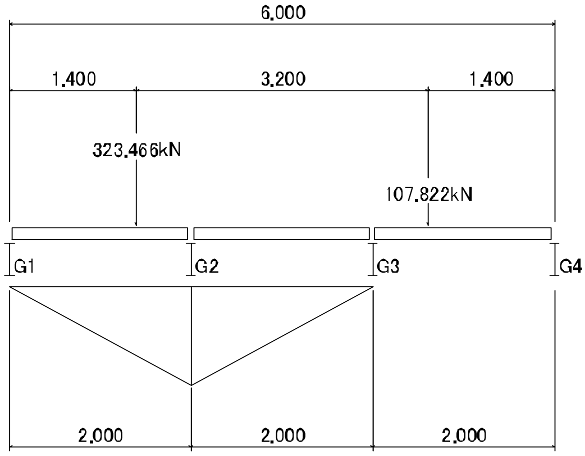
5) Main girder reaction force of crawler crane
Beam seat - Shear force is at maximum, crawler load condition



reaction force of crawler crane

```
        Rc1 = w1 *  { b *  ( a + b/2.0 ) / l1
                    + c *  ( d + c/2.0 ) / l2 }          =   323.466 (kN)
        Rc2 = w2 *  { b *  ( a + b/2.0 ) / l1
                    + c *  ( d + c/2.0 ) / l2 }          =   107.822 (kN)
        where
              w1 : crawler crane load intensity on operation side
                    w1 = (W+ T) / lb *  0.750         =   88.926 (kN/m)
              w2 :  crawler crane load intensity on non-operation side
                    w2 = (W+ T) / lb *  0.250         =   29.642 (kN/m)
               a : unloading length in left span       =     3.765 (m)
               b : loading length in left span         =     2.235 (m)
               c : loading length in right span        =     2.235 (m)
               d : unloading length in right span      =     3.765 (m)
               W : crawler crane self-weight           =   480.000 (kN)
               T : lifting load                        =    50.000 (kN)
              lb : crawler crane contact               =     4.470 (m)
              l1 : length of left span                 =     6.000 (m)
              l2 : length of right span                =     6.000 (m)
```

Beam seat of Shear force is at maximum, crawler load condition

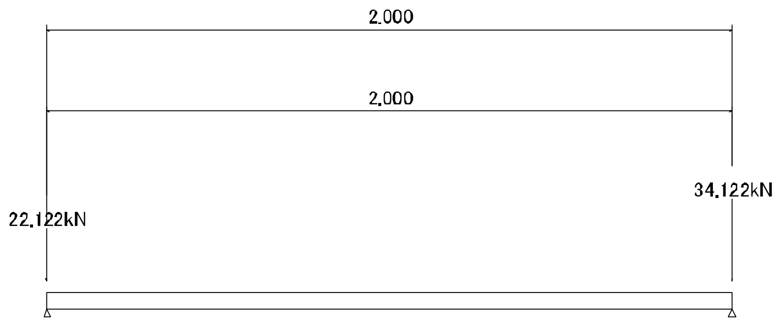


No.	Main girder No.	eachMain girder reaction force(kN)
1	G 1	97.040
2	G 2	226.426
3	G 3	75.475
4	G 4	32.347

6) calculate shear force

Simple beam part

Shear force by fixed load



Sd = 35.446 (kN)

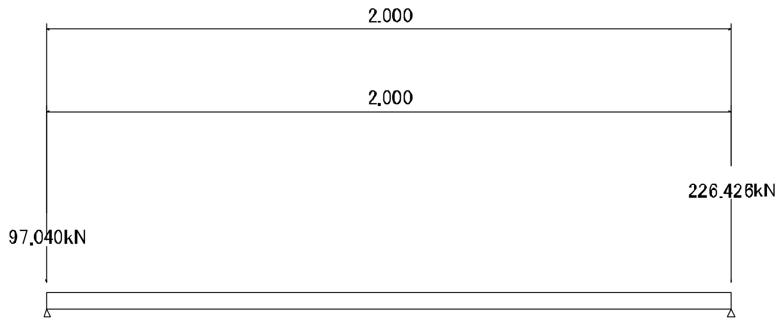
where

l : span length = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

shear force by load



Sj = 226.426 (kN)

7) sum of shear force

fixed load		=	35.446 (kN)
load		=	226.426 (kN)
impact	= 226.426 * 0.300	=	67.928 (kN)
total		S =	329.800 (kN)

2.3.5 Allowable stress calculation

steel material for structure SS400
using member H-350x350x12x19
allowable bending stress
Sig.ba = 205.629 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 200.000 (cm)
b : cross sectional area of compressive flange = 35.000 (cm)
l/b : = 5.714
allowable shear stress
Taua = 120.000

2.3.6 Beam seat stress calculation

using member H-350x350x12x19
bending stress
Sig. = M / Z = 0.290 (N/mm²) <= 205.629 (N/mm²)
where
M : design bending moment = 0.662 (kN.m)
(Truck load(Parallel))
Z : section modulus = 2280.000 (cm³)
shear stress
Tau = S / Aw = 88.088 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 329.800 (kN)
(Crawler crane side hang(Parallel))
Aw : web section area = 37.440 (cm²)

2.3.7 Deflection calculation

Calculate deflection when bending moment is maximum in a simple beam section

$$Del. = \frac{5Mmaxl^2}{48EI} = 0.000\ (cm) \le 0.500\ (cm)$$

where
Mmax: bending moment by load = 0.000 (kN.m)
(Truck load(Parallel))
l : span length = 200.000 (cm)
I : moment of inertia of area = 39800.000 (cm⁴)
E : Young's modulus = $2.0*10^5$(N/mm²)

2.4 Support pile Design

2.4.1 The axial force and horizontal force of Support pile for each load

		axial force at max		horizontal force (kN)
		Support pile No.	axial force (kN)	
truck load	orthogonal	----	--------	--------
	parallel	2	242.389	69.333
crawler crane	moving-orthogonal	----	--------	--------
	moving-parallel	3	237.028	96.000
	0 degree-orthogonal	----	--------	--------
	0 degree-parallel	3	274.145	106.000
	90 degree-orthogonal	----	--------	--------
	90 degree-parallel	3	353.659	106.000
	45 degree-orthogonal	----	--------	--------
	45 degree-parallel	3	352.714	106.000
truck crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	202.847	44.167
	working-orthogonal	----	--------	--------
	working-parallel	----	--------	--------

2.4.2 Axial force calculation for member design

Calculate for the load condition when axial force is maximum

For pile stress and bearing capacity of Support pile, use maximum axial force multiplied by 1/1 .

1) Load condition Crawler crane side hang(Parallel)

2) Support pile Number 3

Checking Support pile left Simple beam part

Checking Support pile left section Number of Main girder = 1

No.	Main girder No.
1	G 2

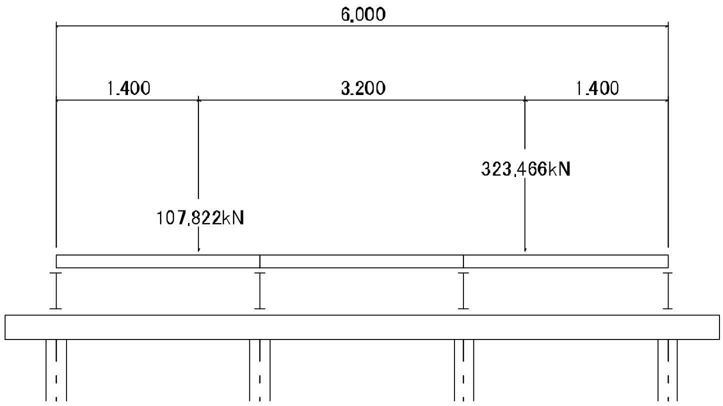
Checking Support pile right Simple beam part

Checking Support pile right section Number of Main girder = 1

No.	Main girder No.
1	G 3

3) calculate max axial force

simple beam + simple beam



axial force by fixed load

Nd = Ndl + Ndr + nd = 59.305 (kN)

where

Ndl : axial force by fixed load on simple beam (left)

Ndl = Sig.(Rdi * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rdi (kN)	lLi (m)
1	G 2	34.122	0.000

Ndr : axial force by fixed load on simple beam (right)

Ndr = Sig.(Rdj * lRj) / lk2 = 34.122 (kN)

No.	Main girder No.	Rdj (kN)	lRj (m)
1	G 3	34.122	2.000

nd : axial force by self-weight

Beam seat Self weight 1.324 * ((lk1 + lk2) / 2.0) = 2.648 (kN)

Hori. joint 0.182 * ls1 * 2 = 0.728 (kN)

Hori. brace 0.000 * ls2 = 0.000 (kN)

Vert. brace 0.146 * lv = 1.054 (kN)

Support pile Self weight 1.324 * lKUI = 20.754 (kN)

other load = 0.000 (kN)

----

total 25.183 (kN)

where

lk1 : left span length of simple beam = 2.000 (m)

lk2 : right span length of simple beam = 2.000 (m)

ls1 : Hori. joint Length = 2.000 (m)

ls1 = ((lk1+lk2) / 2.0) * 1

ls2 : Hori. brace Length = 0.000 (m)

lv : Vert. brace Length = 7.211 (m)

lv = Sig.lvn

$lv1 = \sqrt{lk1^2 + 3.000^2} + \sqrt{lk2^2 + 3.000^2} = 7.211$ (m)

lKUI : Support pile Length = 15.675 (m)

axial force by load

Nj = Njl + Njr = 226.426 (kN)

where

Njl : axial force by load on simple beam(left)

Njl = Sig.(Rji * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rji (kN)	lLi (m)
1	G 2	75.475	0.000

Njr : axial force by load on simple beam(right)

Njr = Sig.(Rjj * lRj) / lk2 = 226.426 (kN)

No.	Main girder No.	Rjj (kN)	lRj (m)
1	G 3	226.426	2.000

member design axial force

fixed load = 59.305 (kN)

load = 226.426 (kN)

impact 226.426 * 0.300 = 67.928 (kN)

----

total N = 353.659 (kN)

member design axial force is 1/1 N * 1/1 = 353.659 (kN)

2.4.3 Horizontal force calculation

1) horizontal force by fixed load

H1 = (W1 + W2 + W3 + W4 + W5 + W6 + W7) * kh = 25.420 (kN)

W1 : weight of steel deck* nominal load

W1 = (Wf1 * Bf1 + Wf2 * Bf2)
* (l + lside) / 2.0 = 72.000 (kN)

Wf1 : steel deck 2m+ nominal load = 2.000 (kN/m²)
Bf1 : steel deck 2m+ width direction = 6.000 (m)
Wf2 : steel deck 3m+ nominal load = 2.000 (kN/m²)
Bf2 : steel deck 3m+ width direction = 0.000 (m)
l : span length = 6.000 (m)
lside : adjacent span length = 6.000 (m)

W2 : dead load weight of wheel guard

W2 = (WL + WR) * (l + lside) / 2.0 = 0.000 (kN)

WL : dead load of left wheel guard = 0.000 (kN/m)
WR : dead load of right wheel guard = 0.000 (kN/m)

W3 : Main girder Weight

W3 = N * WN * (l + lside) / 2.0 = 40.488 (kN)

N : Main girder Members number = 4
WN : Main girder Self weight = 1.687 (kN/m)

W4 : Beam seat Weight

W4 = WH * lH = 9.268 (kN)

WH : Beam seat Self weight = 1.324 (kN/m)
lH : Beam seat length = 7.000 (m)

W5 : Hori. joint Weight

W5 = Ws1 * ls1 * 2 = 2.184 (kN)

Ws1 : Hori. joint Weight = 0.182 (kN/m)
ls1 : Hori. joint Length = 6.000 (m)

W6 : Hori. brace Weight

W6 = Ws2 * ls2 / 2.0 = 0.000 (kN)

Ws2 : Hori. brace Self weight = 0.000 (kN/m)
ls2 : Hori. brace Extension = 0.000 (m)

W7 : Vert. brace Weight

W7 = Wv * lv = 3.161 (kN)

Wv : Vert. brace Self weight = 0.146 (kN/m)
lv : Vert. brace Extension = 21.633 (m)

kh : coefficient for horizontal force estimate

kh = 0.200

2) horizontal load by horizontal force

H_j = R * kh = 106.000 (kN)

R : load case [Crawler crane font hang(Parallel)]

R = W + T = 530.000 (kN)

where

W: heaviest machine weight = 480.000 (kN)

In case truck load, reaction force by truck load on working platform is taken.

T : lifting load(zero when truck load) = 50.000 (kN)

kh : coefficient for horizontal force estimate

kh = 0.200

3) sum of horizontal force

fixed load	=	25.420 (kN)
load	=	106.000 (kN)
total	=	131.420 (kN)

2.4.4 Bending moment by horizontal force(pile top fixed)

Calculate bending moment and displacement using Chang's equation assuming infinite pile.
Since top of support pile are connected with lateral beams, horizontal force at top of transmits to the bottom of lateral beams.
Use bigger value either constrained moment at pile top or max bending moment in subground.

horizontal force on Support pile

H = Sig.H / n = 32.855 (kN)

where

Sig.H : horizontal force acting on one frame plane = 131.420 (kN)

n : Support pileMembers number = 4

constrained moment at pile top

Mo = (1 + Betah) * H / 2Beta = 86.812 (kN.m)

max bending moment in subground

Mmax = - H / 2Beta * (1 + (Betah)^{2})$^{1/2}$ * exp (- Betalm) = 38.932 (kN.m)

depth at max bending moment in subground

lm = 1 / Beta * tan^{-1}(1 /Betah) = 0.925 (m)

horizontal displacement at pile top

Del. = ((1 + Betah)^{3}+ 2) * H / (12 EIBeta^{3}) = 1.615 (cm)

where

h : above ground length = 3.425 (m)

I : Support pilearea moment of inertia = 13600.000 (cm^{4})

E : Support pileYoung modulus = 2.000 * 10^{5}(N/mm^{2})

pile characteristic value

Beta = ^{4}ã(kh* D / (4EI)) = 0.00538 (1/cm)

where

D : Support pilewidth = 35.000 (cm)

subgrade reaction coefficient in lateral direction

kh = kho* (BH/30)$^{-3/4}$ = 25.996 (N/cm^{3})

kho = 1/30* Alp.* Eo = 54.486 (N/cm^{3})

BH = (D/Beta)$^{1/2}$ = 80.467 (cm)

where

BH : pile conversion width of load

Alp.* Eo: average Alp.* Eo in range of 1/Beta = 1634.595 (N/cm^{2})

2.4.5 Support pile buckling stability check

Because Support pile buckling possibly occur under axial direction force and bending moment, check the stability on buckling using next 2 equations.

Sig.c / Sig.caz + Sig.bcz / { Sig.bao * (1 - Sig.c / Sig.eaz) }
= 0.696 <= 1.0

Sig.c + Sig.bcz / (1 - Sig.c / Sig.eaz)
= 139.659 <= Sig.cal

where

Sig.c : compressive stress in axial direction = 20.574 (N/mm²)

Sig.bcz : moment compressive stress by bending moment around weak axis.
Sig.bcz = Mz / zz = 111.872 (N/mm²)

Sig.caz : allowable compressive stress in axial direction around weak axis = 159.024(N/mm²)
lk/r <= 18 --- Sig.caz = 210
18 < lk/r <= 92 --- Sig.caz = { 140 - 0.82 * (lk/r - 18) } * 1.50
92 < lk/r --- Sig.caz = 1200000 / { 6700 + (lk/r)²} * 1.50
lk/r = 528.457 / 8.890 = 59.444

Sig.bao : upper limit of allowable compressive stress without local buckling
= 210.000 (N/mm²)

Sig.cal : allowable stress of free extension plate under comp stress about local buckling
where b' <= 13.1t' = 210.000 (N/mm²)

Sig.eaz : Euler buckling strength around weak axis
Sig.eaz = 1200000 / (lk/rz)² = 339.599 (N/mm²)

N : Support pile acting axial force = 353.659 (kN)

Mz : bending moment around z axis = 86.812 (kN.m)

lk : buckling length = 528.457 (cm)

lLow: lowest design span, height at lowest is added 1/Beta(lk reference value, fixed value).
lLow = lLow' + 1/Beta = 342.500 + 185.957 = 528.457
where,
lLow' : height at lowest = 342.500 (cm)
Beta : characteristic value
Beta = ⁴√(kh* D / (4EI)) = 0.00538 (1/cm)
where
I : Support pilearea moment of inertia = 13600.000 (cm⁴)
E : Support pileYoung modulus = 2.000 * 10⁵(N/mm²)
D : Support pilewidth = 35.000 (cm)
kh : lateral subgrade reaction = 25.996 (N/cm³)

use steel member, H-350x350x12x19·Weak)
A : cross sectional area of steel material = 171.900 (cm²)
zz : section modulus around z axis = 776.000 (cm³)
ry : radius of gyration of area around y axis = 15.200 (cm)
rz : radius of gyration of area around z axis = 8.890 (cm)

Shear stress
horizontal force acting on weak axis of post.
Tau = H / (2 * Af) = 2.470 <= 120.000 (N/mm²)
H : Support pileworking horizontal force = 32.855 (kN)
Af : Support pileFlange area = 66.500 (cm²)

2.4.6 Support pile bearing capacity examination

allowable bearing capacity

Ra = { qd* A + uSig.lifi }/ 2.0 = 664.300 (kN)

(construction method: driving)

where

qd: ultimate bearing capacity at tip ground = 6200.00

qd = 200Alp.N

N : Support pileN value of soil layer at tip= 31.00

Support pile because less than 2m thickness of sound layer from pile tip

N-value in lower ground is N-value of tip ground Support pile.

upper limit is 40.

A : Support piletip area = 0.12 (m²)

u : Support pilePerimeter = 1.400 (m)

li: thickness to be considered circumference friction

fi: maximum skin friction in the layer considered friction

fi=2BetaNs(sand)

Ns upper limit is 50.

fi=10BetaNc(Nc:N-value) , fi=BetaNc(Nc:cohesion)(clay)

where, Nc(N-value 10* Nc) upper limit is 150.

Sig.lifi: circumference friction = 406.500

li(m)	Ns	Nc	fi(kN/m²)	li* fi
1.000	4.0	------	8.000	8.000
1.000	8.0	------	16.000	16.000
1.000	19.0	------	38.000	38.000
1.000	16.0	------	32.000	32.000
1.000	26.0	------	52.000	52.000
1.000	19.0	------	38.000	38.000
1.000	25.0	------	50.000	50.000
1.000	25.0	------	50.000	50.000
1.000	50.0	------	100.000	100.000
0.250	45.0	------	90.000	22.500

Alp. : coefficient of tip bearing capacity for construction method = 1.0

Beta : coefficient of skin friction for construction method = 1.0

max axial force acting on Support pile Crawler crane side hang(Parallel)

N max = 353.659 (kN) <= 664.300 (kN)

2.5 Hori. joint Design

2.5.1 Hori. joint checking

Design Hori. joint as a member receiving compression force.

load condition Crawler crane font hang(Parallel)

compression force acting on Hori. joint

share the horizontal force receiving on a frame plane by single Hori. joint.

Set both sides of Support pile

N = H / 2 = 65.710 (kN)

Sig.c = N / A = 27.714 (N/mm²) <= Sig.ca = 123.770 (N/mm²)

where

H : compressive force acting on a frame plane = 131.420 (kN)

Sig.c : axial direction compressive stress

Sig.ca : allowable axial direction compressive stress = 123.770 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50

l/r = 88.106

Use steel material [-150x75x6.5x10

A : cross sectional area of steel material = 23.710(cm²)

l : buckling length = 2.000(m)

r : radius of gyration of area around weak axis = 2.270(cm)

2.5.2 Connection part checking

compression force acting on Hori. joint

T = 65.710 (kN)

required length for welding part

l = T / (0.7rho* s) = 31.291 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.6 Vert. brace Design

2.6.1 Vert. brace checking

design Vert. brace as a member receiving Compressive force

load condition Crawler crane font hang(Parallel)

horizontal force shared by Vert. brace

share the horizontal force receiving on a frame plane by number of Vert. brace

Hv = H / n = 43.807 (kN)

force Vert. brace acting on Compressive

T = Hv / cos(Theta) = 78.974 (kN)

cos(Theta) = l / (l² + h²)^1/2 = 0.555

where

l : Support pileThe most shortest spacing(length) = 2.000 (m)

h : Hori. jointlongest spacing = 3.000 (m)

Compressive stress

Sig.c = T / A = 41.565 (N/mm²) <= Sig.ca = 44.023 (N/mm²)

where

Sig.ca : allowable axial direction compressive stress = 44.023 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50

l/r = 184.900

Use steel material L-100x100x10

A : effective cross sectional area of steel material = 19.000 (cm²)

l : buckling length = 3.606 (m)

r : radius of gyration of area = 1.950 (cm)

2.6.2 Connection part checking

force Compressive acting on a brace member

T = 78.974 (kN)

required length for welding part

l = T / (0.7rho* s) = 37.607 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.7 Summary export

2.7.1 Steel deck summary report

steel deck : steel deck type2

1) check regarding to bending moment

load condition	Truck crane when moving(Parallel)			
name of steel deck	Steel deck type 2 (1000*2000)			
bending moment due to fixed load	Md =	1.000 (kN.m)		
bending moment due to load	Mmax =	56.875 (kN.m)		
design bending moment	M =	22.950 (kN.m)		
bending stress	Sig. =	73.558 <=	210.000 (N/mm²)	

2) check regarding to shear force

load condition	Truck load(Parallel)			
name of steel deck	Steel deck type 2 (1000*2000)			
shear force due to fixed load	Sd =	2.000 (kN)		
shear force due to load	Smax =	130.000 (kN)		
design shear force	S =	52.400 (kN)		
shear stress	Tau =	64.691 <=	120.000 (N/mm²)	

2.7.2 Main girder Summary report

1) calculate bending moment
load condition Crawler crane diagonal hang(Parallel)
design object Main girder number 2 of

fixed load		=	25.592(kN.m)
load		=	287.922(kN.m)
impact	287.922 * 0.300	=	86.377(kN.m)
total		=	399.891(kN.m)

2) calculate shear force
load condition Crawler crane diagonal hang(Parallel)
design object Main girder number 2

fixed load		=	17.061(kN)
load		=	201.657(kN)
impact	201.657 * 0.300	=	60.497(kN)
total		=	279.215(kN)

3) checking stress
using member H-400x400x13x21

web section area	Aw =	46.540 cm²
section modulus	Z =	3330.000 cm³

bending stress	Sig. = M / Z	= 120.087 (N/mm²)
allowable bending stress	Sig.ba	= 172.200 (N/mm²)
shear stress	Tau = S / Aw	= 59.995 (N/mm²)
allowable shear stress	fs	= 120.000 (N/mm²)

4) deformation
Calculate deformation when bending moment is maximum in a load condition

deformation	Del. =	0.8106 (cm)
allowable deformation	Del.a =	1.5000 (cm)

2.7.3 Beam seat Summary report

1)Calculate bending moment

```
    load condition  Truck load(Parallel)
    design section   2  Simple beam part
      fixed load                                  =     0.662(kN.m)
      load                                        =     0.000(kN.m)
      impact                      0.000 *  0.300  =     0.000(kN.m)
      ---------------------------------------------------------
      tototal                                     =     0.662(kN.m)
```

2)Calculate shear force

```
    load condition  Crawler crane side hang(Parallel)
    design section   2  Simple beam part
      fixed load                                  =    35.446(kN)
      load                                        =   226.426(kN)
      impact                    226.426 *  0.300  =    67.928(kN)
      ---------------------------------------------------------
      total                                       =   329.800(kN)
```

3)checking stresses

```
    material        H-350x350x12x19
    web section area  Aw =    37.440 cm²
    section modulus   Z  =  2280.000 cm³

    bending stress       Sig. =  M / Z    =   0.290 (N/mm²)
      allowable bending stress Sig.ba    = 205.629 (N/mm²)
    shear stress         Tau =  S / Aw    =  88.088 (N/mm²)
      allowable shear stress        Taua  = 120.000 (N/mm²)
```

4)deflection

```
    Calculate deflection when bending moment by live load is at max..
    deflection                 Del.  =     0.0000 (cm)
    allowable deflection       Del.a =     0.5000 (cm)
```

2.7.4 Support pile Summary report

1)load condition that weight on working platform is max. Crawler crane side hang(Parallel)
(axial force for member design)

2)Support pile number 3

3)calculation of axial force

fixed load			=	59.305 (kN)
load			=	226.426 (kN)
impact	226.426 *	0.300	=	67.928 (kN)
total	353.659 *	1/1	=	353.659 (kN)

4)calculation of horizontal force

fixed load	=	25.420 (kN)
load	=	106.000 (kN)
total		131.420 (kN)

5)bending moment by horizontal force

Support pile horizontal force acting on single member = 32.855 (kN)

maximum bending moment = 86.812 (kN.m)

6)Support pile strength check

material used H-350x350x12x19・Weak)

cross sectional area	A	=	171.900 cm^2
section modulus	Z	=	776.000 cm^3
radius of gyration of area around y axis	Ry	=	15.200 cm
radius of gyration of area around z axis	Rz	=	8.890 cm
flange width	B	=	35.000 cm
web section area	Aw	=	66.500 cm^2

Sig.c/Sig.caz + Sig.bcz/{Sig.bao * (1-Sig.c/Sig.eaz)} = 0.696 <= 1.000

Sig.c + Sig.bcz/(1-Sig.c/Sig.eaz) = 139.659 <= 210.000

7) check bearing capacity Support pile

max axial force on Support pile Crawler crane side hang(Parallel)

Nmax = 353.659 <= 664.300 (kN)

2.8 List table

2.8.1 Steel deck List

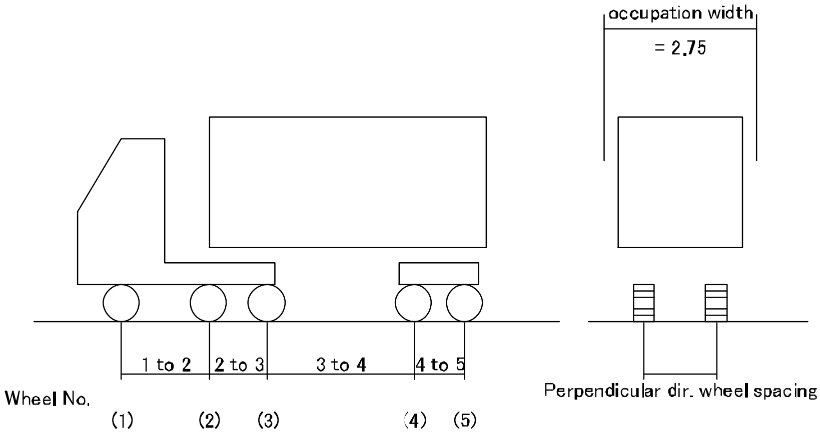
steel deck	name	Steel deck type 2 (1000*2000)
	bending moment max Mmax Sig.	Truck crane when moving(Parallel) 56.875 (kN m) 73.558 <= 210.000 (N/mm²)
	shear force max Smax Tau	Truck load(Parallel) 130.000 (kN) 64.691 <= 120.000 (N/mm²)

2.8.2 Member list table

Main girder	use	H-400x400x13x21
	bending moment max Mmax Sig.	Crawler crane diagonal hang(Parallel) 399.891 (kN.m) 120.087 <= 172.200 (N/mm²)
	shear force max Smax Tau	Crawler crane diagonal hang(Parallel) 279.215 (kN) 59.995 <= 120.000 (N/mm²)
	deflection Del.	Crawler crane diagonal hang(Parallel) 0.811 <= 1.500 (cm)
Beam seat (Support pile)	use	H-350x350x12x19
	bending moment max Mmax Sig.	Truck load(Parallel) 0.662 (kN.m) 0.290 <= 205.629 (N/mm²)
	shear force max Smax Tau	Crawler crane side hang(Parallel) 329.800 (kN) 88.088 <= 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.000 <= 0.500 (cm)
Support pile	use	H-350x350x12x19·Weak)
	load(section) load(bearing capacity)	Crawler crane side hang(Parallel) Crawler crane side hang(Parallel)
	force	N = 353.659 (kN) M = 86.812 (kN.m) S = 32.855 (kN) Sig.c = 20.574 Sig.b = 111.872 (N/mm²) Tau = 2.470 <= Taua = 120.000 (N/mm²)
	check buckling	eq- 1 ------- 0.696 <= 1.000 eq- 2 ------- 139.659 <= 210.000 (N/mm²)
	bearing capacity	353.659 <= 664.300 (kN)
Hori. joint	use	[-150x75x6.5x10
	cmpr stress Sig.c	27.714 <= 123.770 (N/mm²) (N= 65.710kN)
Hori. jointJoint part	required welding length	31.291 (cm)
Vert. brace	use	L-100x100x10
	cmpr stress Sig.c	41.565 <= 44.023 (N/mm²) (T= 78.974kN)
Vert. braceJoint part	required welding length	37.607 (cm)

3 Registered load data export

3.1 Truck load



1	name : TT43		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	30.000	3.250
	2	65.000	7.800
	3	60.000	1.550
	4	60.000	------------------------------------

2	name : T25		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	4.000
	2	100.000	------------------------------------

3	name : T20		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.000
	2	80.000	------------------------------------

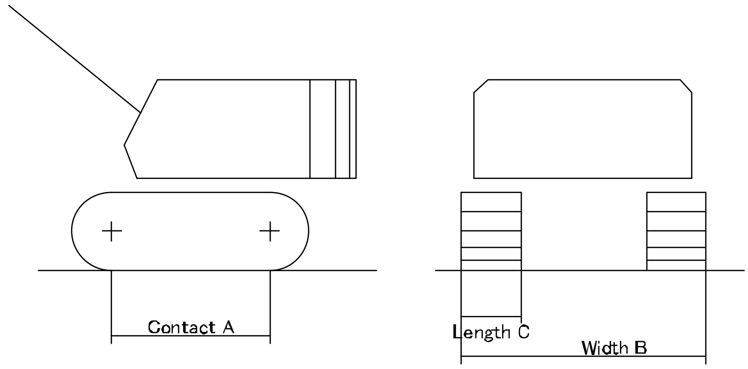
4	name : T14		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	14.000	4.000
	2	56.000	------------------------------------

5	name : Ready mixed concrete Truck(3 cubic meters)		
	wheel distance in perpendicular direction = 1.08 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.200
	2	54.000	------------------------------------

6	name : Ready mixed concrete Truck(5 cubic meters)		
	wheel distance in perpendicular direction = 1.88 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	3.160
	2	55.000	1.880
	3	30.000	------------------------------------

7	name : Surplus soil Truck		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1 2	34.000 63.000	4.000

3.2 Crawler crane



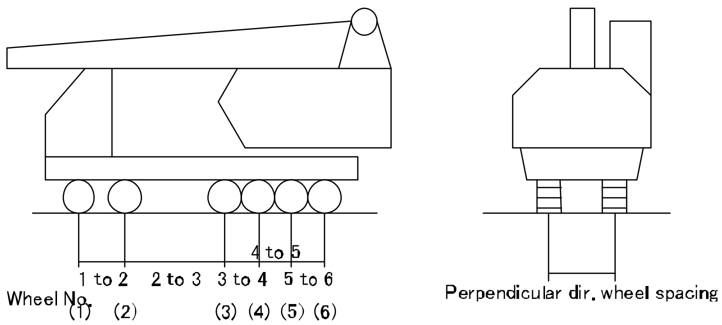
1	name : D408S
	self weight = 480.000(kN) 90 degree distribution ratio = 0.800 lifting load = 50.000(kN) 0 degree distribution ratio = 0.600 contact length A = 4.470(m) 45 degree distribution ratio = 0.700 width B = 4.000(m) 45 degree contact ratio = 0.900 contact width C = 0.800(m)

2	name : P&H440S
	self weight = 400.000(kN) 90 degree distribution ratio = 0.800 lifting load = 50.000(kN) 0 degree distribution ratio = 0.600 contact length A = 4.380(m) 45 degree distribution ratio = 0.700 width B = 3.960(m) 45 degree contact ratio = 0.900 contact width C = 0.760(m)

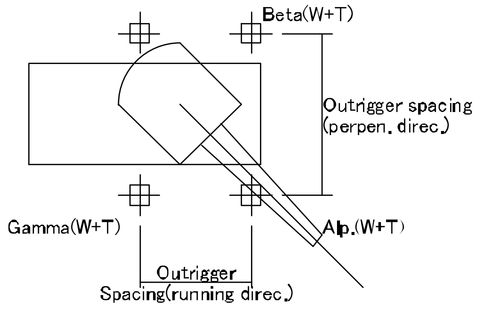
3	name : P&H335AS
	self weight = 350.000(kN) 90 degree distribution ratio = 0.800 lifting load = 30.000(kN) 0 degree distribution ratio = 0.600 contact length A = 4.280(m) 45 degree distribution ratio = 0.700 width B = 3.790(m) 45 degree contact ratio = 0.900 contact width C = 0.590(m)

4	name : P&H325
	self weight = 280.000(kN) 90 degree distribution ratio = 0.800 lifting load = 30.000(kN) 0 degree distribution ratio = 0.600 contact length A = 3.950(m) 45 degree distribution ratio = 0.700 width B = 3.030(m) 45 degree contact ratio = 0.900 contact width C = 0.590(m)

3.3 Truck crane



FORUM8



1	name : NK-300		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	32.000	3.850
	2	64.000	1.350
	3	64.000	--
	self weight W = 320.000(kN) lifting load T = 30.000(kN) load distribution ratio Alp. = 0.700 load distribution ratio Beta = 0.150 load distribution ratio Gam = 0.150		outrigger distance(moving) = 4.750(m) outrigger distance(perpendicular) = 5.600(m) outrigger width = 0.500(m)

2	name : NK-200		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.980
	2	40.000	1.240
	3	40.000	--
	self weight W = 200.000(kN) lifting load T = 30.000(kN) load distribution ratio Alp. = 0.700 load distribution ratio Beta = 0.150 load distribution ratio Gam = 0.150		outrigger distance(moving) = 4.450(m) outrigger distance(perpendicular) = 4.800(m) outrigger width = 0.400(m)

3	name : Rough terrain crane 20tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.000
	2	80.000	--
	self weight W = 200.000(kN) lifting load T = 30.000(kN) load distribution ratio Alp. = 0.700 load distribution ratio Beta = 0.150 load distribution ratio Gam = 0.150		outrigger distance(moving) = 5.700(m) outrigger distance(perpendicular) = 5.700(m) outrigger width = 0.400(m)

4	name : Rough terrain crane 25tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	25.000	3.500
	2	100.000	--
	self weight W = 250.000(kN) lifting load T = 30.000(kN) load distribution ratio Alp. = 0.700 load distribution ratio Beta = 0.150 load distribution ratio Gam = 0.150		outrigger distance(moving) = 6.300(m) outrigger distance(perpendicular) = 6.200(m) outrigger width = 0.400(m)

5	name : Rough terrain crane 40tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	35.000	4.250
	2	140.000	--
	self weight W= 350.000(kN) lifting load T = 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150	outrigger distance(moving) = 7.300(m) outrigger distance(perpendicular) = 6.500(m) outrigger width = 0.500(m)	

4 Registered member data export

4.1 Main girder Registered data

No.						
1	name : H 300x300x10x15					
	unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm²)
	web section area	Aw =	27.00(cm²)	section modulus	Z =	1350.0(cm³)
	moment of inertia	I =	20200.0(cm⁴)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
2	name : H 350x350x12x19					
	unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm²)
	web section area	Aw =	37.44(cm²)	section modulus	Z =	2280.0(cm³)
	moment of inertia	I =	39800.0(cm⁴)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
3	name : H 400x400x13x21					
	unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm²)
	web section area	Aw =	46.54(cm²)	section modulus	Z =	3330.0(cm³)
	moment of inertia	I =	66600.0(cm⁴)	lateral buckling radius	i =	11.00(cm)
	beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)
4	name : H 594x302x14x23					
	unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm²)
	web section area	Aw =	76.72(cm²)	section modulus	Z =	4500.0(cm³)
	moment of inertia	I =	134000.0(cm⁴)	lateral buckling radius	i =	7.96(cm)
	beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)
5	name : H 900x300x16x28					
	unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm²)
	web section area	Aw =	135.04(cm²)	section modulus	Z =	8990.0(cm³)
	moment of inertia	I =	404000.0(cm⁴)	lateral buckling radius	i =	7.68(cm)
	beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)
6	name : H 912x302x18x34					
	unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm²)
	web section area	Aw =	151.92(cm²)	section modulus	Z =	10800.0(cm³)
	moment of inertia	I =	491000.0(cm⁴)	lateral buckling radius	i =	7.84(cm)
	beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)
7	name : H 250x250x9x14					
	unit weight	=	718.0 (N/m)	flange section area	Af =	35.00(cm²)
	web section area	Aw =	19.98(cm²)	section modulus	Z =	860.0(cm³)
	moment of inertia	I =	10700.0(cm⁴)	lateral buckling radius	i =	6.91(cm)
	beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4. 2 Beam seat H-Beam registered data

No.						
	name : H-300x300x10x15					
	unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm^2)
1	web section area	Aw =	27.00(cm^2)	section modulus	Z =	1350.0(cm^3)
	moment of inertia	I =	20200.0(cm^4)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)

No.						
	name : H-350x350x12x19					
	unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm^2)
2	web section area	Aw =	37.44(cm^2)	section modulus	Z =	2280.0(cm^3)
	moment of inertia	I =	39800.0(cm^4)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)

No.						
	name : H-400x400x13x21					
	unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm^2)
3	web section area	Aw =	46.54(cm^2)	section modulus	Z =	3330.0(cm^3)
	moment of inertia	I =	66600.0(cm^4)	lateral buckling radius	i =	11.00(cm)
	beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)

No.						
	name : H-594x302x14x23					
	unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm^2)
4	web section area	Aw =	76.72(cm^2)	section modulus	Z =	4500.0(cm^3)
	moment of inertia	I =	134000.0(cm^4)	lateral buckling radius	i =	7.96(cm)
	beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)

No.						
	name : H-900x300x16x28					
	unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm^2)
5	web section area	Aw =	135.04(cm^2)	section modulus	Z =	8990.0(cm^3)
	moment of inertia	I =	404000.0(cm^4)	lateral buckling radius	i =	7.68(cm)
	beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)

No.						
	name : H-912x302x18x34					
	unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm^2)
6	web section area	Aw =	151.92(cm^2)	section modulus	Z =	10800.0(cm^3)
	moment of inertia	I =	491000.0(cm^4)	lateral buckling radius	i =	7.84(cm)
	beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)

No.						
	name : H-250x250x9x14					
	unit weight	=	704.0 (N/m)	flange section area	Af =	35.00(cm^2)
7	web section area	Aw =	19.98(cm^2)	section modulus	Z =	860.0(cm^3)
	moment of inertia	I =	10700.0(cm^4)	lateral buckling radius	i =	6.91(cm)
	beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4. 3 Beam seat one side U steel

No.						
	name : [-250x90x9x13					
	unit weight	=	339.0(N/m)	section area	Af =	44.07(cm^2)
1	web section area	Aw =	20.16(cm^2)	section modulus	Z =	335.0(cm^3)
	moment of inertia	I =	4180.0(cm^4)	area gyration radius	i =	2.58(cm)
	web height	h =	25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

No.						
	name : [-300x90x9x13					
	unit weight	=	374.0(N/m)	section area	Af =	48.57(cm^2)
2	web section area	Aw =	24.66(cm^2)	section modulus	Z =	429.0(cm^3)
	moment of inertia	I =	6440.0(cm^4)	area gyration radius	i =	2.52(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

	name : [-300x90x10x15.5			
3	unit weight =	430.0(N/m)	section area Af =	55.74(cm^2)
	web section area Aw =	26.90(cm^2)	section modulus Z =	494.0(cm^3)
	moment of inertia I =	7410.0(cm^4)	area gyration radius i =	2.54(cm)
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.55(cm)

	name : [-380x100x10.5x16			
4	unit weight =	534.0(N/m)	section area Af =	69.39(cm^2)
	web section area Aw =	36.54(cm^2)	section modulus Z =	763.0(cm^3)
	moment of inertia I =	14500.0(cm^4)	area gyration radius i =	2.78(cm)
	web height h =	38.0(cm)	compressive flange width b =	10.0(cm)
	web thickness t1 =	1.05(cm)	compressive flange thickness t2 =	1.60(cm)

	name : [-380x100x13x20			
5	unit weight =	660.0(N/m)	section area Af =	85.71(cm^2)
	web section area Aw =	44.20(cm^2)	section modulus Z =	926.0(cm^3)
	moment of inertia I =	17600.0(cm^4)	area gyration radius i =	2.76(cm)
	web height h =	38.0(cm)	compressive flange width b =	10.0(cm)
	web thickness t1 =	1.30(cm)	compressive flange thickness t2 =	2.00(cm)

4.4 Beam seat L section steel Registered data

	name : L-65x65x6			
1	unit weight =	58.0(N/m)	section area A =	7.527(cm^2)
	area gyration radius iy =	1.98(cm)		
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

	name : L-75x75x6			
2	unit weight =	67.2(N/m)	section area A =	8.727(cm^2)
	area gyration radius iy =	2.30(cm)		
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

	name : L-75x75x9			
3	unit weight =	97.7(N/m)	section area A =	12.690(cm^2)
	area gyration radius iy =	2.25(cm)		
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

	name : L-90x90x10			
4	unit weight =	130.4(N/m)	section area A =	17.000(cm^2)
	area gyration radius iy =	2.71(cm)		
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

	name : L-100x100x10			
5	unit weight =	146.1(N/m)	section area A =	19.000(cm^2)
	area gyration radius iy =	3.04(cm)		
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.5 Support pile Registered data

	name : H-300x300x10x15(Weak)			
1	unit weight =	912.0 (N/m)	section area A =	118.40(cm^2)
	flange section area Af =	45.00(cm^2)	web section area Aw =	27.00(cm^2)
	action direction =	weak	area gyration radius iy =	13.10(cm)
	area gyration radius iz =	7.55(cm)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
	section modulus Z =	450.0(cm^3)	moment of inertia I =	6750.0(cm^4)
	pile tip area =	900.0(cm^2)	pile circumference =	120.0(cm)
	pile diameter =	30.0(cm)	pile unit weight =	912.0(N/m)

2	name : H-300x300x10x15(Strong)			
	unit weight =	912.0 (N/m)	section area A =	118.40(cm^2)
	flange section area Af =	45.00(cm^2)	web section area Aw =	27.00(cm^2)
	action direction =	strong	area gyration radius iy =	13.10(cm)
	area gyration radius iz =	7.55(cm)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
	section modulus Z =	1350.0(cm^3)	moment of inertia I =	20200.0(cm^4)
	pile tip area =	900.0(cm^2)	pile circumference =	120.0(cm)
	pile diameter =	30.0(cm)	pile unit weight =	912.0(N/m)

3	name : H-350x350x12x19(Weak)			
	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	weak	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	776.0(cm^3)	moment of inertia I =	13600.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

4	name : H-350x350x12x19(Strong)			
	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	strong	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	2280.0(cm^3)	moment of inertia I =	39800.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

4.6 Hori. joint Registered data

1	name : [-150x75x6.5x10			
	unit weight =	182.0(N/m)	section area A =	23.71(cm^2)
	area gyration radius iy =	2.27(cm)		
	web height h =	15.0(cm)	compressive flange width b =	7.5(cm)
	web thickness t1 =	0.65(cm)	compressive flange thickness t2 =	1.00(cm)

2	name : [-200x90x8x13.5			
	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

3	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area A =	44.07(cm^2)
	area gyration radius iy =	2.64(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

4.7 Vert. brace Registered data

1	name : L-65x65x6			
	unit weight =	58.00(N/m)	section area A =	7.527(cm^2)
	area gyration radius iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm^2)
	area gyration radius iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm^2)
	area gyration radius iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

	name : L 90x90x10			
4	unit weight =	130.40(N/m)	section area A =	17.000(cm²)
	area gyration radius iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

	name : L 100x100x10			
5	unit weight =	146.10(N/m)	section area A =	19.000(cm²)
	area gyration radius iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.8 Hori. brace Registered data

	name : L 65x65x6			
1	unit weight =	58.00(N/m)	section area A =	7.527(cm²)
	moment of inertia iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

	name : L 75x75x6			
2	unit weight =	67.20(N/m)	section area A =	8.727(cm²)
	moment of inertia iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

	name : L 75x75x9			
3	unit weight =	97.70(N/m)	section area A =	12.690(cm²)
	moment of inertia iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

	name : L 90x90x10			
4	unit weight =	130.40(N/m)	section area A =	17.000(cm²)
	moment of inertia iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

	name : L 100x100x10			
5	unit weight =	146.10(N/m)	section area A =	19.000(cm²)
	moment of inertia iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.9 Lateral joint member 1 side U steel Registered data

	name : [-200x90x8x13.5			
1	unit weight =	297.0(N/m)	section area A =	38.65(cm²)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

	name : [-250x90x9x13			
2	unit weight =	339.0(N/m)	section area A =	44.07(cm²)
	area gyration radius iy =	2.58(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

	name : [-300x90x9x13			
3	unit weight =	374.0(N/m)	section area A =	48.57(cm²)
	area gyration radius iy =	2.52(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

	name : [-300x90x10x15.5			
4	unit weight =	430.0(N/m)	section area A =	55.74(cm²)
	area gyration radius iy =	2.54(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.55(cm)

4.10 Lateral joint member L section steel Registered data

No	Data
1	name : L-65x65x6 unit weight = 58.0(N/m) section area A = 7.527(cm²) area gyration radius iy = 1.98(cm) angle edge width B = 6.5(cm) thickness t = 0.60(cm)
2	name : L-75x75x6 unit weight = 67.2(N/m) section area A = 8.727(cm²) area gyration radius iy = 2.30(cm) angle edge width B = 7.5(cm) thickness t = 0.60(cm)
3	name : L-75x75x9 unit weight = 97.7(N/m) section area A = 12.690(cm²) area gyration radius iy = 2.25(cm) angle edge width B = 7.5(cm) thickness t = 0.90(cm)
4	name : L-90x90x10 unit weight = 130.4(N/m) section area A = 17.000(cm²) area gyration radius iy = 2.71(cm) angle edge width B = 9.0(cm) thickness t = 1.00(cm)
5	name : L-100x100x10 unit weight = 146.1(N/m) section area A = 19.000(cm²) area gyration radius iy = 3.04(cm) angle edge width B = 10.0(cm) thickness t = 1.00(cm)

4.11 Retaining wall Steel sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	II	400	100	48.0	153.00	8740	874
2	III	400	125	60.0	191.00	16800	1340
3	III	400	130	60.0	191.00	17400	1340
4	IV	400	170	76.1	242.50	38600	2270
5	VL	500	200	105.0	267.60	63000	3150
6	IIw	600	130	61.8	131.20	13000	1000
7	IIIw	600	180	81.6	173.20	32400	1800
8	IVw	600	210	106.0	225.50	56700	2700

4.12 Retaining wall soldier lateral sheet pile Registered data

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
1	H-100x100x 6x 8	100	100	6.0	8	21.59	16.9	378	76
2	H-125x125x 6x 9	125	125	6.5	9	30.00	23.6	839	134
3	H-150x150x 7x10	150	150	7.0	10	39.65	31.1	1620	216
4	H-175x175x 7x11	175	175	7.5	11	51.42	40.4	2900	331
5	H-200x200x 8x12	200	200	8.0	12	63.53	49.9	4720	472
6	H-250x250x 9x14	250	250	9.0	14	91.43	71.8	10700	860
7	H-300x300x10x15	300	300	10.0	15	118.40	93.0	20200	1350
8	H-350x350x12x19	350	350	12.0	19	171.90	135.0	39800	2280
9	H-400x400x13x21	400	400	13.0	21	218.70	172.0	66600	3330
10	H-400x400x18x28	414	405	18.0	28	295.40	232.0	92800	4480
11	H-400x400x20x35	428	407	20.0	35	360.70	283.0	119000	5570
12	H-400x400x30x50	458	417	30.0	50	528.60	415.0	187000	8170
13	H-400x400x45x70	498	432	45.0	70	770.10	605.0	298000	12000

4.13 Retaining wall Lightweight sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	TypeA	250	36	14.8	75.40	107	60
2	TypeB	333	51	17.9	68.28	510	144
3	TypeC	333	85	19.3	73.80	2000	272
4	TypeD	333	74	21.6	82.53	636	171
5	TypeE	500	160	33.6	85.70	3620	452

Cover

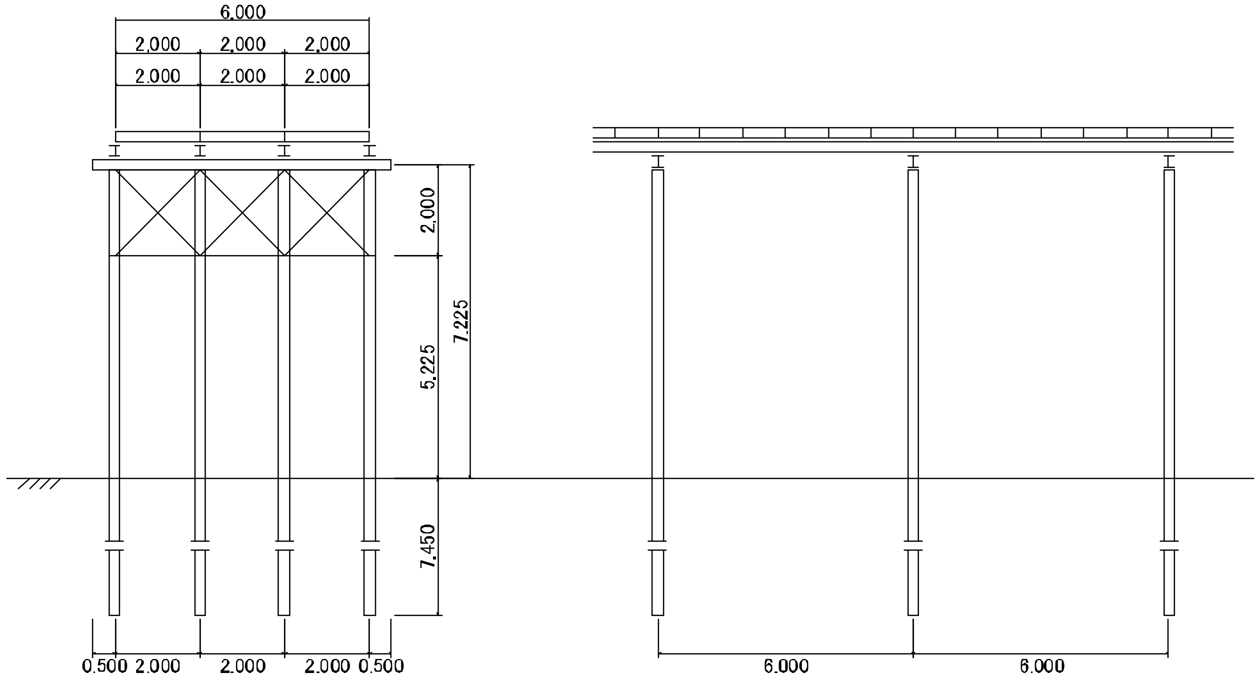
Contents

1 Input data export

1.1 Title

file : Ibrahimia 40cE.F8K
title: Dairout Iburahimia

1.2 Shape data



1.5 Design condition

basic condition

Applied standard	C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
type of working platform	Type i(widthMain girder orthogonal)
adjacent span	Yes
Support pile Foundation type	Support pile

steel deck, coefficient

type of steel deck	Steel deck type 2(Old Metro-deck)
At Steel deck designMain girder treatment	Not consider
impact coefficient steel deck	0.400
other than steel deck	0.300
Horizontal coefficient fixed load	0.200
load truck	= 0.100
heavy equipment	= 0.150

Use horizontal coefficient when truck crane is moving.

impact when horizontal load is calculated	not include impact
impact when deflection is calculated	not include impact

1.4 Member design condition

Beam seatSteel specification	H-Beam
Beam seatCheck share stress	Checking
Beam seat, Support piledesign guideline	Main girder load distribution is considered.
allowable deflection	length of a span/ 400.000
maximum deflection	2.500 (cm)
dead load when deflection is calculated	Not consider
Eq of deflection for single live load	Calculation equation for 1 member
Support piledesign	Examine
Support pileDesign time axial force	maximum axial force / 1
Support pileself weight treatment	Total length
other vertical load	0.000 (kN/ a member)
Support pileHorizontal force load status	Use vertical load when horizontal force is max.
Hori. jointhorizontal force	by next member in Post pile intervalHori. jointis shared
Hori. joint	both sides install
Beam seatunderneathHori. jointinstall:	Not do
Hori. jointJoint part	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)
Hori. joint,brace horizontal force calculation method	Use vertical load when horizontal force is max.
brace member	Design as compressive member
brace connection	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)

1. 4 Design condition

live load

increment of live load movement of live load when member section is calculated for live load Del.L 0.010 (m)

crawler crane load Linear load

Support piledesign

Incase of Penetration length is not satisfied with Beta L >= 2.50 :design as limited length pile

increase rate pile top free	bending moment	1.00
	displacement	1.25
pile top fixed	bending moment	1.10
	displacement	1.20

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1.6 Live load for steel deck design

	Main girder orthogonal to		Main girder parallel to	
	1000* 2000	1000* 3000	1000* 2000	1000* 3000
truck load	NG	NG	OK	NG
crawler crane moving	NG	NG	OK	NG
crawler crane 0 degree	NG	NG	OK	NG
crawler crane 90 degree	NG	NG	OK	NG
crawler crane 45 degree	NG	NG	OK	NG
truck crane moving	NG	NG	OK	NG
truck crane working	NG	NG	NG	NG
reinforcing beam	NG		NG	

OK : design NG : not design

1.7 Live loads for member design

	Main girder orthogonal to	Main girder parallel to
truck load	NG	OK
crawler crane moving	NG	OK
crawler crane 0 degree	NG	OK
crawler crane 90 degree	NG	OK
crawler crane 45 degree	NG	OK
truck crane moving	NG	OK
truck crane working	NG	NG

OK : design NG : not design

1.8 working platform data

Span* adjacent span data

item	symbol	unit	value
main span length	--	m	6.000
adjacent span length	--	m	6.000

Main girder spacing data

No. N	Main girder spacing(m)
1	2.000
2	2.000
3	2.000

steel deck layout data

No. F	steel deck size (m)
1	2
2	2
3	2

Support pile spacing

No. S	Support pile spacing(m)
1	2.000
2	2.000
3	2.000

width, overhang

item	symbol	unit	value
road width	--	m	6.000
gap	--	m	0.000
left overhang length	LL	m	0.500
right overhang length	LR	m	0.500

1.9 frame data

with or without Hori. brace [none]
with or without Vert. brace [Yes]
elevation

No. h	frame spacing (m)
1 2	2.000 5.225

item	symbol	unit	value
Support pilepenetration length	hL	m	7.450
ground level G.L.	--	m	39.000

1.10 Support piledesign condition

Sand layer with N-value more than 30 or delluvial clay with more than 10
embedded more than 3m in the bearing layer Not allow
Pile construction method (not embedded by written above) Striking construction method
Directly input Alp.* Beta No
Pile moment using vertical brace
Calculation method Chang equation
Specify upper limit of N-value in pile tip ground Based on the design strength
Direct input N-value at pile tip ground No
embedment length 7.45 (m)
Young's modulus of pile * 10^5 2.00 (N/mm²)
Modulus of subgrade lateral reaction 0.00 (kN/m³)
Assume sound layer when pile tip bearing capacity is calculated
Lower limit of N-value 20.000
Factor of Safey when allowable bearing capacity is calculated 2.0

1.11 Strata data

No.	layer type	layer thickness	average N-value	coh soil unc cmpr strg(kN/m²)	Alp.* Eo (kN/m²)	cohesion (kN/m²)
1	Sandy soil	1.000	5.000	100.000	14000.00	50.000
2	Sandy soil	5.000	15.000	100.000	42000.00	50.000
3	Sandy soil	4.000	23.000	200.000	64400.00	100.000
4	Sandy soil	8.000	38.000	200.000	106400.00	100.000

1.12 steel deck load distribution ratio specification

* truck load distribution ratio

	Main girder orthogonal to	Main girder parallel to
truck	0.40	0.40

* Crawler crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
0 degree	0.25	0.20
45 degree	0.25	0.20
60 degree	0.25	0.20

Note)use the value of front hang when moving.

* Truck crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
moving	0.40	0.40
working	0.40	0.40

1.13 Steel deck material data

height of steel deck 200(mm)

* in case of 1000* 2000
  1) name of steel deck Steel deck type 2
  2) Aw 8.10 (cm²)
  3) Z 312.0 (cm³)
* in case of 1000* 3000
  1) name of steel deck Steel deck type 2
  2) Aw 8.10 (cm²)
  3) Z 312.0 (cm³)

Note: Web section area, section modulus are input data per one H steel.

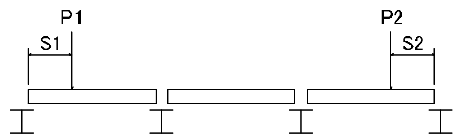
1.14 Reinforcement girder material data

1)name of using material	
2)Aw	54.00 (cm²)
3)Z	2720.0 (cm³)
4)self-weight	1880.0 (N/m)
5)span length	2.0 (m)
6)comment (description)	

1.15 Beam seat Joint part bolt data

Support pile part
bolt is not designed.

1.16 Bridge face(dead) load



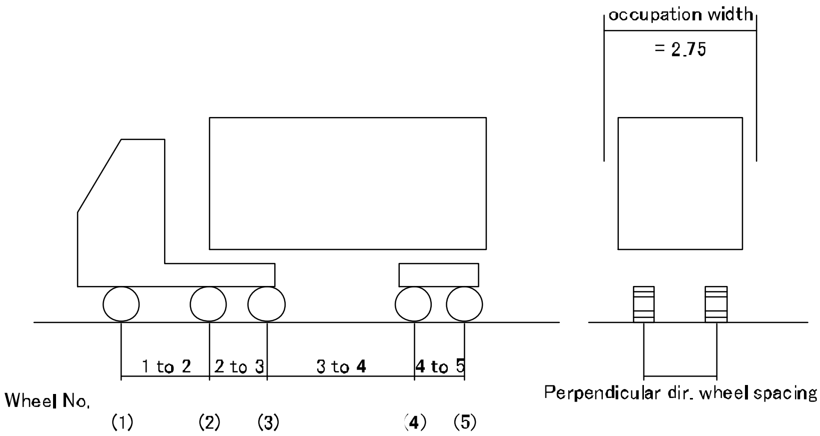
1)left loading position	0.000 (m)
2)right loading position	0.000 (m)
3)left load intensity	0.000 (kN/m)
4)right load intensity	0.000 (kN/m)

1.17 Steel deck/Nominal load

1)steel deck self-weight	1000 * 2000	2.000 (kN/m²)
	1000 * 3000	2.000 (kN/m²)
other		2.000 (kN/m²)
2)nominal load		0.000 (kN/m²)
3)attachment unit		0.100

1.18 Select truck load

* bridge axis direction



1) load selection — Input load
2) registration name — T20
3) axis spacing in perpendicular direction — 1.75 (m)
4) number of wheels — 2
5) axis spacing in moving direction (m)

1 - 2	4.000

6) load intensity (one side) (kN)

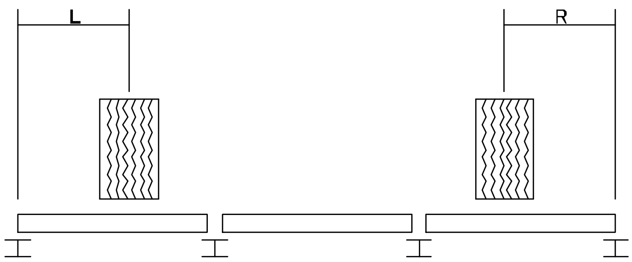
1	20.000
2	80.000

* perpendicular to bridge axis direction
1) load selection Input load
2) load type
P1 T20
P2 T20
P3 T20

1.19 Truck load condition setting

* bridge axis direction
1) train load is considered — No
2) Number in perpendicular direction — 2

1.20 Width of truck load setting



1) load on one side — Consider
2) non-width of load (left) — 0.000 (m)
3) non-width of load (right) — 0.000 (m)

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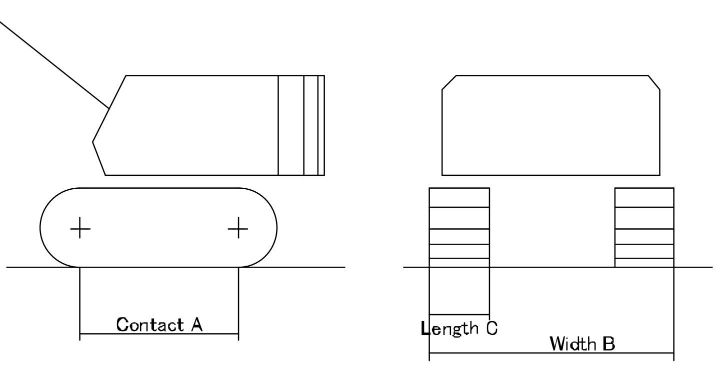
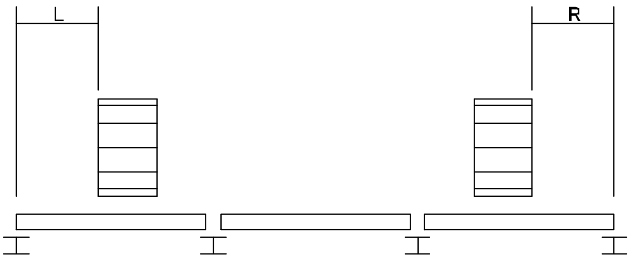
1.21 Crawler crane load selection

1)registration name D408S



2)self-weight	480.000 (kN)
3)hoisting self-weight	50.000 (kN)
4)contact A	4.470 (m)
5)width B	4.000 (m)
6)contact width C	0.800 (m)
7)apportionment on lateral operation side	0.750
8)contact when hoisting forward	0.750
9)apportionment on operation side in orthogonal direction	0.700
10)contact on operation side in orthogonal direction	0.900

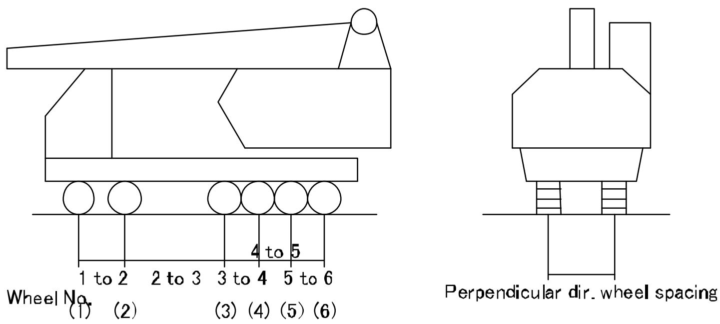
1.22 Width of Crawler crane non-load setting



1)load on one side	Not consider
2)non-width of load (left)	1.000 (m)
3)non-width of load (right)	1.000 (m)
4)location of heavy equipment in bridge axis direction	not specify

1.23 Truck crane load selection

* at moving



1)registration name	NK-200
2)wheel spacing in perpendicular direction	1.90 (m)
3)number of wheels	3

4)wheel spacing in moving direction (m)

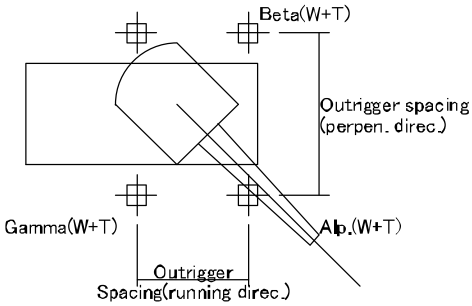
1 - 2	3.980

2 - 3	1.240

5)load intensity(one side) (kN)

1	20.000
2	40.000
3	40.000

* at operating



1)self-weight	W	200.000 (kN)
2)hoisting self-weight	T	30.000 (kN)
3)outrigger spacing (moving)		4.450 (m)
4)outrigger spacing (perpendicular)		4.800 (m)
5)load distribution ratio	Alp.	0.700
6)load distribution ratio	Beta	0.150
7)load distribution ratio	Gam	0.150
8)outrigger width		0.400 (m)

1.24 Width of Truck crane non-load setting

truck crane load is not considered.

1.25 Dead load arbitrary position

Dead load at any location is not input.

1.26 Specify allowable stress

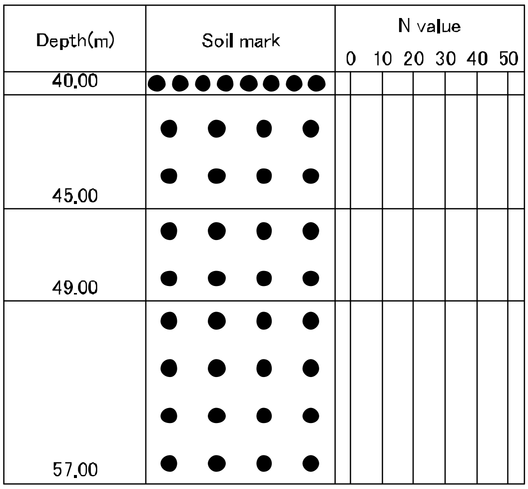
steel type name SS400
load factor of allowable stress 1.50
allowable stress

	direct input of allowable stress			
	bend cmpr (N/mm²)	ax cmpr (N/mm²)	ax tns (N/mm²)	shear (N/mm²)
steel deck	Auto calc	----	----	Auto calc
Main girder	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)H-Beam	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)U shape steel	210.00	----	----	Auto calc
Support pile	Auto calc	Auto calc	----	Auto calc
Hori. joint	----	Auto calc	----	----
brace	----	Auto calc	Auto calc	----

allowable stress automatic calculation(calculate from fixed number in the middle of a member)

	fixed number of middle		member length	
	distance flange fixed	effective buckling length	distance fixed (cm)	effective buckling length(cm)
steel deck	----	----	----	----
Main girder	0	----	0.00	----
Beam seat(Support pilepart)H-Beam	0	----	0.00	----
Beam seat(Support pilepart)U shape steel	0	----	0.00	----
Support pile	0	0	0.00	0.00
Hori. joint	----	0	----	0.00
brace	----	----	----	----

1.27 Borehole log of strata



1.28 Initial input

1)applied standard C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
2)abutment type Type i
3)adjacent span Yes
4)Support pile Foundation type bearing pile embedment length 7.450(m)
5)shape data
* width 6.000(m)
* left overhang 0.500(m)
* right overhang 0.500(m)
* span 6.000(m)
* working platform height 7.225(m)
* steel deck size 2.000(m)
* Support pileBasic spacing 2.000(m)
* frame basic spacing 3.000(m)
6)Design Support pile
* Foundation data
  1.pile construction method driven casting
* Soil data

No.	type	thickness (m)	ave N value	coh soil cmpr strg (kN/m²)	Alp.* Eo (kN/m²)	cohension (kN/m²)
1	Sandy soil	1.000	5.000	100.000	14000.00	50.000
2	Sandy soil	5.000	15.000	100.000	42000.00	50.000
3	Sandy soil	4.000	23.000	200.000	64400.00	100.000
4	Sandy soil	8.000	38.000	200.000	106400.00	100.000

2 Calculation result export

2.1 Steel deck type 2 design (Old Metro-deck)

2.1.1 Sum up bending stress for each load

load status			Bending stress 1000 * 2000 (N/mm²)
truck load		parallel	75.426
		orthogonal	----------
crawler crane	moving	parallel	19.915
		orthogonal	----------
	working 0 degree	parallel	48.928
		orthogonal	----------
	working 90 degree	parallel	32.563
		orthogonal	----------
	working 45 degree	parallel	58.621
		orthogonal	----------
truck crane	moving	parallel	32.051
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			210.000

2.1.2 bending stress calculation

calculate stresses when the load condition induces bending stress maximum

1)load condition Truck load(Parallel)

2)steel deck Steel deck type 2 (1000*2000)

3)bending moment by fixed load (per a steel deck)

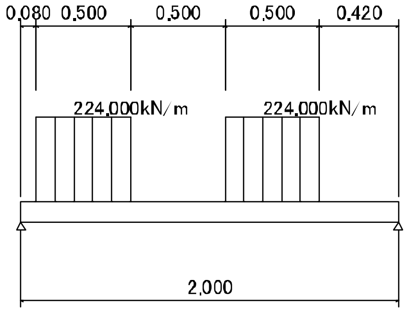
$$Md = w * l^2 / 8 = 1.000 \text{ (kN.m)}$$

where

w : fixed load intensity applied on a steel deck
(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)
l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

FORUM8

4) Truck load(Parallel) of bending moment



Mmax = 58.332 (kN m)

where

w : load intensity

w_1 = 224.000 (kN/m)

w_2 = 224.000 (kN/m)

5) in case of Truck load(Parallel), bending moment per single steel sheet

steel deck type2 1000 * 2000

Sig.M = Mmax * 0.400 + Ml * 20/100 = 23.533 (kN m)

6) stresses in a steel deck

Sig. = Sig.M / Z = 75.426 (N/mm²)

where

Z: section modulus = 312.000 (cm³)

2.1.3 Sum up shear stress for each load

load status			shear stress 1000 * 2000 (N/mm^2)
truck load		parallel	69.630
		orthogonal	----------
crawler crane	moving	parallel	15.342
		orthogonal	----------
	working 0 degree	parallel	37.692
		orthogonal	----------
	working 90 degree	parallel	25.086
		orthogonal	----------
	working 45 degree	parallel	45.160
		orthogonal	----------
truck crane	moving	parallel	24.830
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			120.000

2.1.4 Shear stress calculation

calculate stresses when the load condition induces Shear stress maximum

1)load condition Truck load(Parallel)

2)steel deck Steel deck type 2 (1000*2000)

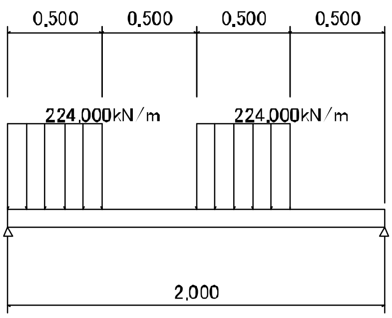
3)Shear force by fixed load (per a steel deck)

$$Sd = w * l / 2 = 2.000 \ (kN)$$

where

w : fixed load intensity applied on a steel deck
(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)
l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4)Truck load(Parallel) of Shear force



$$Smax = 140.000 \ (kN)$$

where

w : load intensity
w_1 = 224.000 (kN/m)
w_2 = 224.000 (kN/m)

FORUM8

5) in case of Truck load(Parallel), Shear force per single steel sheet

steel deck type2 1000 * 2000

Sig.S = Smax * 0.400 + Sd * 20/100 = 56.400 (kN)

6) stresses in a steel deck

Tau = Sig.S / A = 69.630 (N/mm²)

where

A: cross sectional area = 8.100 (cm²)

2.2 Main girder Design

2.2.1 bending moment sum up for each load

load status		Main girder No.	bending moment (kN.m)
truck load	orthogonal	--------	------------
	parallel	G 2	279.092
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	231.160
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	308.616
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	366.064
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	399.891
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	157.289
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.2 bending moment calculation

Calculate load condition when bending moment is maximum

1) load condition　　Crawler crane diagonal hang(Parallel)

2) design Main girder number　　2

3) stresses by fixed load

Equations to calculate stresses by fixed load　　2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load　2.000 *　2.000 /　2.000 =　2.000

steel deck self-weight* nominal load　2.000 *　2.000 /　2.000 =　2.000

Main girder Self weight　=　1.687

----

total　w_d =　5.687 (kN/m)

using Main girder　H-400x400x13x21

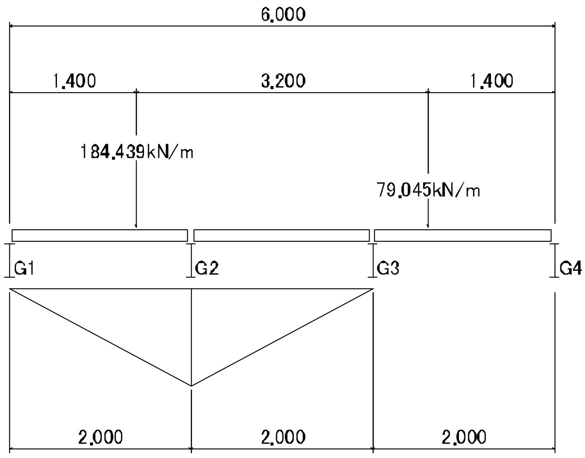
* stresses by fixed load

bending moment

$M_d = w_d * l^2/8 + M_o = 5.687 * 6.000^2/8 + 0.000 = 25.592$ (kN.m)

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



crawler crane load intensity on operation side
  triangular distribution front side   p1 = (W+ T) * 0.700
                                       /(0.900 * lb * 1/2) = 184.439 (kN/m)
  triangular distribution front side   p1'   = 0.000 (kN/m)

crawler crane load intensity on non-operation side
  triangular distribution front side   p2 = (W+ T) * 0.300
                                       /(0.900 * lb * 1/2) = 79.045 (kN/m)
  triangular distribution front side   p2'   = 0.000 (kN/m)

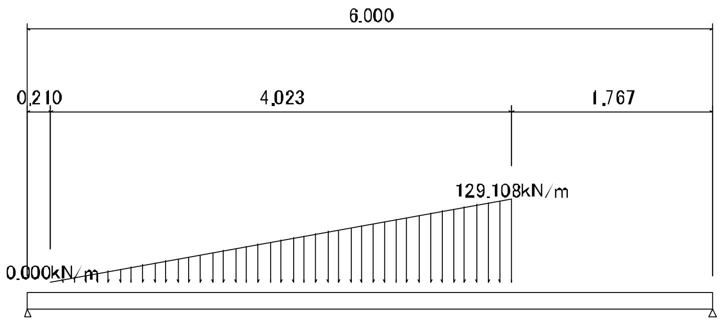
load intensity on focus Main girder
  triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2 = 129.108 (kN/m)
  triangular distribution front side   q1'   = 0.000 (kN/m)

where

W	: crawler crane self-weight	=	480.000 (kN)
T	: lifting load	=	50.000 (kN)
lb	: crawler crane contact	=	4.470 (m)
Eta1	: crawler influence value on operation side	=	0.70000
Eta2	: crawler influence value on non-operation side	=	0.00000

FORUM8

* crawler crane (slant hoisting) bending moment



crawler crane bending moment
Mmax = 287.922 (kN m)
where
lmax : Mmax location = 3.105 (m)

* crawler crane bending moment

fixed load		=	25.592(kN m)
crawler crane load		=	287.922(kN m)
impact	287.922 * 0.300	=	86.377(kN m)
total	M	=	399.891(kN m)

2.2.3 Shear force sum up for each load

load status		Main girder No.	Shear force (kN)
truck load	orthogonal	--------	------------
	parallel	G 2	200.144
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	154.107
	0 degree-orthogonal	--------	------------
	0 degree-parallel	G 2	213.038
	90 degree-orthogonal	--------	------------
	90 degree-parallel	G 2	244.043
	45 degree-orthogonal	--------	------------
	45 degree-parallel	G 2	279.215
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	118.526
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.4 Shear force calculation

Calculate load condition when Shear force is maximum

1)load condition Crawler crane diagonal hang(Parallel)

2)design Main girder number 2

3)stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

Main girder Self weight = 1.687

----

total wd = 5.687 (kN/m)

using Main girder H-400x400x13x21

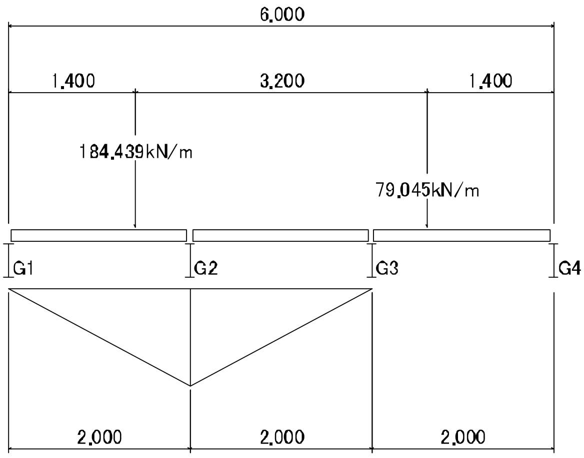
* stresses by fixed load

Shear force

Sd = wd * l / 2 + So = 5.687 * 6.000 / 2 + 0.000 = 17.061(kN)

Calculate stresses of crawler crane (slant hoisting)   2 of Main girder

* calculation of load intensity



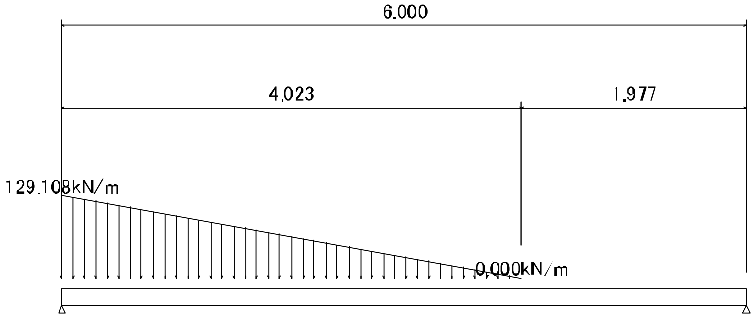
crawler crane load intensity on operation side
  triangular distribution front side   p1 = (W+ T) * 0.700
                                        /(0.900 * lb * 1/2) = 184.439 (kN/m)
  triangular distribution front side   p1'   = 0.000 (kN/m)

crawler crane load intensity on non-operation side
  triangular distribution front side   p2 = (W+ T) * 0.300
                                        /(0.900 * lb * 1/2) = 79.045 (kN/m)
  triangular distribution front side   p2'   = 0.000 (kN/m)

load intensity on focus Main girder
  triangular distribution front side   q1 = p1 * Eta1 + p2 * Eta2 = 129.108 (kN/m)
  triangular distribution front side   q1'   = 0.000 (kN/m)

where
  W : crawler crane self-weight = 480.000 (kN)
  T : lifting load = 50.000 (kN)
  lb : crawler crane contact = 4.470 (m)
  Eta1: crawler influence value on operation side = 0.70000
  Eta2: crawler influence value on non-operation side = 0.00000

* crawler crane (slant hoisting) Shear force



crawler crane Shear force
Smax = 201.657 (kN)

* crawler crane Shear force

fixed load			=	17.061(kN)
crawler crane load			=	201.657(kN)
impact	201.657 * 0.300		=	60.497(kN)
total		S	=	279.215(kN)

2.2.5 Allowable stress calculation

steel material for structure SS400
using member H-400x400x13x21
allowable bending stress
Sig.ba = 172.200 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 600.000 (cm)
b : cross sectional area of compressive flange = 40.000 (cm)
l/b : = 15.000
allowable shear stress
Taua = 120.000

2.2.6 Main girder stress calculation

using member H-400x400x13x21
bending stress
Sig. = M/ Z = 120.087 (N/mm²) <= 172.200 (N/mm²)
where
M : design bending moment = 399.891 (kN.m)
(Crawler crane diagonal hang(Parallel))
Z : section modulus = 3330.000 (cm³)
shear stress
Tau = S / Aw = 59.995 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 279.215 (kN)
(Crawler crane diagonal hang(Parallel))
Aw : web section area = 46.540 (cm²)

2.2.7 Deflection calculation

Calculate deflection when bending moment is maximum

$$Del. = \frac{5 M_{max} l^2}{48EI} = 0.811 \text{ (cm)} \le 1.500 \text{ (cm)}$$

where
Mmax: bending moment by load = 287.922 (kN.m)
(Crawler crane diagonal hang(Parallel))
l : span length = 600.000 (cm)
I : moment of inertia of area = 66600.000 (cm⁴)
E : Young's modulus = $2.0 * 10^5$ (N/mm²)

2.3 Beam seat Design

2.3.1 Sum up bending moment for each load

load condition		section	bending moment (kN m)
truck load	orthogonal	----------------------	----------
	parallel	section- 2 Simple beam part	0.662
crawler crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	0 degree-orthogonal	----------------------	----------
	0 degree-parallel	section- 2 Simple beam part	0.662
	90 degree-orthogonal	----------------------	----------
	90 degree-parallel	section- 2 Simple beam part	0.662
	45 degree-orthogonal	----------------------	----------
	45 degree-parallel	section- 2 Simple beam part	0.662
truck crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	0.662
	working-orthogonal	----------------------	----------
	working-parallel	----------------------	----------

Note) Bending moment is the sum of moment by fixed load, load, and impact.

2.3.2 Bending moment computation

Calculate in the load condition that induces bending moment maximum

1) load condition Truck load(Parallel)

2) design section - 2 Simple beam part

3) include Main girder in design section

No.	Main girder No.
1	G 2

4) Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

where

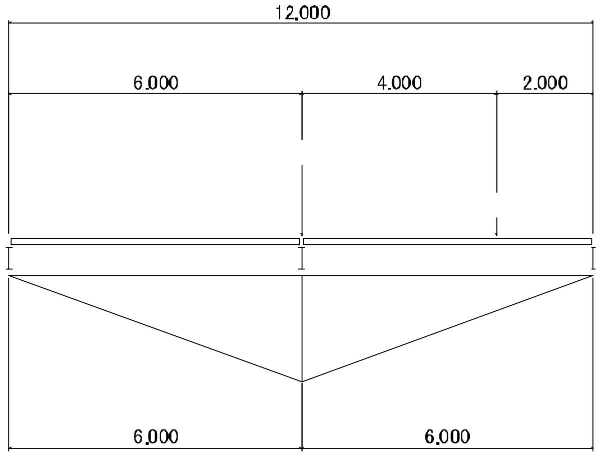
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force by truck load

in case that Beam seat of bending moment is at maximum, truck load position.

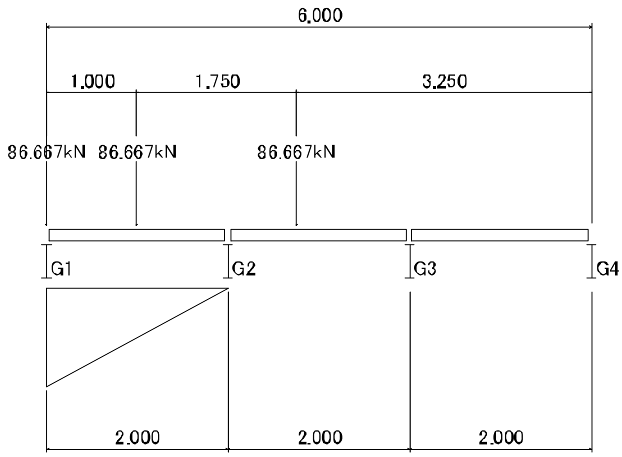


reaction force by train load

Rj = Sig. PJi * Etai = 86.667 (kN)

wheel No.	load PJi (kN)	influence value on reaction force Etai
1	80.000	1.000
2	20.000	0.333

in case that Beam seat of bending moment is at maximum, truck load position.



1 Main girder reaction force is maximum, then Beam seat bending moment is maximum

influence value of each beam

No.	Main girder No.	influence value
1	G 1	1.500
2	G 2	1.125
3	G 3	0.375
4	G 4	0.000

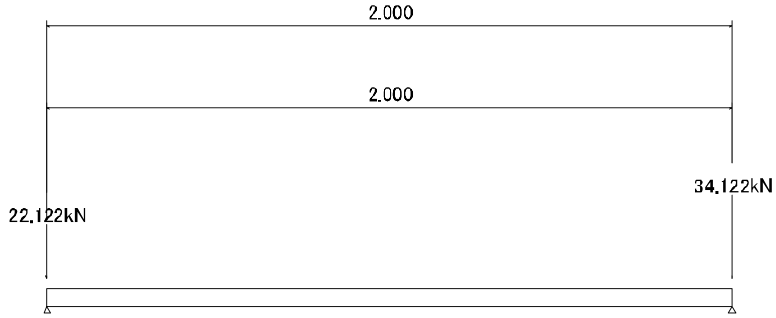
Rji = Rj * Ii

No.	Main girder No.	eachMain girder effect value Ii	Rji (kN)
1	G 1	1.500	130.000
2	G 2	1.125	97.500
3	G 3	0.375	32.500
4	G 4	0.000	0.000

6)calculate bending moment

Simple beam part

Bending moment by fixed load



Md = 0.662 (kN.m)

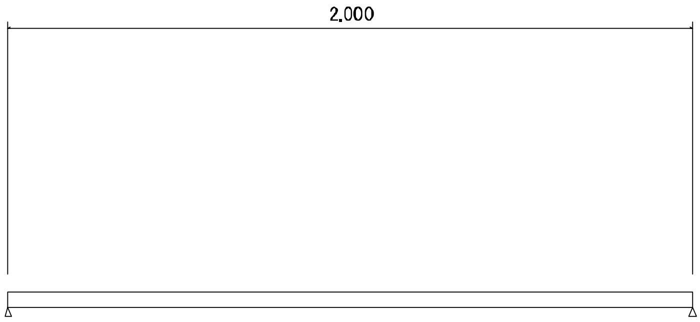
where

lmax : Mmax position(from left support point) = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

Bending moment by load



Ml = 0.000 (kN.m)

where

lmax : Mmax position (from left support point) = 0.000 (m)

7) sum of bending moment

fixed load		=	0.662 (kN.m)
load		=	0.000 (kN.m)
impact	= 0.000 * 0.300	=	0.000 (kN.m)
--			
total		M =	0.662 (kN.m)

2.3.3 Sum up shear force for each load

load condition		section	shear force (kN)
truck load	orthogonal	---------------------	----------
	parallel	section- 2 Simple beam part	218.529
crawler crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	213.169
	0 degree-orthogonal	---------------------	----------
	0 degree-parallel	section- 2 Simple beam part	250.286
	90 degree-orthogonal	---------------------	----------
	90 degree-parallel	section- 2 Simple beam part	329.800
	45 degree-orthogonal	---------------------	----------
	45 degree-parallel	section- 2 Simple beam part	328.855
truck crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	142.553
	working-orthogonal	---------------------	----------
	working-parallel	---------------------	----------

Note) Shear force is the sum of shear force by fixed load,
load, and impact.

2.3.4 Shear force computation

Calculate in the load condition that induces shear force maximum

1)load condition   Crawler crane side hang(Parallel)

2)design section - 2   Simple beam part

3)include Main girder in design section

No.	Main girder No.
1	G 2

4)Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN/m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.687	0.000	22.122
2	G 2	5.687	0.000	34.122
3	G 3	5.687	0.000	34.122
4	G 4	3.687	0.000	22.122

where

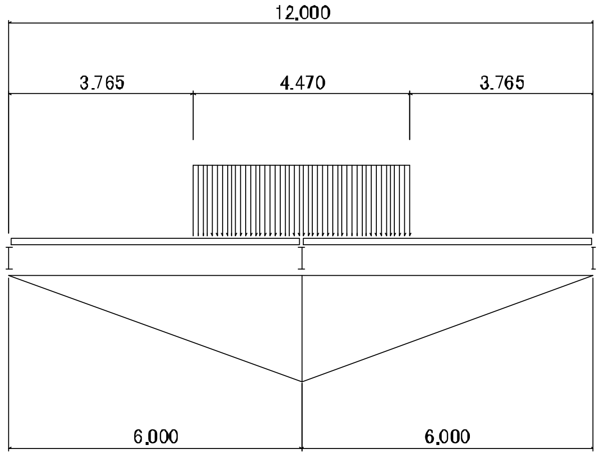
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force of crawler crane

Beam seat - Shear force is at maximum, crawler load condition



reaction force of crawler crane

Rc1 = w1 * { b * (a + b/2.0) / l1
+ c * (d + c/2.0) / l2 } = 323.466 (kN)

Rc2 = w2 * { b * (a + b/2.0) / l1
+ c * (d + c/2.0) / l2 } = 107.822 (kN)

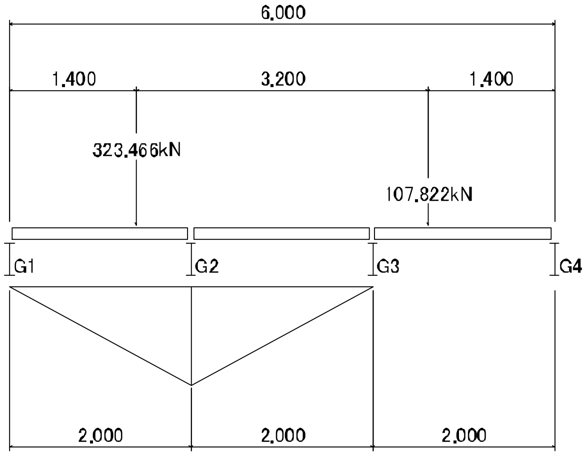
where

w1 : crawler crane load intensity on operation side
w1 = (W + T) / lb * 0.750 = 88.926 (kN/m)

w2 : crawler crane load intensity on non-operation side
w2 = (W + T) / lb * 0.250 = 29.642 (kN/m)

a :	unloading length in left span	=	3.765 (m)
b :	loading length in left span	=	2.235 (m)
c :	loading length in right span	=	2.235 (m)
d :	unloading length in right span	=	3.765 (m)
W :	crawler crane self-weight	=	480.000 (kN)
T :	lifting load	=	50.000 (kN)
lb :	crawler crane contact	=	4.470 (m)
l1 :	length of left span	=	6.000 (m)
l2 :	length of right span	=	6.000 (m)

Beam seat of Shear force is at maximum, crawler load condition

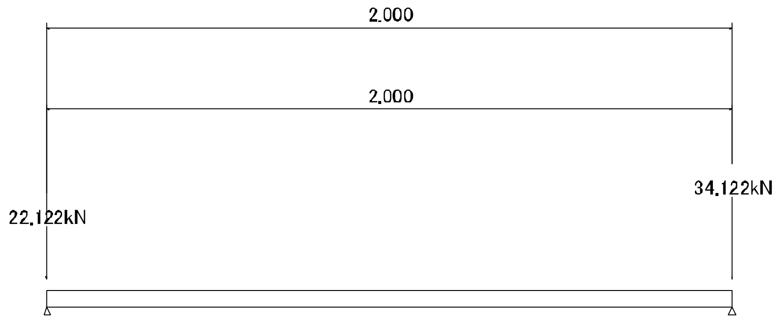


No.	Main girder No.	eachMain girder reaction force(kN)
1	G 1	97.040
2	G 2	226.426
3	G 3	75.475
4	G 4	32.347

6) calculate shear force

Simple beam part

Shear force by fixed load



Sd = 35.446 (kN)

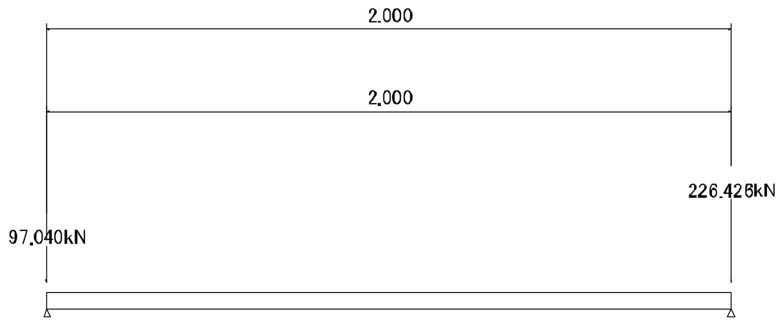
where

l : span length = 2.000 (m)

wd : self-weight = 1.3240 (kN/m)

member used H-350x350x12x19

shear force by load



Sj = 226.426 (kN)

7) sum of shear force

fixed load		=	35.446	(kN)
load		=	226.426	(kN)
impact	= 226.426 * 0.300	=	67.928	(kN)
total		S =	329.800	(kN)

2.3.5 Allowable stress calculation

steel material for structure SS400
using member H 350x350x12x19
allowable bending stress
Sig.ba = 205.629 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 200.000 (cm)
b : cross sectional area of compressive flange = 35.000 (cm)
l/b : = 5.714
allowable shear stress
Taua = 120.000

2.3.6 Beam seat stress calculation

using member H 350x350x12x19
bending stress
Sig. = M / Z = 0.290 (N/mm²) <= 205.629 (N/mm²)
where
M : design bending moment = 0.662 (kN.m)
(Truck load(Parallel))
Z : section modulus = 2280.000 (cm³)
shear stress
Tau = S / Aw = 88.088 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 329.800 (kN)
(Crawler crane side hang(Parallel))
Aw : web section area = 37.440 (cm²)

2.3.7 Deflection calculation

Calculate deflection when bending moment is maximum in a simple beam section

$$Del. = \frac{5 M_{max} l^2}{48 EI} = 0.000 \text{ (cm)} <= 0.500 \text{ (cm)}$$

where
Mmax: bending moment by load = 0.000 (kN.m)
(Truck load(Parallel))
l : span length = 200.000 (cm)
I : moment of inertia of area = 39800.000 (cm⁴)
E : Young's modulus = $2.0 * 10^5$ (N/mm²)

2.4 Support pile Design

2.4.1 The axial force and horizontal force of Support pile for each load

		axial force at max		horizontal force (kN)
		Support pileNo.	axial force (kN)	
truck load	orthogonal	----	--------	--------
	parallel	2	240.837	34.667
crawler crane	moving-orthogonal	----	--------	--------
	moving-parallel	3	235.477	72.000
	0 degree-orthogonal	----	--------	--------
	0 degree-parallel	3	272.594	79.500
	90 degree-orthogonal	----	--------	--------
	90 degree-parallel	3	352.108	79.500
	45 degree-orthogonal	----	--------	--------
	45 degree-parallel	3	351.163	79.500
truck crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	164.861	23.540
	working-orthogonal	----	--------	--------
	working-parallel	----	--------	--------

2.4.2 Axial force calculation for member design

Calculate for the load condition when axial force is maximum

For pile stress and bearing capacity of Support pile,use maximum axial force multiplied by 1/1 .

1) Load condition Crawler crane side hang(Parallel)

2) Support pile Number 3

Checking Support pile left Simple beam part

Checking Support pile left section Number of Main girder = 1

No.	Main girder No.
1	G 2

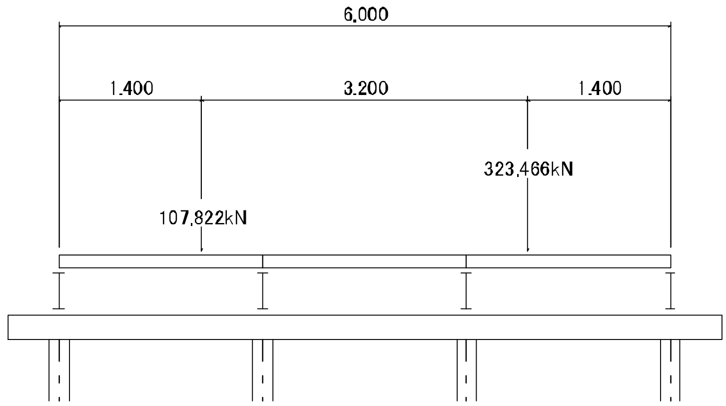
Checking Support pile right Simple beam part

Checking Support pile right section Number of Main girder = 1

No.	Main girder No.
1	G 3

3) calculate max axial force

simple beam + simple beam



axial force by fixed load

Nd = Ndl + Ndr + nd = 57.754 (kN)

where

Ndl : axial force by fixed load on simple beam (left)

Ndl = Sig.(Rdi * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rdi (kN)	lLi (m)
1	G 2	34.122	0.000

Ndr : axial force by fixed load on simple beam (right)

Ndr = Sig.(Rdj * lRj) / lk2 = 34.122 (kN)

No.	Main girder No.	Rdj (kN)	lRj (m)
1	G 3	34.122	2.000

nd : axial force by self-weight

Beam seat Self weight 1.324 * ((lk1 + lk2) / 2.0) = 2.648 (kN)

Hori. joint 0.182 * ls1 * 2 = 0.728 (kN)

Hori. brace 0.000 * ls2 = 0.000 (kN)

Vert. brace 0.146 * lv = 0.826 (kN)

Support pile Self weight 1.324 * lKUI = 19.430 (kN)

other load = 0.000 (kN)

----

total 23.632 (kN)

where

lk1 : left span length of simple beam = 2.000 (m)

lk2 : right span length of simple beam = 2.000 (m)

ls1 : Hori. joint Length = 2.000 (m)

ls1 = ((lk1+lk2) / 2.0) * 1

ls2 : Hori. brace Length = 0.000 (m)

lv : Vert. brace Length = 5.657 (m)

lv = Sig. lvn

lv1 = $\sqrt{lk1^2 + 2.000^2} + \sqrt{lk2^2 + 2.000^2}$ = 5.657 (m)

lKUI : Support pile Length = 14.675 (m)

axial force by load

Nj = Njl + Njr = 226.426 (kN)

where

Njl : axial force by load on simple beam(left)

Njl = Sig.(Rji * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rji (kN)	lLi (m)
1	G 2	75.475	0.000

Njr : axial force by load on simple beam(right)

Njr = Sig.(Rjj * lRj) / lk2 = 226.426 (kN)

No.	Main girder No.	Rjj (kN)	lRj (m)
1	G 3	226.426	2.000

member design axial force

fixed load = 57.754 (kN)

load = 226.426 (kN)

impact 226.426 * 0.300 = 67.928 (kN)

----

total N = 352.108 (kN)

member design axial force is 1/1 N * 1/1 = 352.108 (kN)

2.4.3 Horizontal force calculation

1) horizontal force by fixed load

Hl = (W1 + W2 + W3 + W4 + W5 + W6 + W7) * kh = 25.284 (kN)

W1 : weight of steel deck* nominal load

W1 = (Wf1 * Bf1 + Wf2 * Bf2) * (l + lside) / 2.0 = 72.000 (kN)

Wf1	steel deck 2m+ nominal load	=	2.000 (kN/m²)
Bf1	steel deck 2m+ width direction	=	6.000 (m)
Wf2	steel deck 3m+ nominal load	=	2.000 (kN/m²)
Bf2	steel deck 3m+ width direction	=	0.000 (m)
l	span length	=	6.000 (m)
lside	adjacent span length	=	6.000 (m)

W2 : dead load weight of wheel guard

W2 = (WL + WR) * (l + lside) / 2.0 = 0.000 (kN)

WL	dead load of left wheel guard	=	0.000 (kN/m)
WR	dead load of right wheel guard	=	0.000 (kN/m)

W3 : Main girder Weight

W3 = N * WN * (l + lside) / 2.0 = 40.488 (kN)

N	Main girder Members number	=	4
WN	Main girder Self weight	=	1.687 (kN/m)

W4 : Beam seat Weight

W4 = WH * lH = 9.268 (kN)

WH	Beam seat Self weight	=	1.324 (kN/m)
lH	Beam seat length	=	7.000 (m)

W5 : Hori. joint Weight

W5 = Ws1 * ls1 * 2 = 2.184 (kN)

Ws1	Hori. joint Weight	=	0.182 (kN/m)
ls1	Hori. joint Length	=	6.000 (m)

W6 : Hori. brace Weight

W6 = Ws2 * ls2 / 2.0 = 0.000 (kN)

Ws2	Hori. brace Self weight	=	0.000 (kN/m)
ls2	Hori. brace Extension	=	0.000 (m)

W7 : Vert. brace Weight

W7 = Wv * lv = 2.479 (kN)

Wv	Vert. brace Self weight	=	0.146 (kN/m)
lv	Vert. brace Extension	=	16.971 (m)

kh : coefficient for horizontal force estimate

kh = 0.200

FORUM8

2) horizontal load by horizontal force

Hj = R * kh = 79.500 (kN)

R : load case [Crawler crane font hang(Parallel)]

R = W + T = 530.000 (kN)

where

W: heaviest machine weight = 480.000 (kN)

In case truck load, reaction force by truck load on working platform is taken.

T : lifting load(zero when truck load) = 50.000 (kN)

kh : coefficient for horizontal force estimate

kh = 0.150

3) sum of horizontal force

fixed load	=	25.284 (kN)
load	=	79.500 (kN)
total	=	104.784 (kN)

2.4.4 Bending moment by horizontal force(pile top fixed)

Calculate bending moment and displacement using Chang's equation assuming infinite pile.
Since top of support pile are connected with lateral beams, horizontal force at top of transmits to the bottom of lateral beams.
Use bigger value either constrained moment at pile top or max bending moment in subground.

horizontal force on Support pile
H = Sig.H / n = 26.196 (kN)
where
Sig.H : horizontal force acting on one frame plane = 104.784 (kN)
n : Support pileMembers number = 4

constrained moment at pile top
Mo = (1 + Betah) * H / 2Beta = 90.087 (kN.m)
max bending moment in subground
Mmax = - H / 2Beta * (1 + (Betah)^{2})$^{1/2}$ * exp (- Betalm) = 52.837 (kN.m)
depth at max bending moment in subground
lm = 1 / Beta * tan^{-1}(1 /Betah) = 0.506 (m)
horizontal displacement at pile top
Del. = ((1 + Betah)^{3}+ 2) * H / (12 EIBeta^{3}) = 2.684 (cm)
where
h : above ground length = 5.225 (m)
I : Support pilearea moment of inertia = 13600.000 (cm^{4})
E : Support pileYoung modulus = 2.000 * 10^{5}(N/mm^{2})

pile characteristic value
Beta = ^{4}ã(kh* D / (4EI)) = 0.00605 (1/cm)
where
D : Support pilewidth = 35.000 (cm)

subgrade reaction coefficient in lateral direction
kh = kho* (BH/30)$^{-3/4}$ = 41.647 (N/cm^{3})
kho = 1/30* Alp.* Eo = 83.860 (N/cm^{3})
BH = (D/Beta)$^{1/2}$ = 76.281 (cm)
where
BH : pile conversion width of load
Alp.* Eo: average Alp.* Eo in range of 1/Beta = 2515.789 (N/cm^{2})

2.4.5 Support pile buckling stability check

Because Support pile buckling possibly occur under axial direction force and bending moment, check the stability on buckling using next 2 equations.

Sig.c / Sig.caz + Sig.bcz / { Sig.bao * (1 - Sig.c / Sig.eaz) }
= 0.765 <= 1.0

Sig.c + Sig.bcz / (1 - Sig.c / Sig.eaz)
= 149.785 <= Sig.cal

where

Sig.c : compressive stress in axial direction = 20.483 (N/mm²)

Sig.bcz : moment compressive stress by bending moment around weak axis.
Sig.bcz = Mz / zz = 116.091 (N/mm²)

Sig.caz : allowable compressive stress in axial direction around weak axis = 136.979(N/mm²)
lk/r <= 18 --- Sig.caz = 210
18 < lk/r <= 92 --- Sig.caz = { 140 - 0.82 * (lk/r - 18) } * 1.50
92 < lk/r --- Sig.caz = 1200000 / { 6700 + (lk/r)^2} * 1.50
lk/r = 687.789 / 8.890 = 77.367

Sig.bao : upper limit of allowable compressive stress without local buckling
= 210.000 (N/mm²)

Sig.cal : allowable stress of free extension plate under comp stress about local buckling
where b' <= 13.1t' = 210.000 (N/mm²)

Sig.eaz : Euler buckling strength around weak axis
Sig.eaz = 1200000 / (lk/rz)^2 = 200.481 (N/mm²)

N : Support pile acting axial force = 352.108 (kN)

Mz : bending moment around z axis = 90.087 (kN.m)

lk : buckling length = 687.789 (cm)

lLow: lowest design span, height at lowest is added 1/Beta(lk reference value, fixed value).
lLow = lLow' + 1/Beta = 522.500 + 165.289 = 687.789

where,
lLow' : height at lowest = 522.500 (cm)
Beta : characteristic value
Beta = $\sqrt[4]{}$(kh* D / (4EI)) = 0.00605 (1/cm)
where
I : Support pilearea moment of inertia = 13600.000 (cm⁴)
E : Support pileYoung modulus = 2.000 * 10^5(N/mm²)
D : Support pilewidth = 35.000 (cm)
kh : lateral subgrade reaction = 41.647 (N/cm³)

use steel member, H-350x350x12x19·Weak)
A : cross sectional area of steel material = 171.900 (cm²)
zz : section modulus around z axis = 776.000 (cm³)
ry : radius of gyration of area around y axis = 15.200 (cm)
rz : radius of gyration of area around z axis = 8.890 (cm)

Shear stress

horizontal force acting on weak axis of post.
Tau = H / (2 * Af) = 1.970 <= 120.000 (N/mm²)
H : Support pileworking horizontal force = 26.196 (kN)
Af : Support pileFlange area = 66.500 (cm²)

2.4.6 Support pile bearing capacity examination

allowable bearing capacity

Ra = { qd* A + uSig.lifi }/ 2.0 = 426.965 (kN)

(construction method: driving)

where

qd: ultimate bearing capacity at tip ground = 4380.00

qd = 200Alp.N

N : Support pileN value of soil layer at tip= 21.90

N = (N1 + N2) / 2

upper limit is 40.

N1: Support pileN value at tip position = 23.00

N2: Support pile in the range of 2m above from tip

average N-value = 20.80

A : Support piletip area = 0.12 (m²)

u : Support pilePerimeter = 1.400 (m)

li: thickness to be considered circumference friction

fi: maximum skin friction in the layer considered friction

fi=2BetaNs(sand)

Ns upper limit is 50.

fi=10BetaNc(Nc:N-value) , fi=BetaNc(Nc:cohesion)(clay)

where, Nc(N-value 10* Nc) upper limit is 150.

Sig.lifi: circumference friction = 226.700

li(m)	Ns	Nc	fi(kN/m²)	li* fi
1.000	5.0	------	10.000	10.000
5.000	15.0	------	30.000	150.000
1.450	23.0	------	46.000	66.700

Alp. : coefficient of tip bearing capacity for construction method = 1.0

Beta : coefficient of skin friction for construction method = 1.0

max axial force acting on Support pile Crawler crane side hang(Parallel)

N max = 352.108 (kN) <= 426.965 (kN)

2.5 Hori. joint Design

2.5.1 Hori. joint checking

Design Hori. joint as a member receiving compression force.

load condition Crawler crane font hang(Parallel)

compression force acting on Hori. joint

share the horizontal force receiving on a frame plane by dividing into Support pile with the spacing corres

Set both sides of Support pile

N = H / n / 2 = 17.464 (kN)

Sig.c = N / A = 7.366 (N/mm²) <= Sig.ca = 123.770 (N/mm²)

where

H : compressive force acting on a frame plane = 104.784 (kN)

n : Hori. jointnumber = 3

Sig.c : axial direction compressive stress

Sig.ca : allowable axial direction compressive stress = 123.770 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + $(l/r)^2$} * 1.50

l/r = 88.106

Use steel material [-150x75x6.5x10

A : cross sectional area of steel material = 23.710(cm²)

l : buckling length = 2.000(m)

r : radius of gyration of area around weak axis = 2.270(cm)

2.5.2 Connection part checking

compression force acting on Hori. joint

T = 17.464 (kN)

required length for welding part

l = T / (0.7rho* s) = 8.316 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.6 Vert. brace Design

2.6.1 Vert. brace checking

design Vert. brace as a member receiving Compressive force

load condition Crawler crane font hang(Parallel)

horizontal force shared by Vert. brace

share the horizontal force receiving on a frame plane by number of Vert. brace

Hv = H / n = 34.928 (kN)

force Vert. brace acting on Compressive

T = Hv / cos(Theta) = 49.396 (kN)

cos(Theta) = l / $(l^2 + h^2)^{1/2}$ = 0.707

where

l : Support pileThe most shortest spacing(length) = 2.000 (m)

h : Hori. jointlongest spacing = 2.000 (m)

Compressive stress

Sig.c = T / A = 25.998 (N/mm²) <= Sig.ca = 64.891 (N/mm²)

where

Sig.ca : allowable axial direction compressive stress = 64.891 (N/mm²)

l/r <= 18 --- Sig.ca = 210

18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50

92 < l/r --- Sig.ca = 1200000 / {6700 + $(l/r)^2$} * 1.50

l/r = 145.048

Use steel material L-100x100x10

A : effective cross sectional area of steel material = 19.000 (cm²)

l : buckling length = 2.828 (m)

r : radius of gyration of area = 1.950 (cm)

2.6.2 Connection part checking

force Compressive acting on a brace member

T = 49.396 (kN)

required length for welding part

l = T / (0.7rho* s) = 23.522 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.7 Summary export

2.7.1 Steel deck summary report

steel deck : steel deck type2

1) check regarding to bending moment

load condition Truck load(Parallel)
name of steel deck Steel deck type 2 (1000*2000)
bending moment due to fixed load Md = 1.000 (kN.m)
bending moment due to load Mmax = 58.332 (kN.m)
design bending moment M = 23.533 (kN.m)
bending stress Sig. = 75.426 <= 210.000 (N/mm²)

2) check regarding to shear force

load condition Truck load(Parallel)
name of steel deck Steel deck type 2 (1000*2000)
shear force due to fixed load Sd = 2.000 (kN)
shear force due to load Smax = 140.000 (kN)
design shear force S = 56.400 (kN)
shear stress Tau = 69.630 <= 120.000 (N/mm²)

2.7.2 Main girder Summary report

```
1) calculate bending moment
    load condition  Crawler crane diagonal hang(Parallel)
    design object Main girder  number  2 of
        fixed load                                  =   25.592(kN.m)
        load                                        =  287.922(kN.m)
        impact                 287.922 *  0.300     =   86.377(kN.m)
        ----------------------------------------------------------
        total                                       =  399.891(kN.m)

  2)calculate shear force
      load condition  Crawler crane diagonal hang(Parallel)
      design object Main girder  number  2
        fixed load                                  =   17.061(kN)
        load                                        =  201.657(kN)
        impact                 201.657 *  0.300     =   60.497(kN)
        ----------------------------------------------------------
        total                                       =  279.215(kN)

  3)checking stress
      using member     H-400x400x13x21
      web section area                     Aw =     46.540 cm²
      section modulus                      Z  =   3330.000 cm³

      bending stress             Sig. =  M / Z  = 120.087 (N/mm²)
      allowable bending stress   Sig.ba         = 172.200 (N/mm²)
      shear stress               Tau =  S / Aw  =  59.995 (N/mm²)
      allowable shear stress     fs             = 120.000 (N/mm²)

  4)deformation
      Calculate deformation when bending moment is maximum in a load condition
      deformation                     Del.  =    0.8106 (cm)
      allowable deformation           Del.a =    1.5000 (cm)
```

2.7.3 Beam seat Summary report

1)Calculate bending moment

```
    load condition  Truck load(Parallel)
    design section   2  Simple beam part
      fixed load                              =    0.662(kN.m)
      load                                    =    0.000(kN.m)
      impact                   0.000 *  0.300  =    0.000(kN.m)
      ----------------------------------------------------
      tototal                                 =    0.662(kN.m)
```

2)Calculate shear force

```
    load condition  Crawler crane side hang(Parallel)
    design section   2  Simple beam part
      fixed load                              =   35.446(kN)
      load                                    =  226.426(kN)
      impact                 226.426 *  0.300  =   67.928(kN)
      ----------------------------------------------------
      total                                   =  329.800(kN)
```

3)checking stresses

```
    material        H-350x350x12x19
    web section area  Aw =    37.440 cm²
    section modulus    Z  =  2280.000 cm³

    bending stress       Sig. =  M / Z   =   0.290 (N/mm²)
      allowable bending stress Sig.ba   = 205.629 (N/mm²)
    shear stress         Tau =  S / Aw   =  88.088 (N/mm²)
      allowable shear stress       Taua  = 120.000 (N/mm²)
```

4)deflection

```
    Calculate deflection when bending moment by live load is at max..
    deflection                 Del.  =     0.0000 (cm)
    allowable deflection       Del.a =     0.5000 (cm)
```

2.7.4 Support pile Summary report

1)load condition that weight on working platform is max. Crawler crane side hang(Parallel)
(axial force for member design)

2)Support pile number 3

3)calculation of axial force

```
fixed load                               =   57.754 (kN)
load                                     =  226.426 (kN)
impact             226.426 *    0.300    =   67.928 (kN)
--------------------------------------------------------
total                    352.108 *  1/1  =  352.108 (kN)
```

4)calculation of horizontal force

```
fixed load                               =   25.284 (kN)
load                                     =   79.500 (kN)
---------------------------------------------------
total                                       104.784 (kN)
```

5)bending moment by horizontal force

Support pile horizontal force acting on single member = 26.196 (kN)
maximum bending moment = 90.087 (kN.m)

6)Support pile strength check

material used H-350x350x12x19・Weak)

cross sectional area	A =	171.900 cm²
section modulus	Z =	776.000 cm³
radius of gyration of area around y axis	Ry =	15.200 cm
radius of gyration of area around z axis	Rz =	8.890 cm
flange width	B =	35.000 cm
web section area	Aw =	66.500 cm²

Sig.c/Sig.caz + Sig.bcz/{Sig.bao * (1-Sig.c/Sig.eaz)} = 0.765 <= 1.000
Sig.c + Sig.bcz/(1-Sig.c/Sig.eaz) = 149.785 <= 210.000

7) check bearing capacity Support pile

max axial force on Support pile Crawler crane side hang(Parallel)
Nmax = 352.108 <= 426.965 (kN)

2.8 List table

2.8.1 Steel deck List

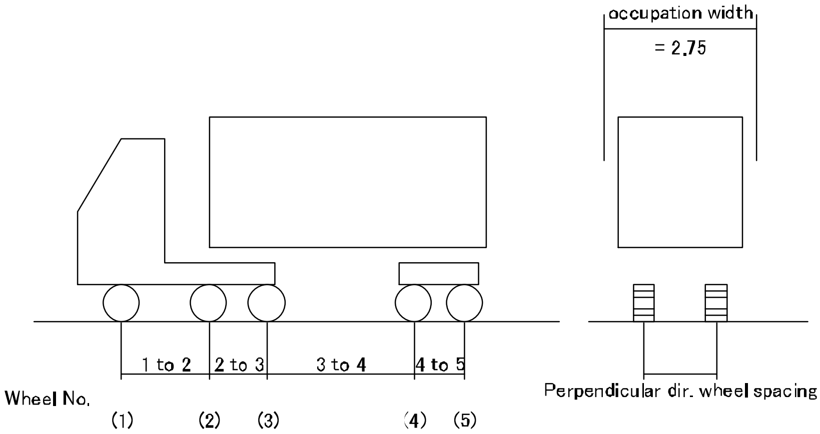
steel deck	name	Steel deck type 2 (1000*2000)
	bending moment max Mmax Sig.	Truck load(Parallel) 58.332 (kN m) 75.426 <= 210.000 (N/mm²)
	shear force max Smax Tau	Truck load(Parallel) 140.000 (kN) 69.630 <= 120.000 (N/mm²)

2.8.2 Member list table

Main girder	use	H-400x400x13x21
	bending moment max Mmax Sig.	Crawler crane diagonal hang(Parallel) 399.891 (kN.m) 120.087 <= 172.200 (N/mm²)
	shear force max Smax Tau	Crawler crane diagonal hang(Parallel) 279.215 (kN) 59.995 <= 120.000 (N/mm²)
	deflection Del.	Crawler crane diagonal hang(Parallel) 0.811 <= 1.500 (cm)
Beam seat (Support pile)	use	H-350x350x12x19
	bending moment max Mmax Sig.	Truck load(Parallel) 0.662 (kN.m) 0.290 <= 205.629 (N/mm²)
	shear force max Smax Tau	Crawler crane side hang(Parallel) 329.800 (kN) 88.088 <= 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.000 <= 0.500 (cm)
Support pile	use	H-350x350x12x19・Weak)
	load(section) load(bearing capacity)	Crawler crane side hang(Parallel) Crawler crane side hang(Parallel)
	force	N = 352.108 (kN) M = 90.087 (kN.m) S = 26.196 (kN) Sig.c = 20.483 Sig.b = 116.091 (N/mm²) Tau = 1.970 <= Taua = 120.000 (N/mm²)
	check buckling	eq-1 ------- 0.765 <= 1.000 eq-2 ------- 149.785 <= 210.000 (N/mm²)
	bearing capacity	352.108 <= 426.965 (kN)
Hori. joint	use	[-150x75x6.5x10
	cmpr stress Sig.c	7.366 <= 123.770 (N/mm²) (N= 17.464kN)
Hori. jointJoint part	required welding length	8.316 (cm)
Vert. brace	use	L-100x100x10
	cmpr stress Sig.c	25.998 <= 64.891 (N/mm²) (T= 49.396kN)
Vert. braceJoint part	required welding length	23.522 (cm)

3 Registered load data export

3.1 Truck load



1	name : TT43		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	30.000	3.250
	2	65.000	7.800
	3	60.000	1.550
	4	60.000	------------------------------------

2	name : T25		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	4.000
	2	100.000	------------------------------------

3	name : T20		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.000
	2	80.000	------------------------------------

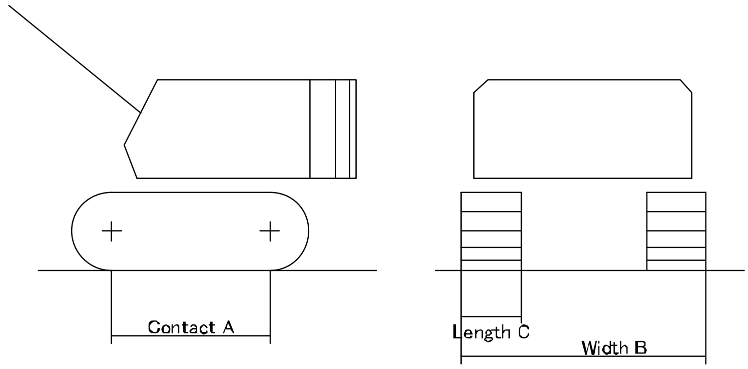
4	name : T14		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	14.000	4.000
	2	56.000	------------------------------------

5	name : Ready mixed concrete Truck(3 cubic meters)		
	wheel distance in perpendicular direction = 1.08 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.200
	2	54.000	------------------------------------

6	name : Ready mixed concrete Truck(5 cubic meters)		
	wheel distance in perpendicular direction = 1.88 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	3.160
	2	55.000	1.880
	3	30.000	------------------------------------

7	name : Surplus soil Truck	
	wheel distance in perpendicular direction = 1.90 (m)	
	load intsty(1 side)(kN)	wheel distance in moving direction(m)
1	34.000	4.000
2	63.000	------------------------------------

3.2 Crawler crane



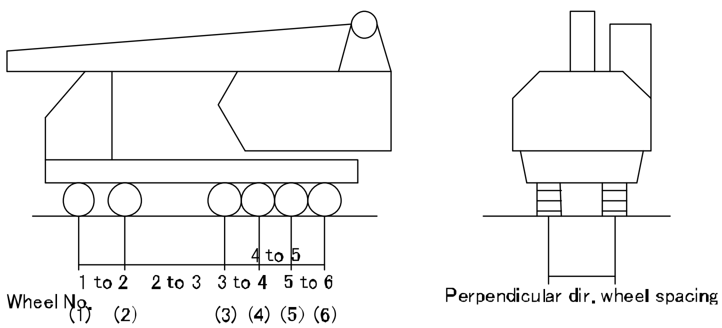
1	name : D408S	
	self weight = 480.000(kN)	90 degree distribution ratio = 0.800
	lifting load = 50.000(kN)	0 degree distribution ratio = 0.600
	contact length A = 4.470(m)	45 degree distribution ratio = 0.700
	width B = 4.000(m)	45 degree contact ratio = 0.900
	contact width C = 0.800(m)	

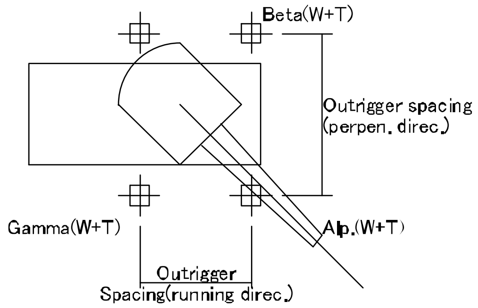
2	name : P&H440S	
	self weight = 400.000(kN)	90 degree distribution ratio = 0.800
	lifting load = 50.000(kN)	0 degree distribution ratio = 0.600
	contact length A = 4.380(m)	45 degree distribution ratio = 0.700
	width B = 3.960(m)	45 degree contact ratio = 0.900
	contact width C = 0.760(m)	

3	name : P&H335AS	
	self weight = 350.000(kN)	90 degree distribution ratio = 0.800
	lifting load = 30.000(kN)	0 degree distribution ratio = 0.600
	contact length A = 4.280(m)	45 degree distribution ratio = 0.700
	width B = 3.790(m)	45 degree contact ratio = 0.900
	contact width C = 0.590(m)	

4	name : P&H325	
	self weight = 280.000(kN)	90 degree distribution ratio = 0.800
	lifting load = 30.000(kN)	0 degree distribution ratio = 0.600
	contact length A = 3.950(m)	45 degree distribution ratio = 0.700
	width B = 3.030(m)	45 degree contact ratio = 0.900
	contact width C = 0.590(m)	

3.3 Truck crane





1	name : NK-300		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1 2 3	32.000 64.000 64.000	3.850 1.350 --
	self weight W= 320.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.750(m) outrigger distance(perpendicular) = 5.600(m) outrigger width = 0.500(m)

2	name : NK-200		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1 2 3	20.000 40.000 40.000	3.980 1.240 --
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.450(m) outrigger distance(perpendicular) = 4.800(m) outrigger width = 0.400(m)

3	name : Rough terrain crane 20tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1 2	20.000 80.000	3.000 --
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 5.700(m) outrigger distance(perpendicular) = 5.700(m) outrigger width = 0.400(m)

4	name : Rough terrain crane 25tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1 2	25.000 100.000	3.500 --
	self weight W= 250.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 6.300(m) outrigger distance(perpendicular) = 6.200(m) outrigger width = 0.400(m)

No.	
5	name : Rough terrain crane 40tons wheel distance in perpendicular direction = 2.10 (m) load intensity (1 side)(kN) / wheel distance in moving direction (m) 1: 35.000 / 4.250 2: 140.000 / --- self weight W= 350.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150 outrigger distance(moving) = 7.300(m) outrigger distance(perpendicular) = 6.500(m) outrigger width = 0.500(m)

4 Registered member data export

4.1 Main girder Registered data

No.	name	unit weight (N/m)	web section area Aw (cm²)	moment of inertia I (cm⁴)	beam height h (cm)	web thickness t1 (cm)	flange section area Af (cm²)	section modulus Z (cm³)	lateral buckling radius i (cm)	compressive flange width b (cm)	compressive flange thickness t2 (cm)
1	H 300x300x10x15	912.0	27.00	20200.0	30.0	1.00	45.00	1350.0	8.23	30.0	1.50
2	H 350x350x12x19	1324.0	37.44	39800.0	35.0	1.20	66.50	2280.0	9.65	35.0	1.90
3	H 400x400x13x21	1687.0	46.54	66600.0	40.0	1.30	84.00	3330.0	11.00	40.0	2.10
4	H 594x302x14x23	1667.0	76.72	134000.0	59.4	1.40	69.46	4500.0	7.96	30.2	2.30
5	H 900x300x16x28	2354.0	135.04	404000.0	90.0	1.60	84.00	8990.0	7.68	30.0	2.80
6	H 912x302x18x34	2775.0	151.92	491000.0	91.2	1.80	102.68	10800.0	7.84	30.2	3.40
7	H 250x250x9x14	718.0	19.98	10700.0	25.0	0.90	35.00	860.0	6.91	25.0	1.40

4.2 Beam seat H-Beam registered data

No.				
1	name : H-300x300x10x15			
	unit weight =	912.0 (N/m)	flange section area Af =	45.00(cm²)
	web section area Aw =	27.00(cm²)	section modulus Z =	1350.0(cm³)
	moment of inertia I =	20200.0(cm⁴)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
2	name : H-350x350x12x19			
	unit weight =	1324.0 (N/m)	flange section area Af =	66.50(cm²)
	web section area Aw =	37.44(cm²)	section modulus Z =	2280.0(cm³)
	moment of inertia I =	39800.0(cm⁴)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
3	name : H-400x400x13x21			
	unit weight =	1687.0 (N/m)	flange section area Af =	84.00(cm²)
	web section area Aw =	46.54(cm²)	section modulus Z =	3330.0(cm³)
	moment of inertia I =	66600.0(cm⁴)	lateral buckling radius i =	11.00(cm)
	beam height h =	40.0(cm)	compressive flange width b =	40.0(cm)
	web thickness t1 =	1.30(cm)	compressive flange thickness t2 =	2.10(cm)
4	name : H-594x302x14x23			
	unit weight =	1667.0 (N/m)	flange section area Af =	69.46(cm²)
	web section area Aw =	76.72(cm²)	section modulus Z =	4500.0(cm³)
	moment of inertia I =	134000.0(cm⁴)	lateral buckling radius i =	7.96(cm)
	beam height h =	59.4(cm)	compressive flange width b =	30.2(cm)
	web thickness t1 =	1.40(cm)	compressive flange thickness t2 =	2.30(cm)
5	name : H-900x300x16x28			
	unit weight =	2354.0 (N/m)	flange section area Af =	84.00(cm²)
	web section area Aw =	135.04(cm²)	section modulus Z =	8990.0(cm³)
	moment of inertia I =	404000.0(cm⁴)	lateral buckling radius i =	7.68(cm)
	beam height h =	90.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.60(cm)	compressive flange thickness t2 =	2.80(cm)
6	name : H-912x302x18x34			
	unit weight =	2775.0 (N/m)	flange section area Af =	102.68(cm²)
	web section area Aw =	151.92(cm²)	section modulus Z =	10800.0(cm³)
	moment of inertia I =	491000.0(cm⁴)	lateral buckling radius i =	7.84(cm)
	beam height h =	91.2(cm)	compressive flange width b =	30.2(cm)
	web thickness t1 =	1.80(cm)	compressive flange thickness t2 =	3.40(cm)
7	name : H-250x250x9x14			
	unit weight =	704.0 (N/m)	flange section area Af =	35.00(cm²)
	web section area Aw =	19.98(cm²)	section modulus Z =	860.0(cm³)
	moment of inertia I =	10700.0(cm⁴)	lateral buckling radius i =	6.91(cm)
	beam height h =	25.0(cm)	compressive flange width b =	25.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.40(cm)

4.3 Beam seat one side U steel

No.				
1	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area Af =	44.07(cm²)
	web section area Aw =	20.16(cm²)	section modulus Z =	335.0(cm³)
	moment of inertia I =	4180.0(cm⁴)	area gyration radius i =	2.58(cm)
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)
2	name : [-300x90x9x13			
	unit weight =	374.0(N/m)	section area Af =	48.57(cm²)
	web section area Aw =	24.66(cm²)	section modulus Z =	429.0(cm³)
	moment of inertia I =	6440.0(cm⁴)	area gyration radius i =	2.52(cm)
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

No.	name : [-300x90x10x15.5					
3	unit weight	=	430.0(N/m)	section area	Af =	55.74(cm²)
	web section area	Aw =	26.90(cm²)	section modulus	Z =	494.0(cm³)
	moment of inertia	I =	7410.0(cm⁴)	area gyration radius	i =	2.54(cm)
	web height	h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.55(cm)

No.	name : [-380x100x10.5x16					
4	unit weight	=	534.0(N/m)	section area	Af =	69.39(cm²)
	web section area	Aw =	36.54(cm²)	section modulus	Z =	763.0(cm³)
	moment of inertia	I =	14500.0(cm⁴)	area gyration radius	i =	2.78(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.05(cm)	compressive flange thickness	t2 =	1.60(cm)

No.	name : [-380x100x13x20					
5	unit weight	=	660.0(N/m)	section area	Af =	85.71(cm²)
	web section area	Aw =	44.20(cm²)	section modulus	Z =	926.0(cm³)
	moment of inertia	I =	17600.0(cm⁴)	area gyration radius	i =	2.76(cm)
	web height	h =	38.0(cm)	compressive flange width	b =	10.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.00(cm)

4.4 Beam seat L section steel Registered data

No.	name : L-65x65x6					
1	unit weight	=	58.0(N/m)	section area	A =	7.527(cm²)
	area gyration radius	iy =	1.98(cm)			
	angle edge width	B =	6.5(cm)	thickness	t =	0.60(cm)

No.	name : L-75x75x6					
2	unit weight	=	67.2(N/m)	section area	A =	8.727(cm²)
	area gyration radius	iy =	2.30(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.60(cm)

No.	name : L-75x75x9					
3	unit weight	=	97.7(N/m)	section area	A =	12.690(cm²)
	area gyration radius	iy =	2.25(cm)			
	angle edge width	B =	7.5(cm)	thickness	t =	0.90(cm)

No.	name : L-90x90x10					
4	unit weight	=	130.4(N/m)	section area	A =	17.000(cm²)
	area gyration radius	iy =	2.71(cm)			
	angle edge width	B =	9.0(cm)	thickness	t =	1.00(cm)

No.	name : L-100x100x10					
5	unit weight	=	146.1(N/m)	section area	A =	19.000(cm²)
	area gyration radius	iy =	3.04(cm)			
	angle edge width	B =	10.0(cm)	thickness	t =	1.00(cm)

4.5 Support pile Registered data

No.	name : H-300x300x10x15(Weak)					
1	unit weight	=	912.0 (N/m)	section area	A =	118.40(cm²)
	flange section area	Af =	45.00(cm²)	web section area	Aw =	27.00(cm²)
	action direction	=	weak	area gyration radius	iy =	13.10(cm)
	area gyration radius	iz =	7.55(cm)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
	section modulus	Z =	450.0(cm³)	moment of inertia	I =	6750.0(cm⁴)
	pile tip area	=	900.0(cm²)	pile circumference	=	120.0(cm)
	pile diameter	=	30.0(cm)	pile unit weight	=	912.0(N/m)

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2	name : H-300x300x10x15(Strong)			
	unit weight =	912.0 (N/m)	section area A =	118.40(cm^2)
	flange section area Af =	45.00(cm^2)	web section area Aw =	27.00(cm^2)
	action direction =	strong	area gyration radius iy =	13.10(cm)
	area gyration radius iz =	7.55(cm)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)
	section modulus Z =	1350.0(cm^3)	moment of inertia I =	20200.0(cm^4)
	pile tip area =	900.0(cm^2)	pile circumference =	120.0(cm)
	pile diameter =	30.0(cm)	pile unit weight =	912.0(N/m)

3	name : H-350x350x12x19(Weak)			
	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	weak	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	776.0(cm^3)	moment of inertia I =	13600.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

4	name : H-350x350x12x19(Strong)			
	unit weight =	1324.0 (N/m)	section area A =	171.90(cm^2)
	flange section area Af =	66.50(cm^2)	web section area Aw =	37.44(cm^2)
	action direction =	strong	area gyration radius iy =	15.20(cm)
	area gyration radius iz =	8.89(cm)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)
	section modulus Z =	2280.0(cm^3)	moment of inertia I =	39800.0(cm^4)
	pile tip area =	1225.0(cm^2)	pile circumference =	140.0(cm)
	pile diameter =	35.0(cm)	pile unit weight =	1323.9(N/m)

4.6 Hori. joint Registered data

1	name : [-150x75x6.5x10			
	unit weight =	182.0(N/m)	section area A =	23.71(cm^2)
	area gyration radius iy =	2.27(cm)		
	web height h =	15.0(cm)	compressive flange width b =	7.5(cm)
	web thickness t1 =	0.65(cm)	compressive flange thickness t2 =	1.00(cm)

2	name : [-200x90x8x13.5			
	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

3	name : [-250x90x9x13			
	unit weight =	339.0(N/m)	section area A =	44.07(cm^2)
	area gyration radius iy =	2.64(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

4.7 Vert. brace Registered data

1	name : L-65x65x6			
	unit weight =	58.00(N/m)	section area A =	7.527(cm^2)
	area gyration radius iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

2	name : L-75x75x6			
	unit weight =	67.20(N/m)	section area A =	8.727(cm^2)
	area gyration radius iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

3	name : L-75x75x9			
	unit weight =	97.70(N/m)	section area A =	12.690(cm^2)
	area gyration radius iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

No.				
	name : L-90x90x10			
4	unit weight =	130.40(N/m)	section area A =	17.000(cm^2)
	area gyration radius iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

No.				
	name : L-100x100x10			
5	unit weight =	146.10(N/m)	section area A =	19.000(cm^2)
	area gyration radius iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.8 Hori. brace Registered data

No.				
	name : L-65x65x6			
1	unit weight =	58.00(N/m)	section area A =	7.527(cm^2)
	moment of inertia iy =	1.98(cm)	min area gyration radius iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness t =	0.60(cm)

No.				
	name : L-75x75x6			
2	unit weight =	67.20(N/m)	section area A =	8.727(cm^2)
	moment of inertia iy =	2.30(cm)	min area gyration radius iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.60(cm)

No.				
	name : L-75x75x9			
3	unit weight =	97.70(N/m)	section area A =	12.690(cm^2)
	moment of inertia iy =	2.25(cm)	min area gyration radius iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness t =	0.90(cm)

No.				
	name : L-90x90x10			
4	unit weight =	130.40(N/m)	section area A =	17.000(cm^2)
	moment of inertia iy =	2.71(cm)	min area gyration radius iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness t =	1.00(cm)

No.				
	name : L-100x100x10			
5	unit weight =	146.10(N/m)	section area A =	19.000(cm^2)
	moment of inertia iy =	3.04(cm)	min area gyration radius iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness t =	1.00(cm)

4.9 Lateral joint member 1 side U steel Registered data

No.				
	name : [-200x90x8x13.5			
1	unit weight =	297.0(N/m)	section area A =	38.65(cm^2)
	area gyration radius iy =	2.68(cm)		
	web height h =	20.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness t2 =	1.35(cm)

No.				
	name : [-250x90x9x13			
2	unit weight =	339.0(N/m)	section area A =	44.07(cm^2)
	area gyration radius iy =	2.58(cm)		
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

No.				
	name : [-300x90x9x13			
3	unit weight =	374.0(N/m)	section area A =	48.57(cm^2)
	area gyration radius iy =	2.52(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

No.				
	name : [-300x90x10x15.5			
4	unit weight =	430.0(N/m)	section area A =	55.74(cm^2)
	area gyration radius iy =	2.54(cm)		
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.55(cm)

4.10 Lateral joint member L section steel Registered data

1	name : L-65x65x6		
	unit weight = 58.0(N/m)	section area A = 7.527(cm²)	
	area gyration radius iy = 1.98(cm)		
	angle edge width B = 6.5(cm)	thickness t = 0.60(cm)	

2	name : L-75x75x6		
	unit weight = 67.2(N/m)	section area A = 8.727(cm²)	
	area gyration radius iy = 2.30(cm)		
	angle edge width B = 7.5(cm)	thickness t = 0.60(cm)	

3	name : L-75x75x9		
	unit weight = 97.7(N/m)	section area A = 12.690(cm²)	
	area gyration radius iy = 2.25(cm)		
	angle edge width B = 7.5(cm)	thickness t = 0.90(cm)	

4	name : L-90x90x10		
	unit weight = 130.4(N/m)	section area A = 17.000(cm²)	
	area gyration radius iy = 2.71(cm)		
	angle edge width B = 9.0(cm)	thickness t = 1.00(cm)	

5	name : L-100x100x10		
	unit weight = 146.1(N/m)	section area A = 19.000(cm²)	
	area gyration radius iy = 3.04(cm)		
	angle edge width B = 10.0(cm)	thickness t = 1.00(cm)	

4.11 Retaining wall Steel sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	II	400	100	48.0	153.00	8740	874
2	III	400	125	60.0	191.00	16800	1340
3	III	400	130	60.0	191.00	17400	1340
4	IV	400	170	76.1	242.50	38600	2270
5	VL	500	200	105.0	267.60	63000	3150
6	IIw	600	130	61.8	131.20	13000	1000
7	IIIw	600	180	81.6	173.20	32400	1800
8	IVw	600	210	106.0	225.50	56700	2700

4.12 Retaining wall soldier lateral sheet pile Registered data

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
1	H-100x100x 6x 8	100	100	6.0	8	21.59	16.9	378	76
2	H-125x125x 6x 9	125	125	6.5	9	30.00	23.6	839	134
3	H-150x150x 7x10	150	150	7.0	10	39.65	31.1	1620	216
4	H-175x175x 7x11	175	175	7.5	11	51.42	40.4	2900	331
5	H-200x200x 8x12	200	200	8.0	12	63.53	49.9	4720	472
6	H-250x250x 9x14	250	250	9.0	14	91.43	71.8	10700	860
7	H-300x300x10x15	300	300	10.0	15	118.40	93.0	20200	1350
8	H-350x350x12x19	350	350	12.0	19	171.90	135.0	39800	2280
9	H-400x400x13x21	400	400	13.0	21	218.70	172.0	66600	3330
10	H-400x400x18x28	414	405	18.0	28	295.40	232.0	92800	4480
11	H-400x400x20x35	428	407	20.0	35	360.70	283.0	119000	5570
12	H-400x400x30x50	458	417	30.0	50	528.60	415.0	187000	8170
13	H-400x400x45x70	498	432	45.0	70	770.10	605.0	298000	12000

4.13 Retaining wall Lightweight sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	TypeA	250	36	14.8	75.40	107	60
2	TypeB	333	51	17.9	68.28	510	144
3	TypeC	333	85	19.3	73.80	2000	272
4	TypeD	333	74	21.6	82.53	636	171
5	TypeE	500	160	33.6	85.70	3620	452

Cover

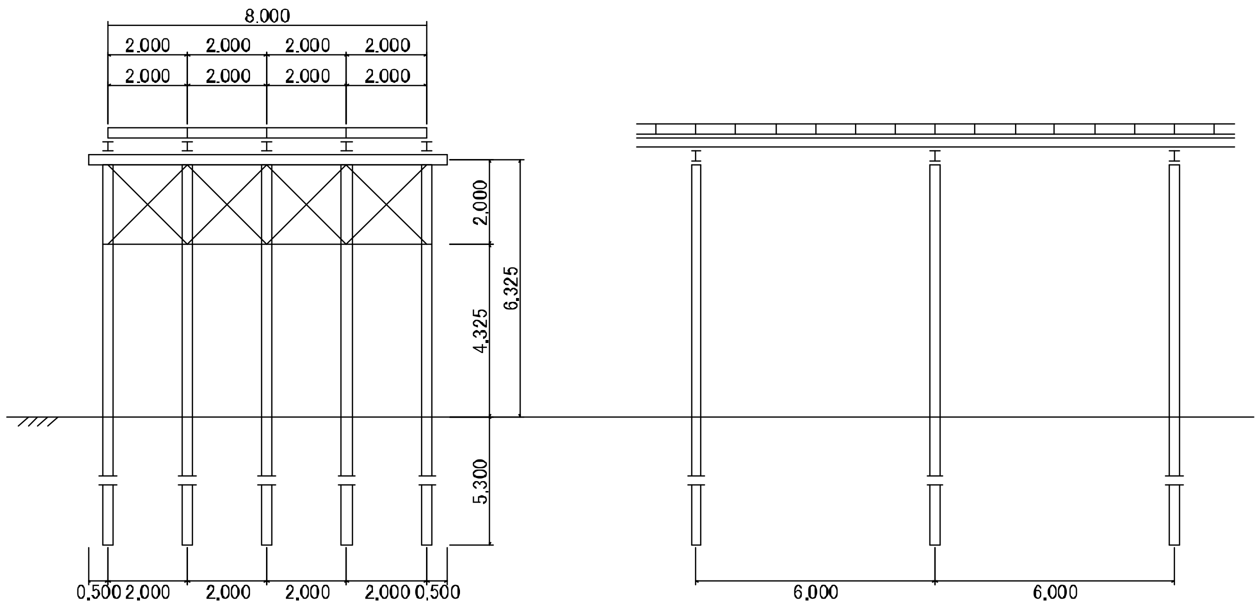
Contents

1 Input data export

1.1 Title

file : Badraman20E1.F8K
title: Dairout Badraman2

1.2 Shape data



FORUM8

1.3 Design condition

basic condition

Applied standard	C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
type of working platform	Type i(widthMain girder orthogonal)
adjacent span	Yes
Support pile Foundation type	Support pile

steel deck, coefficient

type of steel deck		Steel deck type 2(Old Metro-deck)
At Steel deck designMain girder treatment		Consider
impact coefficient steel deck		0.400
other than steel deck		0.300
Horizontal coefficient	fixed load	0.200
load	truck	= 0.100
	heavy equipment	= 0.150

Use horizontal coefficient when truck crane is moving.

impact when horizontal load is calculated	not include impact
impact when deflection is calculated	not include impact

1.4 Member design condition

Beam seatSteel specification	H Beam
Beam seatCheck share stress	Checking
Beam seat, Support piledesign guideline	Main girder load distribution is considered.
allowable deflection	length of a span/ 400.000
maximum deflection	2.500 (cm)
dead load when deflection is calculated	Not consider
Eq of deflection for single live load	Calculation equation for 1 member
Support piledesign	Examine
Support pileDesign time axial force	maximum axial force / 1
Support pileself weight treatment	Total length
other vertical load	0.000 (kN/ a member)
Support pileHorizontal force load status	Use vertical load when horizontal force is max.
Hori. jointhorizontal force	1 memberHori. jointshare(by before member)
Hori. joint	both sides install
Beam seatunderneathHori. jointinstall:	Not do
Hori. jointJoint part	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)
Hori. joint,brace horizontal force calculation method	Use vertical load when horizontal force is max.
brace member	Design as compressive member
brace connection	welding
foot length	0.300 (cm)
allowable shear stress of fillet welding	100.000 (N/mm²)

1.5 Design condition

live load

increment of live load movement of live load when member section is calculated for live load Del.L 0.010 (m)

crawler crane load　Linear load

Support piledesign

Incase of Penetration length is not satisfied with Beta L >= 2.50 :design as limited length pile

increase rate	pile top free bending moment	1.00
	displacement	1.25
	pile top fixed bending moment	1.10
	displacement	1.20

1.6 Live load for steel deck design

	Main girder orthogonal to		Main girder parallel to	
	1000* 2000	1000* 3000	1000* 2000	1000* 3000
truck load	NG	NG	OK	NG
crawler crane moving	NG	NG	OK	NG
crawler crane 0 degree	NG	NG	NG	NG
crawler crane 90 degree	NG	NG	NG	NG
crawler crane 45 degree	NG	NG	NG	NG
truck crane moving	NG	NG	OK	NG
truck crane working	NG	NG	NG	NG
reinforcing beam	NG		NG	

OK : design NG : not design

1.7 Live loads for member design

	Main girder orthogonal to	Main girder parallel to
truck load	NG	OK
crawler crane moving	NG	OK
crawler crane 0 degree	NG	NG
crawler crane 90 degree	NG	NG
crawler crane 45 degree	NG	NG
truck crane moving	NG	OK
truck crane working	NG	NG

OK : design NG : not design

1.8 working platform data

Span* adjacent span data

item	symbol	unit	value
main span length	--	m	6.000
adjacent span length	--	m	6.000

Main girder spacing data

No. N	Main girder spacing(m)
1	2.000
2	2.000
3	2.000
4	2.000

steel deck layout data

No. F	steel deck size (m)
1	2
2	2
3	2
4	2

Support pile spacing

No. S	Support pile spacing(m)
1	2.000
2	2.000
3	2.000
4	2.000

width, overhang

item	symbol	unit	value
road width	--	m	8.000
gap	--	m	0.000
left overhang length	LL	m	0.500
right overhang length	LR	m	0.500

1.9 frame data

with or without Hori. brace [none]
with or without Vert. brace [Yes]
elevation

No. h	frame spacing (m)
1	2.000
2	4.325

item	symbol	unit	value
Support pilepenetration length	hL	m	5.300
ground level G.L.	--	m	43.000

1.10 Support piledesign condition

Sand layer with N-value more than 30 or delluvial clay with more than 10
embedded more than 3min the bearing layer Not allow
Pile construction method (not embedded by written above) Striking construction method
Directly input Alp.* Beta No
Pile moment using vertical brace
Calculation method Chang equation
Specify upper limit of N-value in pile tip ground Based on the design strength
Direct input N-value at pile tip ground No
embedment length 5.30 (m)
Young's modulus of pile * 10^5 2.00 (N/mm²)
Modulus of subgrade lateral reaction 0.00 (kN/m³)
Assume sound layer when pile tip bearing capacity is calculated
Lower limit of N-value 20.000
Factor of Safey when allowable bearing capacity is calculated 2.0

1.11 Strata data

No.	layer type	layer thickness	average N-value	coh soil unc cmpr strg(kN/m²)	Alp.* Eo (kN/m²)	cohesion (kN/m²)
1	Cohesive soil	3.000	6.000	250.000	16800.00	125.000
2	Cohesive soil	8.000	14.000	250.000	39200.00	125.000
3	Sandy soil	7.000	24.000	250.000	67200.00	125.000
4	Sandy soil	2.000	35.000	250.000	98000.00	125.000
5	Sandy soil	3.000	39.000	250.000	109200.00	125.000

1.12 steel deck load distribution ratio specification

* truck load distribution ratio

	Main girder orthogonal to	Main girder parallel to
truck	0.40	0.40

* Crawler crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
0 degree	0.25	0.20
45 degree	0.25	0.20
60 degree	0.25	0.20

Note)use the value of front hang when moving.

* Truck crane load distribution ratio

	Main girder orthogonal to	Main girder parallel to
moving	0.40	0.40
working	0.40	0.40

1.13 Steel deck material data

height of steel deck 200(mm)

* in case of 1000*2000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm^2)
3) Z 312.0 (cm^3)

* in case of 1000*3000

1) name of steel deck Steel deck type 2
2) Aw 8.10 (cm^2)
3) Z 312.0 (cm^3)

Note: Web section area, section modulus are input data per one H steel.

1.14 Reinforcement girder material data

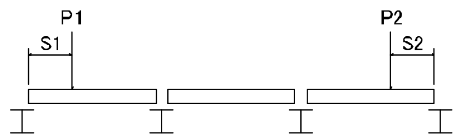
1) name of using material
2) Aw 54.00 (cm^2)
3) Z 2720.0 (cm^3)
4) self-weight 1880.0 (N/m)
5) span length 2.0 (m)
6) comment (description)

1.15 Beam seat Joint part bolt data

Support pile part

bolt is not designed.

1.16 Bridge face(dead) load



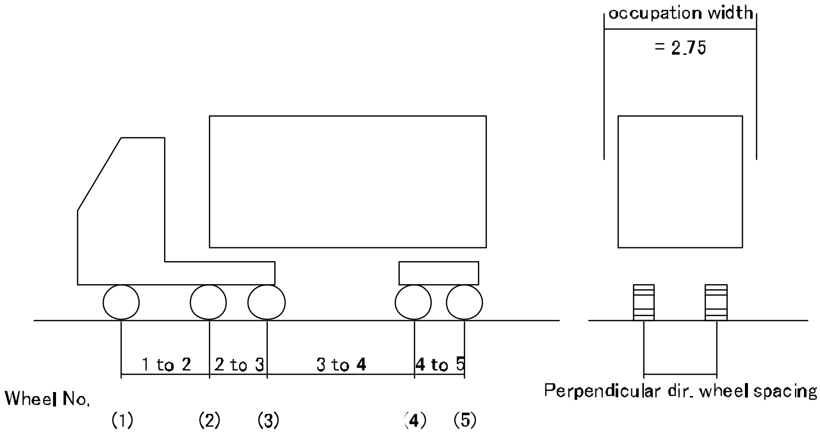
1) left loading position 0.000 (m)
2) right loading position 0.000 (m)
3) left load intensity 0.000 (kN/m)
4) right load intensity 0.000 (kN/m)

1.17 Steel deck/Nominal load

1) steel deck self-weight	1000 * 2000	2.000 (kN/m^2)
	1000 * 3000	2.000 (kN/m^2)
other		2.000 (kN/m^2)
2) nominal load		0.000 (kN/m^2)
3) attachment unit		0.100

1.18 Select truck load

* bridge axis direction



1) load selection　　Input load
2) registration name　　T20
3) axis spacing in perpendicular direction　　1.75 (m)
4) number of wheels　　2
5) axis spacing in moving direction (m)

1 - 2	4.000

6) load intensity (one side) (kN)

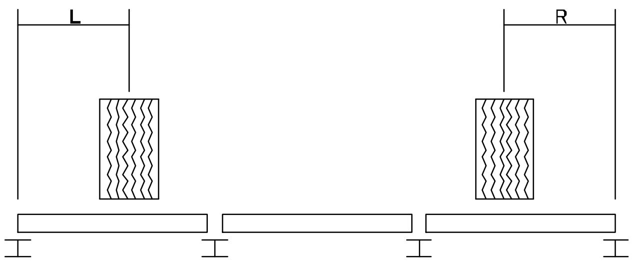
1	20.000
2	80.000

* perpendicular to bridge axis direction
1) load selection　Input load
2) load type
P1　T20
P2　T20
P3　T20

1.19 Truck load condition setting

* bridge axis direction
1) train load is considered　　No
2) Number in perpendicular direction　　2

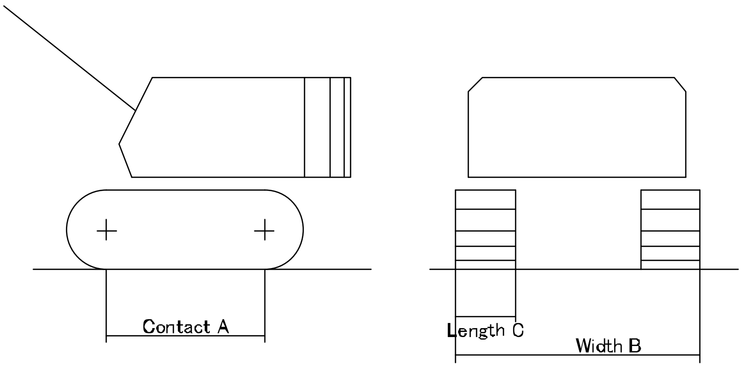
1.20 Width of truck load setting



1) load on one side　　Consider
2) non-width of load (left)　　0.000 (m)
3) non-width of load (right)　　0.000 (m)

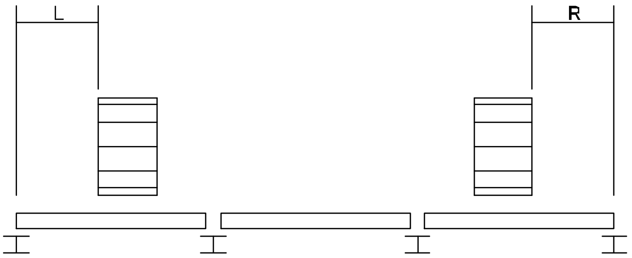
1.21 Crawler crane load selection

1)registration name P&H440S



2)self-weight 400.000 (kN)
3)hoisting self-weight 50.000 (kN)
4)contact A 4.380 (m)
5)width B 3.960 (m)
6)contact width C 0.760 (m)
7)apportionment on lateral operation side 0.800
8)contact when hoisting forward 0.600
9)apportionment on operation side in orthogonal direction 0.700
10)contact on operation side in orthogonal direction 0.900

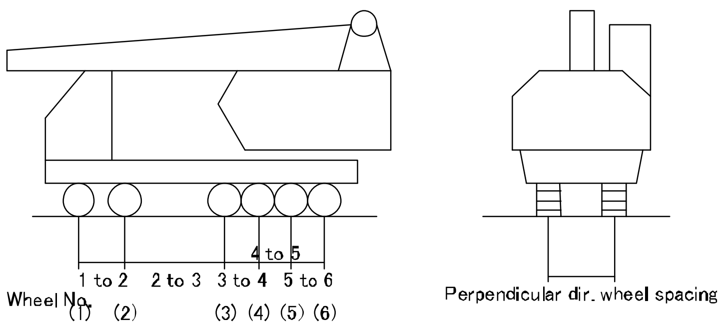
1.22 Width of Crawler crane non-load setting



1)load on one side Not consider
2)non-width of load (left) 1.500 (m)
3)non-width of load (right) 1.500 (m)
4)location of heavy equipment in bridge axis direction not specify

1.23 Truck crane load selection

* at moving



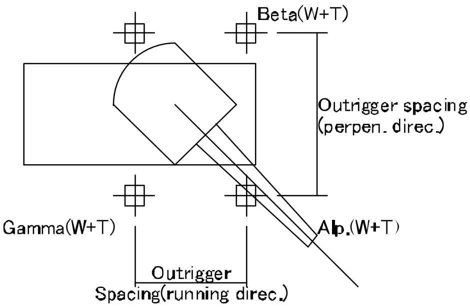
1)registration name Rough terrain crane 25tons
2)wheel spacing in perpendicular direction 2.10 (m)
3)number of wheels 2
4)wheel spacing in moving direction (m)

1 - 2	3.500

5) load intensity(one side) (kN)

1	25.000
2	100.000

* at operating



1) self-weight W 250.000 (kN)
2) hoisting self-weight T 30.000 (kN)
3) outrigger spacing (moving) 6.300 (m)
4) outrigger spacing (perpendicular) 6.200 (m)
5) load distribution ratio Alp. 0.700
6) load distribution ratio Beta 0.150
7) load distribution ratio Gam 0.150
8) outrigger width 0.400 (m)

1.24 Width of Truck crane non-load setting

truck crane load is not considered.

1.25 Dead load arbitrary position

Dead load at any location is not input.

1.26 Specify allowable stress

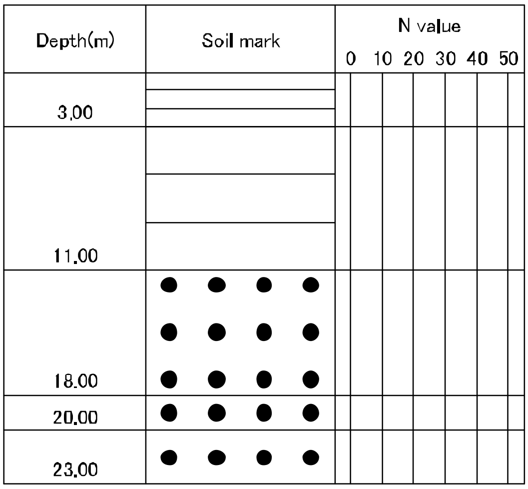
steel type name SS400
load factor of allowable stress 1.50
allowable stress

	direct input of allowable stress			
	bend cmpr (N/mm²)	ax cmpr (N/mm²)	ax tns (N/mm²)	shear (N/mm²)
steel deck	Auto calc	----	----	Auto calc
Main girder	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)H-Beam	Auto calc	----	----	Auto calc
Beam seat(Support pilepart)U shape steel	210.00	----	----	Auto calc
Support pile	Auto calc	Auto calc	----	Auto calc
Hori. joint	----	Auto calc	----	----
brace	----	Auto calc	Auto calc	----

allowable stress automatic calculation(calculate from fixed number in the middle of a member)

	fixed number of middle		member length	
	distance flange fixed	effective buckling length	distance fixed (cm)	effective buckling length(cm)
steel deck	----	----	----	----
Main girder	0	----	0.00	----
Beam seat(Support pilepart)H-Beam	0	----	0.00	----
Beam seat(Support pilepart)U shape steel	0	----	0.00	----
Support pile	0	0	0.00	0.00
Hori. joint	----	0	----	0.00
brace	----	----	----	----

1.27 Borehole log of strata



1.28 Initial input

1)applied standard — C.E(Road and bridge, Metro. expressway, Temp. Str. Const. Guid.)
2)abutment type — Type i
3)adjacent span — Yes
4)Support pile Foundation type — bearing pile embedment length 5.300(m)
5)shape data
* width — 8.000(m)
* left overhang — 0.500(m)
* right overhang — 0.500(m)
* span — 6.000(m)
* working platform height — 6.325(m)
* steel deck size — 2.000(m)
* Support pileBasic spacing — 2.000(m)
* frame basic spacing — 3.000(m)
6)Design Support pile
* Foundation data
  1.pile construction method — driven casting
* Soil data

No.	type	thickness (m)	ave N value	coh soil cmpr strg (kN/m²)	Alp.* Eo (kN/m²)	cohension (kN/m²)
1	Cohesive soil	3.000	6.000	250.000	16800.00	125.000
2	Cohesive soil	8.000	14.000	250.000	39200.00	125.000
3	Sandy soil	7.000	24.000	250.000	67200.00	125.000
4	Sandy soil	2.000	35.000	250.000	98000.00	125.000
5	Sandy soil	3.000	39.000	250.000	109200.00	125.000

2 Calculation result export

2.1 Steel deck type 2 design (Old Metro-deck)

2.1.1 Sum up bending stress for each load

load status			Bending stress 1000 * 2000(2.0m) (N/mm²)
truck load		parallel	75.426
		orthogonal	----------
crawler crane	moving	parallel	17.237
		orthogonal	----------
	working 0 degree	parallel	----------
		orthogonal	----------
	working 90 degree	parallel	----------
		orthogonal	----------
	working 45 degree	parallel	----------
		orthogonal	----------
truck crane	moving	parallel	79.167
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			210.000

2.1.2 bending stress calculation

calculate stresses when the load condition induces bending stress maximum

1)load condition Truck crane when moving(Parallel)

2)steel deck Steel deck type 2 (1000*2000)

3)bending moment by fixed load (per a steel deck)

$$Md = w * l^2 / 8 = 1.000 \text{ (kN.m)}$$

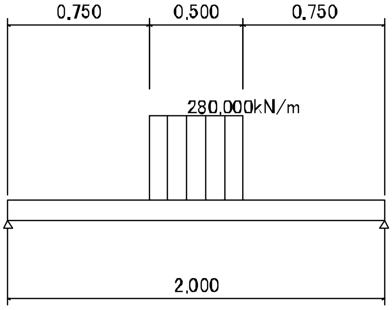
where

w : fixed load intensity applied on a steel deck

(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)

l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4) Truck crane when moving(Parallel) of bending moment



Mmax = 61.250 (kN m)

where
w : load intensity
w_1 = 280.000 (kN/m)

5) in case of Truck crane when moving(Parallel), bending moment per single steel sheet
steel deck type2 1000 * 2000
Sig.M = Mmax * 0.400 + Ml * 20/100 = 24.700 (kN m)

6) stresses in a steel deck
Sig. = Sig.M / Z = 79.167 (N/mm²)
where
Z: section modulus = 312.000 (cm³)

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2.1.3 Sum up shear stress for each load

load status			shear stress 1000 * 2000(2.0m) (N/mm²)
truck load		parallel	69.630
		orthogonal	----------
crawler crane	moving	parallel	13.279
		orthogonal	----------
	working 0 degree	parallel	----------
		orthogonal	----------
	working 90 degree	parallel	----------
		orthogonal	----------
	working 45 degree	parallel	----------
		orthogonal	----------
truck crane	moving	parallel	60.988
		orthogonal	----------
	working	parallel	----------
		orthogonal	----------
allowable			120.000

2.1.4 Shear stress calculation

calculate stresses when the load condition induces Shear stress maximum

1) load condition Truck load(Parallel)

2) steel deck Steel deck type 2 (1000*2000)

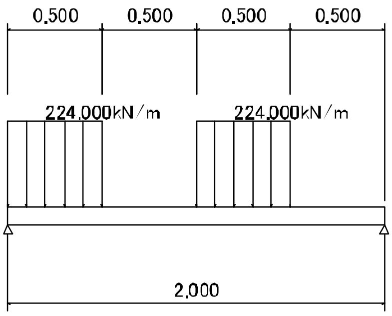
3) Shear force by fixed load (per a steel deck)

$$Sd = w * l / 2 = 2.000 \ (kN)$$

where

w : fixed load intensity applied on a steel deck
(self-weight of a steel deck + nominal load)* (width of a steel deck)= 2.000 (kN/m)
l : length of a steel deck (covering plate girder beam spacing) = 2.000 (m)

4) Truck load(Parallel) of Shear force



$$Smax = 140.000 \ (kN)$$

where

w : load intensity
w_1 = 224.000 (kN/m)
w_2 = 224.000 (kN/m)

FORUM8

5) in case of Truck load(Parallel), Shear force per single steel sheet

steel deck type2 1000 * 2000

Sig.S = Smax * 0.400 + Sd * 20/100 = 56.400 (kN)

6) stresses in a steel deck

Tau = Sig.S / A = 69.630 (N/mm²)

where

A: cross sectional area = 8.100 (cm²)

2.2 Main girder Design

2.2.1 bending moment sum up for each load

load status		Main girder No.	bending moment (kN.m)
truck load	orthogonal	--------	------------
	parallel	G 2	277.458
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	271.608
	0 degree-orthogonal	--------	------------
	0 degree-parallel	--------	------------
	90 degree-orthogonal	--------	------------
	90 degree-parallel	--------	------------
	45 degree-orthogonal	--------	------------
	45 degree-parallel	--------	------------
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	218.958
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.2 bending moment calculation

Calculate load condition when bending moment is maximum

1) load condition Truck load(Parallel)

2) design Main girder number 2

3) stresses by fixed load

Equations to calculate stresses by fixed load 2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

steel deck self-weight* nominal load 2.000 * 2.000 / 2.000 = 2.000

Main girder Self weight = 1.324

----

total wd = 5.324 (kN/m)

using Main girder H-350x350x12x19

* stresses by fixed load

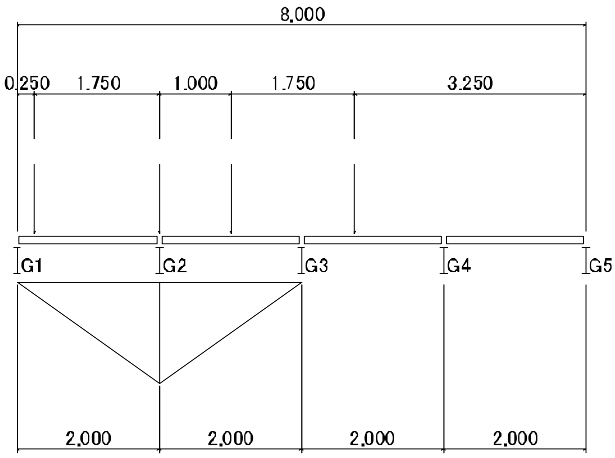
bending moment

$M_d = wd * l^2 / 8 + M_b = 5.324 * 6.000^2 / 8 + 0.000 = 23.958$ (kN.m)

FORUM8

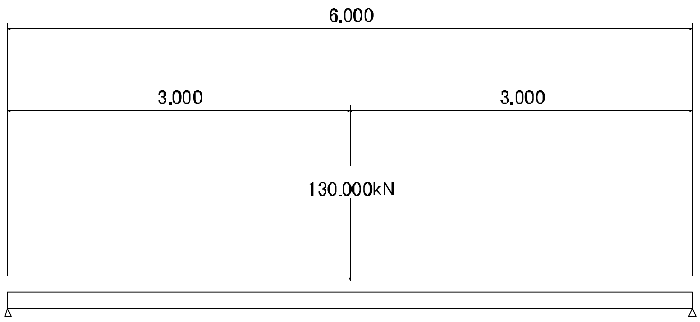
Calculate stresses by truck load 2 th Main girder

* truck load intensity



sum of influence value = 1.6250
number of wheel axis in moving direction = 2
live load intensity P 1 = 20.000 * 1.6250 = 32.500 (kN)
P 2 = 80.000 * 1.6250 = 130.000 (kN)

* by truck load bending moment



by truck load bending moment
Mmax = 195.000 (kN m)
where
l max : Mmax location = 3.000 (m)

* truck loading time bending moment

fixed load		=	23.958(kN m)
truck load		=	195.000(kN m)
impact	195.000 * 0.300	=	58.500(kN m)
total	M	=	277.458(kN m)

FORUM8

2.2.3 Shear force sum up for each load

load status		Main girder No.	Shear force (kN)
truck load	orthogonal	--------	------------
	parallel	G 2	199.055
crawler crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	181.072
	0 degree-orthogonal	--------	------------
	0 degree-parallel	--------	------------
	90 degree-orthogonal	--------	------------
	90 degree-parallel	--------	------------
	45 degree-orthogonal	--------	------------
	45 degree-parallel	--------	------------
truck crane	moving-orthogonal	--------	------------
	moving-parallel	G 2	159.514
	working-orthogonal	--------	------------
	working-parallel	--------	------------

2.2.4 Shear force calculation

Calculate load condition when Shear force is maximum

1) load condition   Truck load(Parallel)

2) design Main girder number   2

3) stresses by fixed load

Equations to calculate stresses by fixed load   2 of Main girder

* fixed load intensity

steel deck self-weight* nominal load   2.000 *   2.000 /   2.000 =   2.000

steel deck self-weight* nominal load   2.000 *   2.000 /   2.000 =   2.000

Main girder Self weight   =   1.324

----

total   wd = 5.324 (kN/m)

using Main girder   H-350x350x12x19

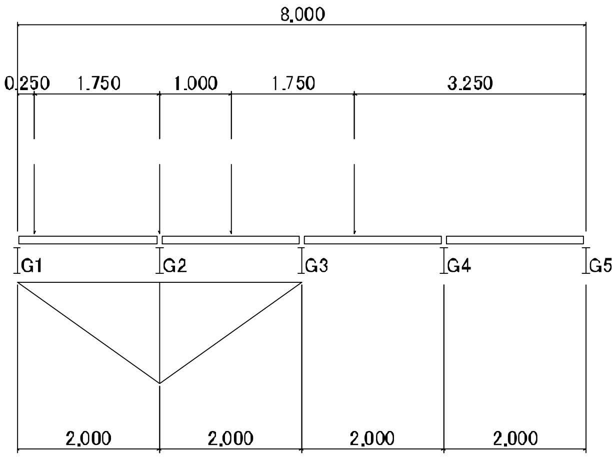
* stresses by fixed load

Shear force

Sd = wd * l / 2 + So = 5.324 * 6.000 / 2 + 0.000 = 15.972(kN)

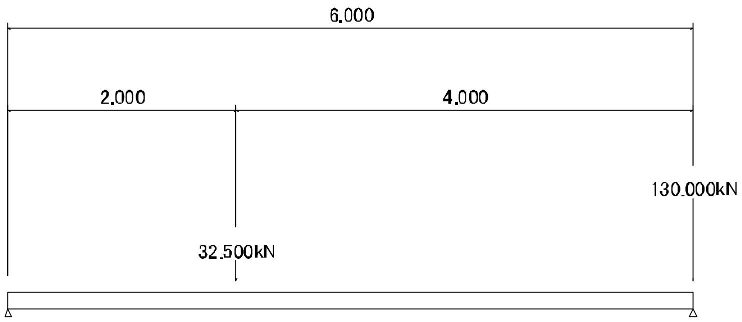
Calculate stresses by truck load 2 th Main girder

* truck load intensity



sum of influence value = 1.6250
number of wheel axis in moving direction = 2
live load intensity P 1 = 20.000 * 1.6250 = 32.500 (kN)
P 2 = 80.000 * 1.6250 = 130.000 (kN)

* by truck load Shear force



by truck load Shear force
Smax = 140.833 (kN)

* truck loading time Shear force

fixed load		=	15.972(kN)
truck load		=	140.833(kN)
impact	140.833 * 0.300	=	42.250(kN)
total	S	=	199.055(kN)

FORUM8

2.2.5 Allowable stress calculation

steel material for structure SS400
using member H-350x350x12x19
allowable bending stress
Sig.ba = 164.486 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 600.000 (cm)
b : cross sectional area of compressive flange = 35.000 (cm)
l/b : = 17.143
allowable shear stress
Taua = 120.000

2.2.6 Main girder stress calculation

using member H-350x350x12x19
bending stress
Sig. = M / Z = 121.692 (N/mm²) <= 164.486 (N/mm²)
where
M : design bending moment = 277.458 (kN.m)
(Truck load(Parallel))
Z : section modulus = 2280.000 (cm³)
shear stress
Tau = S / Aw = 53.166 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 199.055 (kN)
(Truck load(Parallel))
Aw : web section area = 37.440 (cm²)

2.2.7 Deflection calculation

Calculate deflection when bending moment is maximum

$$\text{Del.} = \frac{Pol^3}{48EI} = 0.735\ (cm) <= 1.500\ (cm)$$

where
Po : load intensity = 130.000 (kN)
(Truck load(Parallel))
l : span length = 600.000 (cm)
I : moment of inertia of area = 39800.000 (cm⁴)
E : Young's modulus = $2.0*10^5$ (N/mm²)

2.3 Beam seat Design

2.3.1 Sum up bending moment for each load

load condition		section	bending moment (kN m)
truck load	orthogonal	---------------------	----------
	parallel	section- 2 Simple beam part	1.387
crawler crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	1.387
	0 degree-orthogonal	---------------------	----------
	0 degree-parallel	---------------------	----------
	90 degree-orthogonal	---------------------	----------
	90 degree-parallel	---------------------	----------
	45 degree-orthogonal	---------------------	----------
	45 degree-parallel	---------------------	----------
truck crane	moving-orthogonal	---------------------	----------
	moving-parallel	section- 2 Simple beam part	1.387
	working-orthogonal	---------------------	----------
	working-parallel	---------------------	----------

Note) Bending moment is the sum of moment by fixed load, load, and impact.

2.3.2 Bending moment computation

Calculate in the load condition that induces bending moment maximum

1) load condition   Truck load(Parallel)

2) design section - 2   Simple beam part

3) include Main girder in design section

No.	Main girder No.
1	G 2

4) Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.324	0.000	19.944
2	G 2	5.324	0.000	31.944
3	G 3	5.324	0.000	31.944
4	G 4	5.324	0.000	31.944
5	G 5	3.324	0.000	19.944

where

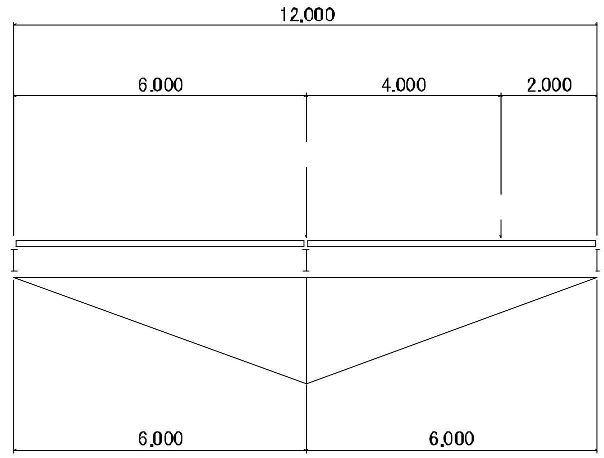
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force by truck load

in case that Beam seat of bending moment is at maximum, truck load position.

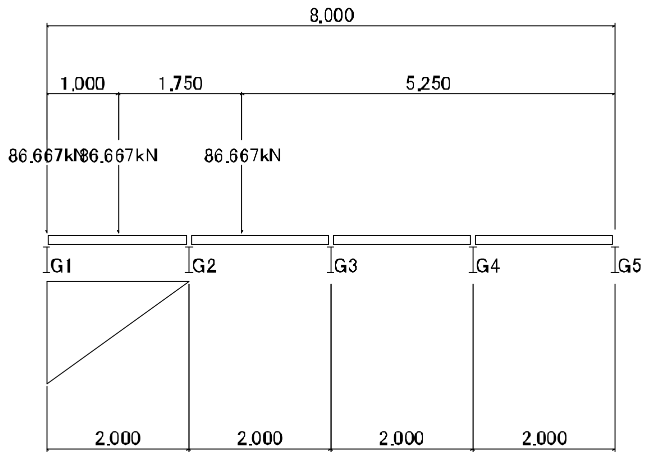


reaction force by train load

Rj = Sig. PJi * Etai = 86.667 (kN)

wheel No.	load PJi (kN)	influence value on reaction force Etai
1	80.000	1.000
2	20.000	0.333

in case that Beam seat of bending moment is at maximum, truck load position.



1 Main girder reaction force is maximum, then Beam seat bending moment is maximum

influence value of each beam

No.	Main girder No.	influence value
1	G 1	1.500
2	G 2	1.125
3	G 3	0.375
4	G 4	0.000
5	G 5	0.000

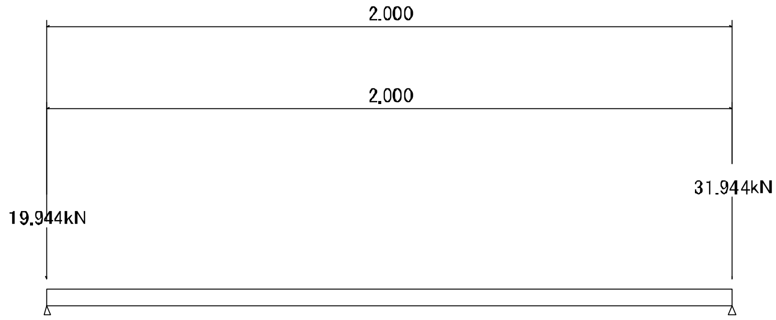
Rji = Rj * Ii

No.	Main girder No.	eachMain girder effect value Ii	Rji (kN)
1	G 1	1.500	130.000
2	G 2	1.125	97.500
3	G 3	0.375	32.500
4	G 4	0.000	0.000
5	G 5	0.000	0.000

6)calculate bending moment

Simple beam part

Bending moment by fixed load



Md = 1.387 (kN.m)

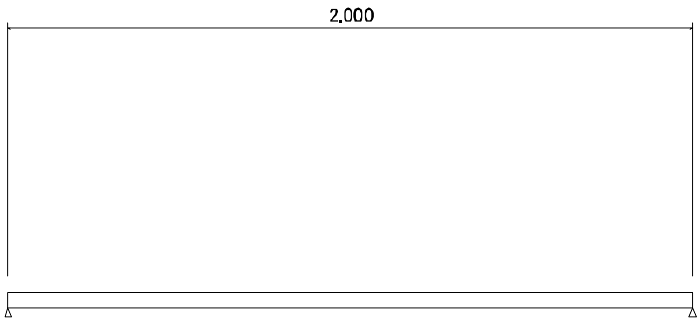
where

lmax : Mmax position(from left support point) = 2.000 (m)

wd : self-weight = 2.7750 (kN/m)

member used H-912x302x18x34

Bending moment by load



Ml = 0.000 (kN.m)

where

lmax : Mmax position (from left support point) = 0.000 (m)

7) sum of bending moment

fixed load	=	1.387 (kN.m)
load	=	0.000 (kN.m)
impact = 0.000 * 0.300	=	0.000 (kN.m)
total	M =	1.387 (kN.m)

2.3.3 Sum up shear force for each load

load condition		section	shear force (kN)
truck load	orthogonal	----------------------	----------
	parallel	section- 2 Simple beam part	217.802
crawler crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	247.269
	0 degree-orthogonal	----------------------	----------
	0 degree-parallel	----------------------	----------
	90 degree-orthogonal	----------------------	----------
	90 degree-parallel	----------------------	----------
	45 degree-orthogonal	----------------------	----------
	45 degree-parallel	----------------------	----------
truck crane	moving-orthogonal	----------------------	----------
	moving-parallel	section- 2 Simple beam part	178.261
	working-orthogonal	----------------------	----------
	working-parallel	----------------------	----------

Note) Shear force is the sum of shear force by fixed load,
load, and impact.

2.3.4 Shear force computation

Calculate in the load condition that induces shear force maximum

1)load condition Crawler crane when moving(Parallel)

2)design section - 2 Simple beam part

3)include Main girder in design section

No.	Main girder No.
1	G 2

4)Main girder reaction force by fixed load

Rdi = wdi * (l+ lside) / 2.0 + wd2i

No.	Main girder No.	ded ld strg wdi(kN/m)	othr ded ld wd2i(kN)	Rdi (kN)
1	G 1	3.324	0.000	19.944
2	G 2	5.324	0.000	31.944
3	G 3	5.324	0.000	31.944
4	G 4	5.324	0.000	31.944
5	G 5	3.324	0.000	19.944

where

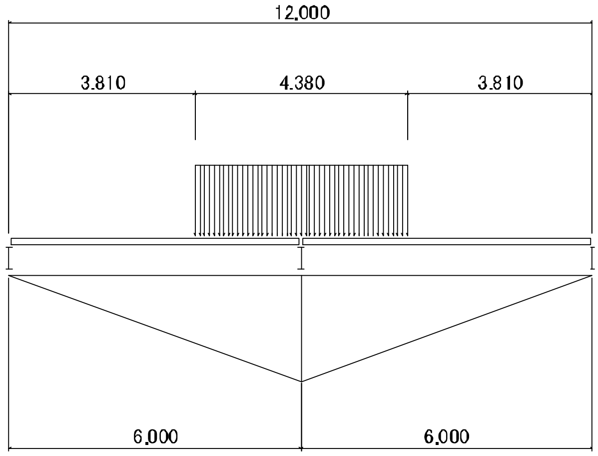
Rdi : reaction force by fixed load acting from Main girder to Beam seat

l : Main girder span length = 6.000 (m)

lside : adjacent span length = 6.000 (m)

5) Main girder reaction force of crawler crane

Beam seat - Shear force is at maximum, crawler load condition



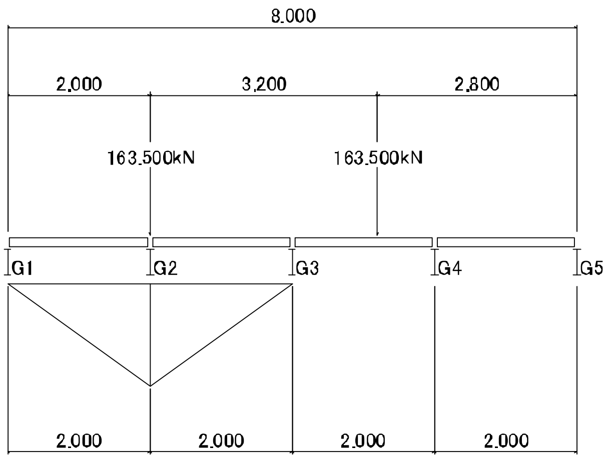
reaction force of crawler crane

Rc = w * { b * (a + b/2.0) / l1
+ c * (d + c/2.0) / l2 } = 163.500 (kN)

where

w :	crawler crane load intensity		
	w = (W+T) / lb * 0.500	=	45.662 (kN/m)
a :	unloading length in left span	=	3.810 (m)
b :	loading length in left span	=	2.190 (m)
c :	loading length in right span	=	2.190 (m)
d :	unloading length in right span	=	3.810 (m)
W :	crawler crane self-weight	=	400.000 (kN)
T :	lifting load	=	0.000 (kN)
lb :	crawler crane contact	=	4.380 (m)
l1 :	length of left span	=	6.000 (m)
l2 :	length of right span	=	6.000 (m)

Beam seat of Shear force is at maximum, crawler load condition

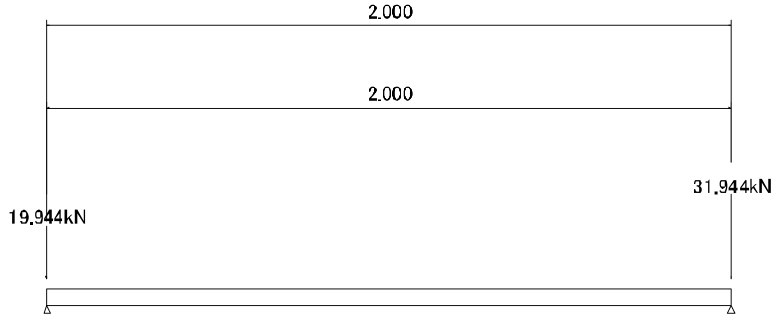


No.	Main girder No.	eachMain girder reaction force(kN)
1	G 1	0.000
2	G 2	163.500
3	G 3	65.400
4	G 4	98.100
5	G 5	0.000

6) calculate shear force

Simple beam part

Shear force by fixed load



Sd = 34.719 (kN)

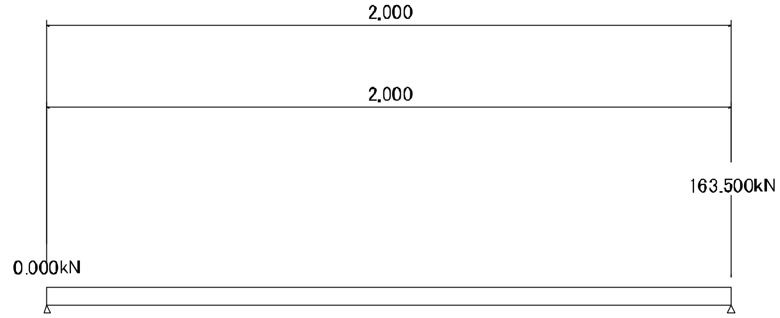
where

l : span length = 2.000 (m)

wd : self-weight = 2.7750 (kN/m)

member used H-912x302x18x34

shear force by load



Sj = 163.500 (kN)

7) sum of shear force

fixed load		=	34.719 (kN)
load		=	163.500 (kN)
impact	= 163.500 * 0.300	=	49.050 (kN)
total		S =	247.269 (kN)

FORUM8

2.3.5 Allowable stress calculation

steel material for structure SS400
using member H-912x302x18x34
allowable bending stress
Sig.ba = 202.359 (N/mm²)
l/b<= 4.5 Sig.ba = 210 (N/mm²)
4.5 < l/b<= 30.0 Sig.ba = { 140 - 2.4 * (l/b - 4.5) } * 1.50 (N/mm²)
where
l : buckling span between compressive flange supports = 200.000 (cm)
b : cross sectional area of compressive flange = 30.200 (cm)
l/b : = 6.623
allowable shear stress
Taua = 120.000

2.3.6 Beam seat stress calculation

using member H-912x302x18x34
bending stress
Sig. = M / Z = 0.128 (N/mm²) <= 202.359 (N/mm²)
where
M : design bending moment = 1.387 (kN.m)
(Truck load(Parallel))
Z : section modulus = 10800.000 (cm³)
shear stress
Tau = S / Aw = 16.276 (N/mm²) <= 120.000 (N/mm²)
where
S : design shear force = 247.269 (kN)
(Crawler crane when moving(Parallel))
Aw : web section area = 151.920 (cm²)

2.3.7 Deflection calculation

Calculate deflection when bending moment is maximum in a simple beam section

$$Del. = \frac{5Mmaxl^2}{48EI} = 0.000\ (cm) <= 0.500\ (cm)$$

where
Mmax: bending moment by load = 0.000 (kN.m)
(Truck load(Parallel))
l : span length = 200.000 (cm)
I : moment of inertia of area = 491000.000 (cm⁴)
E : Young's modulus = $2.0 * 10^5$ (N/mm²)

2.4 Support pile Design

2.4.1 The axial force and horizontal force of Support pile for each load

		axial force at max		horizontal force (kN)
		Support pileNo.	axial force (kN)	
truck load	orthogonal	----	--------	--------
	parallel	2	232.734	34.667
crawler crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	262.200	60.000
	0 degree-orthogonal	----	--------	--------
	0 degree-parallel	----	--------	--------
	90 degree-orthogonal	----	--------	--------
	90 degree-parallel	----	--------	--------
	45 degree-orthogonal	----	--------	--------
	45 degree-parallel	----	--------	--------
truck crane	moving-orthogonal	----	--------	--------
	moving-parallel	2	193.192	33.125
	working-orthogonal	----	--------	--------
	working-parallel	----	--------	--------

2.4.2 Axial force calculation for member design

Calculate for the load condition when axial force is maximum

For pile stress and bearing capacity of Support pile,use maximum axial force multiplied by 1/1 .

1) Load condition Crawler crane when moving(Parallel)

2) Support pile Number 2

Checking Support pile left Simple beam part

Checking Support pile left section Number of Main girder = 1

No.	Main girder No.
1	G 1

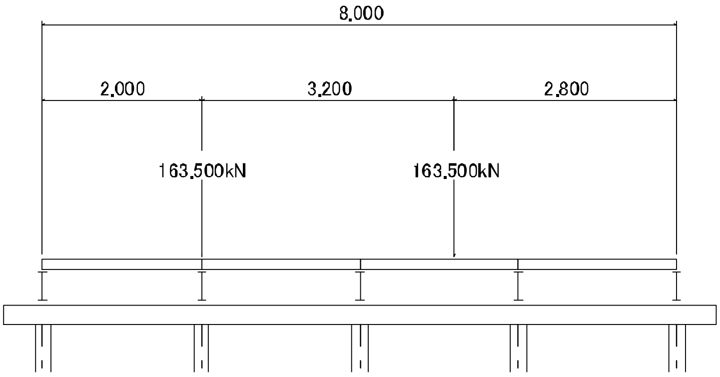
Checking Support pile right Simple beam part

Checking Support pile right section Number of Main girder = 1

No.	Main girder No.
1	G 2

3) calculate max axial force

simple beam + simple beam



axial force by fixed load

Nd = Ndl + Ndr + nd = 49.650 (kN)

where

Ndl : axial force by fixed load on simple beam (left)

Ndl = Sig.(Rdi * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rdi (kN)	lLi (m)
1	G 1	19.944	0.000

Ndr : axial force by fixed load on simple beam (right)

Ndr = Sig.(Rdj * lRj) / lk2 = 31.944 (kN)

No.	Main girder No.	Rdj (kN)	lRj (m)
1	G 2	31.944	2.000

nd : axial force by self-weight

Beam seat Self weight 2.775 * ((lk1 + lk2) / 2.0) = 5.550 (kN)

Hori. joint 0.182 * ls1 * 2 = 0.728 (kN)

Hori. brace 0.000 * ls2 = 0.000 (kN)

Vert. brace 0.146 * lv = 0.826 (kN)

Support pile Self weight 0.912 * lKUI = 10.602 (kN)

other load = 0.000 (kN)

----

total 17.706 (kN)

where

lk1 : left span length of simple beam = 2.000 (m)

lk2 : right span length of simple beam = 2.000 (m)

ls1 : Hori. joint Length = 2.000 (m)

ls1 = ((lk1+lk2) / 2.0) * 1

ls2 : Hori. brace Length = 0.000 (m)

lv : Vert. brace Length = 5.657 (m)

lv = Sig.lvn

lv1 = $\sqrt{lk1^2 + 2.000^2} + \sqrt{lk2^2 + 2.000^2}$ = 5.657 (m)

lKUI : Support pile Length = 11.625 (m)

axial force by load

Nj = Njl + Njr = 163.500 (kN)

where

Njl : axial force by load on simple beam(left)

Njl = Sig.(Rji * lLi) / lk1 = 0.000 (kN)

No.	Main girder No.	Rji (kN)	lLi (m)
1	G 1	0.000	0.000

Njr : axial force by load on simple beam(right)

Njr = Sig.(Rjj * lRj) / lk2 = 163.500 (kN)

No.	Main girder No.	Rjj (kN)	lRj (m)
1	G 2	163.500	2.000

member design axial force

fixed load = 49.650 (kN)

load = 163.500 (kN)

impact 163.500 * 0.300 = 49.050 (kN)

----

total N = 262.200 (kN)

member design axial force is 1/1 N * 1/1 = 262.200 (kN)

2.4.3 Horizontal force calculation

1) horizontal force by fixed load

H1 = (W1 + W2 + W3 + W4 + W5 + W6 + W7) * kh = 33.383 (kN)

W1 : weight of steel deck* nominal load

W1 = (Wf1 * Bf1 + Wf2 * Bf2) * (l + lside) / 2.0 = 96.000 (kN)

Wf1 : steel deck 2m+ nominal load = 2.000 (kN/m²)
Bf1 : steel deck 2m+ width direction = 8.000 (m)
Wf2 : steel deck 3m+ nominal load = 2.000 (kN/m²)
Bf2 : steel deck 3m+ width direction = 0.000 (m)
l : span length = 6.000 (m)
lside : adjacent span length = 6.000 (m)

W2 : dead load weight of wheel guard

W2 = (WL + WR) * (l + lside) / 2.0 = 0.000 (kN)

WL : dead load of left wheel guard = 0.000 (kN/m)
WR : dead load of right wheel guard = 0.000 (kN/m)

W3 : Main girder Weight

W3 = N * WN * (l + lside) / 2.0 = 39.720 (kN)

N : Main girder Members number = 5
WN : Main girder Self weight = 1.324 (kN/m)

W4 : Beam seat Weight

W4 = WH * lH = 24.975 (kN)

WH : Beam seat Self weight = 2.775 (kN/m)
lH : Beam seat length = 9.000 (m)

W5 : Hori. joint Weight

W5 = Ws1 * ls1 * 2 = 2.912 (kN)

Ws1 : Hori. joint Weight = 0.182 (kN/m)
ls1 : Hori. joint Length = 8.000 (m)

W6 : Hori. brace Weight

W6 = Ws2 * ls2 / 2.0 = 0.000 (kN)

Ws2 : Hori. brace Self weight = 0.000 (kN/m)
ls2 : Hori. brace Extension = 0.000 (m)

W7 : Vert. brace Weight

W7 = Wv * lv = 3.306 (kN)

Wv : Vert. brace Self weight = 0.146 (kN/m)
lv : Vert. brace Extension = 22.627 (m)

kh : coefficient for horizontal force estimate

kh = 0.200

2) horizontal load by horizontal force

H_j = R * kh = 60.000 (kN)

R : load case [Crawler crane when moving(Parallel)]

R = W + T = 400.000 (kN)

where

W: heaviest machine weight = 400.000 (kN)

In case truck load, reaction force by truck load on working platform is taken.

T : lifting load(zero when truck load) = 0.000 (kN)

kh : coefficient for horizontal force estimate

kh = 0.150

3) sum of horizontal force

fixed load	=	33.383 (kN)
load	=	60.000 (kN)
total	=	93.383 (kN)

2.4.4 Bending moment by horizontal force(pile top fixed)

Calculate bending moment and displacement using Chang's equation assuming infinite pile.
Since top of support pile are connected with lateral beams, horizontal force at top of transmits to the bottom of lateral beams.
Use bigger value either constrained moment at pile top or max bending moment in subground.

horizontal force on Support pile

H = Sig.H / n = 18.677 (kN)

where

Sig.H : horizontal force acting on one frame plane = 93.383 (kN)

n : Support pileMembers number = 5

constrained moment at pile top

Mo = (1 + Betah) * H / 2Beta = 54.976 (kN.m)

max bending moment in subground

Mmax = - H / 2Beta * (1 + (Betah)^{2})$^{1/2}$ * exp (- Betalm) = 30.363 (kN.m)

depth at max bending moment in subground

lm = 1 / Beta * tan^{-1}(1 /Betah) = 0.541 (m)

horizontal displacement at pile top

Del. = ((1 + Betah)^{3}+ 2) * H / (12 EIBeta^{3}) = 2.440 (cm)

where

h : above ground length = 4.325 (m)

I : Support pilearea moment of inertia = 6750.000 (cm^{4})

E : Support pileYoung modulus = 2.000 * 10^{5}(N/mm^{2})

pile characteristic value

Beta = ^{4}ã(kh* D / (4EI)) = 0.00640 (1/cm)

where

D : Support pilewidth = 30.000 (cm)

subgrade reaction coefficient in lateral direction

kh = kho* (BH/30)$^{-3/4}$ = 30.228 (N/cm^{3})

kho = 1/30* Alp.* Eo = 56.000 (N/cm^{3})

BH = (D/Beta)$^{1/2}$ = 68.260 (cm)

where

BH : pile conversion width of load

Alp.* Eo: average Alp.* Eo in range of 1/Beta = 1680.000 (N/cm^{2})

2.4.5 Support pile buckling stability check

Because Support pile buckling possibly occur under axial direction force and bending moment, check the stability on buckling using next 2 equations.

Sig.c / Sig.caz + Sig.bcz / { Sig.bao * (1 - Sig.c / Sig.eaz) }
= 0.818 <= 1.0

Sig.c + Sig.bcz / (1 - Sig.c / Sig.eaz)
= 159.753 <= Sig.cal

where

Sig.c : compressive stress in axial direction = 22.145 (N/mm²)

Sig.bcz : moment compressive stress by bending moment around weak axis.
Sig.bcz = Mz / zz = 122.168 (N/mm²)

Sig.caz : allowable compressive stress in axial direction around weak axis = 136.230(N/mm²)
lk/r <= 18 --- Sig.caz = 210
18 < lk/r <= 92 --- Sig.caz = { 140 - 0.82 * (lk/r - 18) } * 1.50
92 < lk/r --- Sig.caz = 1200000 / { 6700 + (lk/r)²} * 1.50
lk/r = 588.713 / 7.550 = 77.975

Sig.bao : upper limit of allowable compressive stress without local buckling
= 210.000 (N/mm²)

Sig.cal : allowable stress of free extension plate under comp stress about local buckling
where b' <= 13.1t' = 210.000 (N/mm²)

Sig.eaz : Euler buckling strength around weak axis
Sig.eaz = 1200000 / (lk/rz)² = 197.364 (N/mm²)

N : Support pile acting axial force = 262.200 (kN)
Mz : bending moment around z axis = 54.976 (kN.m)
lk : buckling length = 588.713 (cm)
lLow: lowest design span, height at lowest is added 1/Beta(lk reference value, fixed value).
lLow = lLow' + 1/Beta = 432.500 + 156.213 = 588.713
where,
lLow' : height at lowest = 432.500 (cm)
Beta : characteristic value
Beta = ⁴ā(kh* D / (4EI)) = 0.00640 (1/cm)
where
I : Support pilearea moment of inertia = 6750.000 (cm⁴)
E : Support pileYoung modulus = 2.000 * 10⁵(N/mm²)
D : Support pilewidth = 30.000 (cm)
kh : lateral subgrade reaction = 30.228 (N/cm³)

use steel member, H-300x300x10x15(Weak)
A : cross sectional area of steel material = 118.400 (cm²)
zz : section modulus around z axis = 450.000 (cm³)
ry : radius of gyration of area around y axis = 13.100 (cm)
rz : radius of gyration of area around z axis = 7.550 (cm)

Shear stress
horizontal force acting on weak axis of post.
Tau = H / (2 * Af) = 2.075 <= 120.000 (N/mm²)
H : Support pileworking horizontal force = 18.677 (kN)
Af : Support pileFlange area = 45.000 (cm²)

2.4.6 Support pile bearing capacity examination

allowable bearing capacity

Ra = { qd* A + uSig.lifi }/ 2.0 = 523.500 (kN)

(construction method: driving)

where

qd: ultimate bearing capacity at tip ground = 2800.00

qd = 200Alp.N

N : Support pileN value of soil layer at tip= 14.00

N = (N1 + N2) / 2

upper limit is 40.

N1: Support pileN value at tip position = 14.00

N2: Support pile in the range of 2m above from tip

average N-value = 14.00

A : Support piletip area = 0.09 (m²)

u : Support pilePerimeter = 1.200 (m)

li: thickness to be considered circumference friction

fi: maximum skin friction in the layer considered friction

fi=2BetaNs(sand)

Ns upper limit is 50.

fi=10BetaNc(Nc:N-value) , fi=BetaNc(Nc:cohesion)(clay)

where, Nc(N-value 10* Nc) upper limit is 150.

Sig.lifi: circumference friction = 662.500

li(m)	Ns	Nc	fi(kN/m²)	li* fi
3.000	------	125.0	125.000	375.000
2.300	------	125.0	125.000	287.500

Alp. : coefficient of tip bearing capacity for construction method = 1.0

Beta : coefficient of skin friction for construction method = 1.0

max axial force acting on Support pile Crawler crane when moving(Parallel)

N max = 262.200 (kN) <= 523.500 (kN)

2.5 Hori. joint Design

2.5.1 Hori. joint checking

Design Hori. joint as a member receiving compression force.
load condition Crawler crane when moving(Parallel)
compression force acting on Hori. joint
share the horizontal force receiving on a frame plane by single Hori. joint.
Set both sides of Support pile
N = H / 2 = 46.691 (kN)
Sig.c = N / A = 19.693 (N/mm²) <= Sig.ca = 123.770 (N/mm²)
where
H : compressive force acting on a frame plane = 93.383 (kN)
Sig.c : axial direction compressive stress
Sig.ca : allowable axial direction compressive stress = 123.770 (N/mm²)
l/r <= 18 --- Sig.ca = 210
18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50
92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50
l/r = 88.106
Use steel material [-150x75x6.5x10
A : cross sectional area of steel material = 23.710(cm²)
l : buckling length = 2.000(m)
r : radius of gyration of area around weak axis = 2.270(cm)

2.5.2 Connection part checking

compression force acting on Hori. joint
T = 46.691 (kN)
required length for welding part
l = T / (0.7rho* s) = 22.234 (cm)
rho : allowable stress of welding joint = 100.000 (N/mm²)
s : foot length = 0.300 (cm)

2.6 Vert. brace Design

2.6.1 Vert. brace checking

design Vert. brace as a member receiving Compressive force
load condition Crawler crane when moving(Parallel)
horizontal force shared by Vert. brace
share the horizontal force receiving on a frame plane by number of Vert. brace
Hv = H / n = 23.346 (kN)
force Vert. brace acting on Compressive
T = Hv / cos(Theta) = 33.016 (kN)
cos(Theta) = l / ($l^2 + h^2$)$^{1/2}$ = 0.707
where
l : Support pileThe most shortest spacing(length) = 2.000 (m)
h : Hori. jointlongest spacing = 2.000 (m)
Compressive stress
Sig.c = T / A = 17.377 (N/mm²) <= Sig.ca = 64.891 (N/mm²)
where
Sig.ca : allowable axial direction compressive stress = 64.891 (N/mm²)
l/r <= 18 --- Sig.ca = 210
18 < l/r <= 92 --- Sig.ca = { 140 - 0.82 * (l/r -18) } * 1.50
92 < l/r --- Sig.ca = 1200000 / {6700 + (l/r)²} * 1.50
l/r = 145.048
Use steel material L-100x100x10
A : effective cross sectional area of steel material = 19.000 (cm²)
l : buckling length = 2.828 (m)
r : radius of gyration of area = 1.950 (cm)

2.6.2 Connection part checking

force Compressive acting on a brace member

T = 33.016 (kN)

required length for welding part

l = T / (0.7rho* s) = 15.722 (cm)

rho : allowable stress of welding joint = 100.000 (N/mm²)

s : foot length = 0.300 (cm)

2.7 Summary export

2.7.1 Steel deck summary report

steel deck : steel deck type2

1) check regarding to bending moment

load condition	Truck crane when moving(Parallel)				
name of steel deck	Steel deck type 2 (1000*2000)				
bending moment due to fixed load	Md	=	1.000 (kN.m)		
bending moment due to load	Mmax	=	61.250 (kN.m)		
design bending moment	M	=	24.700 (kN.m)		
bending stress	Sig.	=	79.167	<=	210.000 (N/mm²)

2) check regarding to shear force

load condition	Truck load(Parallel)				
name of steel deck	Steel deck type 2 (1000*2000)				
shear force due to fixed load	Sd	=	2.000 (kN)		
shear force due to load	Smax	=	140.000 (kN)		
design shear force	S	=	56.400 (kN)		
shear stress	Tau	=	69.630	<=	120.000 (N/mm²)

2.7.2 Main girder Summary report

1) calculate bending moment
load condition Truck load(Parallel)
design object Main girder number 2 of

fixed load		=	23.958(kN.m)
load		=	195.000(kN.m)
impact	195.000 * 0.300	=	58.500(kN.m)
total		=	277.458(kN.m)

2)calculate shear force
load condition Truck load(Parallel)
design object Main girder number 2

fixed load		=	15.972(kN)
load		=	140.833(kN)
impact	140.833 * 0.300	=	42.250(kN)
total		=	199.055(kN)

3)checking stress
using member H-350x350x12x19

web section area	Aw =	37.440 cm²
section modulus	Z =	2280.000 cm³

bending stress	Sig. = M / Z	= 121.692 (N/mm²)
allowable bending stress	Sig.ba	= 164.486 (N/mm²)
shear stress	Tau = S / Aw	= 53.166 (N/mm²)
allowable shear stress	fs	= 120.000 (N/mm²)

4)deformation
Calculate deformation when bending moment is maximum in a load condition

deformation	Del. =	0.7349 (cm)
allowable deformation	Del.a =	1.5000 (cm)

2.7.3 Beam seat Summary report

1)Calculate bending moment
    load condition Truck load(Parallel)
    design section 2 Simple beam part
      fixed load   =   1.387(kN.m)
      load   =   0.000(kN.m)
      impact   0.000 * 0.300 =   0.000(kN.m)
      ----
      tototal   =   1.387(kN.m)

2)Calculate shear force
    load condition Crawler crane when moving(Parallel)
    design section 2 Simple beam part
      fixed load   =   34.719(kN)
      load   = 163.500(kN)
      impact   163.500 * 0.300 =   49.050(kN)
      ----
      total   = 247.269(kN)

3)checking stresses
    material   H-912x302x18x34
    web section area Aw =   151.920 cm^2
    section modulus   Z = 10800.000 cm^3

    bending stress   Sig. = M / Z   =   0.128 (N/mm^2)
      allowable bending stress Sig.ba   = 202.359 (N/mm^2)
    shear stress   Tau = S / Aw   = 16.276 (N/mm^2)
      allowable shear stress   Taua = 120.000 (N/mm^2)

4)deflection
    Calculate deflection when bending moment by live load is at max..
    deflection   Del. =   0.0000 (cm)
    allowable deflection   Del.a =   0.5000 (cm)

2.7.4 Support pile Summary report

1)load condition that weight on working platform is max. Crawler crane when moving(Parallel)
(axial force for member design)

2)Support pile number 2

3)calculation of axial force

fixed load			=	49.650	(kN)
load			=	163.500	(kN)
impact	163.500 *	0.300	=	49.050	(kN)
total	262.200 *	1/1	=	262.200	(kN)

4)calculation of horizontal force

fixed load	=	33.383	(kN)
load	=	60.000	(kN)
total		93.383	(kN)

5)bending moment by horizontal force

Support pile horizontal force acting on single member = 18.677 (kN)

maximum bending moment = 54.976 (kN.m)

6)Support pile strength check

material used H-300x300x10x15(Weak)

cross sectional area	A	=	118.400	cm^2
section modulus	Z	=	450.000	cm^3
radius of gyration of area around y axis	Ry	=	13.100	cm
radius of gyration of area around z axis	Rz	=	7.550	cm
flange width	B	=	30.000	cm
web section area	Aw	=	45.000	cm^2

Sig.c/Sig.caz + Sig.bcz/{Sig.bao * (1-Sig.c/Sig.eaz)} = 0.818 <= 1.000

Sig.c + Sig.bcz/(1-Sig.c/Sig.eaz) = 159.753 <= 210.000

7) check bearing capacity Support pile

max axial force on Support pile Crawler crane when moving(Parallel)

Nmax = 262.200 <= 523.500 (kN)

2.8 List table

2.8.1 Steel deck List

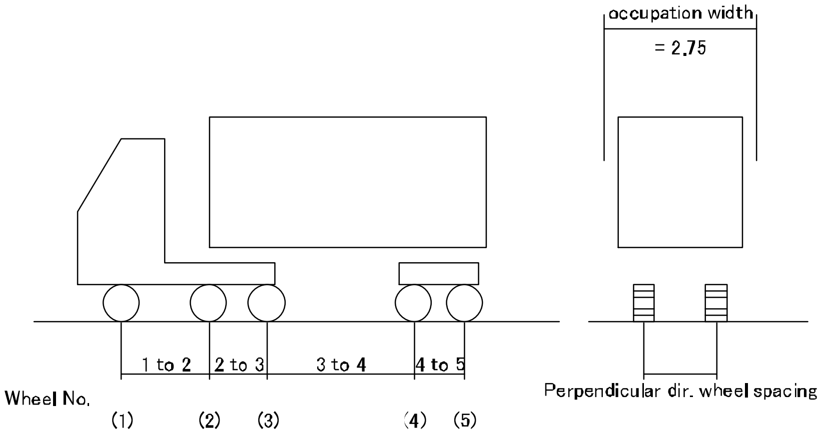
steel deck	name	Steel deck type 2 (1000*2000)
	bending moment max Mmax Sig.	Truck crane when moving(Parallel) 61.250 (kN m) 79.167 <= 210.000 (N/mm²)
	shear force max Smax Tau	Truck load(Parallel) 140.000 (kN) 69.630 <= 120.000 (N/mm²)

2.8.2 Member list table

Main girder	use	H-350x350x12x19
	bending moment max Mmax Sig.	Truck load(Parallel) 277.458 (kN.m) 121.692 <= 164.486 (N/mm²)
	shear force max Smax Tau	Truck load(Parallel) 199.055 (kN) 53.166 <= 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.735 <= 1.500 (cm)
Beam seat (Support pile)	use	H-912x302x18x34
	bending moment max Mmax Sig.	Truck load(Parallel) 1.387 (kN.m) 0.128 <= 202.359 (N/mm²)
	shear force max Smax Tau	Crawler crane when moving(Parallel) 247.269 (kN) 16.276 <= 120.000 (N/mm²)
	deflection Del.	Truck load(Parallel) 0.000 <= 0.500 (cm)
Support pile	use	H-300x300x10x15(Weak)
	load(section) load(bearing capacity)	Crawler crane when moving(Parallel) Crawler crane when moving(Parallel)
	force	N = 262.200 (kN) M = 54.976 (kN.m) S = 18.677 (kN) Sig.c = 22.145 Sig.b = 122.168 (N/mm²) Tau = 2.075 <= Taua = 120.000 (N/mm²)
	check buckling	eq-1 ------- 0.818 <= 1.000 eq-2 ------- 159.753 <= 210.000 (N/mm²)
	bearing capacity	262.200 <= 523.500 (kN)
Hori. joint	use	[-150x75x6.5x10
	cmpr stress Sig.c	19.693 <= 123.770 (N/mm²) (N= 46.691kN)
Hori. jointJoint part	required welding length	22.234 (cm)
Vert. brace	use	L-100x100x10
	cmpr stress Sig.c	17.377 <= 64.891 (N/mm²) (T= 33.016kN)
Vert. braceJoint part	required welding length	15.722 (cm)

3 Registered load data export

3.1 Truck load



1	name : TT43		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	30.000	3.250
	2	65.000	7.800
	3	60.000	1.550
	4	60.000	------------------------------------

2	name : T25		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	4.000
	2	100.000	------------------------------------

3	name : T20		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.000
	2	80.000	------------------------------------

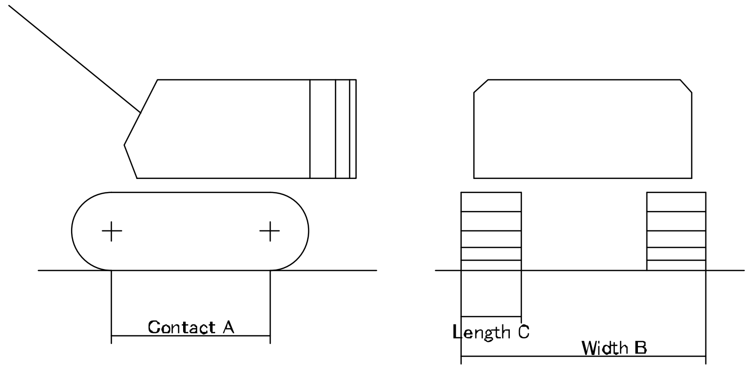
4	name : T14		
	wheel distance in perpendicular direction = 1.75 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	14.000	4.000
	2	56.000	------------------------------------

5	name : Ready mixed concrete Truck(3 cubic meters)		
	wheel distance in perpendicular direction = 1.08 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	20.000	4.200
	2	54.000	------------------------------------

6	name : Ready mixed concrete Truck(5 cubic meters)		
	wheel distance in perpendicular direction = 1.88 (m)		
		load intsty(1 side)(kN)	wheel distance in moving direction(m)
	1	25.000	3.160
	2	55.000	1.880
	3	30.000	------------------------------------

7	name : Surplus soil Truck	
	wheel distance in perpendicular direction = 1.90 (m)	
	load intsty(1 side)(kN)	wheel distance in moving direction(m)
1	34.000	4.000
2	63.000	

3.2 Crawler crane



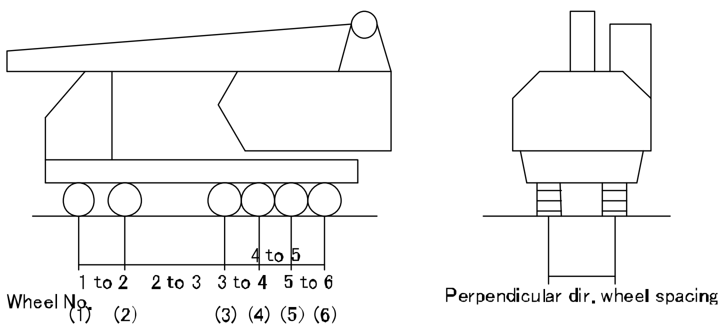
1	name : D408S	
	self weight = 480.000(kN) lifting load = 50.000(kN) contact length A = 4.470(m) width B = 4.000(m) contact width C = 0.800(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

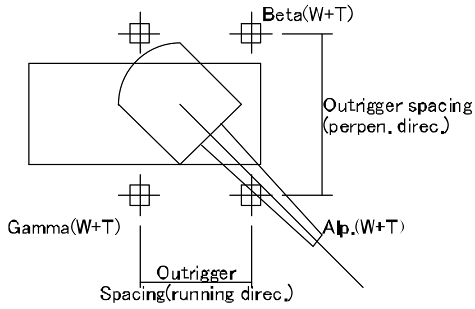
2	name : P&H440S	
	self weight = 400.000(kN) lifting load = 50.000(kN) contact length A = 4.380(m) width B = 3.960(m) contact width C = 0.760(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

3	name : P&H335AS	
	self weight = 350.000(kN) lifting load = 30.000(kN) contact length A = 4.280(m) width B = 3.790(m) contact width C = 0.590(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

4	name : P&H325	
	self weight = 280.000(kN) lifting load = 30.000(kN) contact length A = 3.950(m) width B = 3.030(m) contact width C = 0.590(m)	90 degree distribution ratio = 0.800 0 degree distribution ratio = 0.600 45 degree distribution ratio = 0.700 45 degree contact ratio = 0.900

3.3 Truck crane





1	name : NK-300		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	32.000	3.850
	2	64.000	1.350
	3	64.000	--
	self weight W= 320.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.750(m) outrigger distance(perpendicular) = 5.600(m) outrigger width = 0.500(m)

2	name : NK-200		
	wheel distance in perpendicular direction = 1.90 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.980
	2	40.000	1.240
	3	40.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 4.450(m) outrigger distance(perpendicular) = 4.800(m) outrigger width = 0.400(m)

3	name : Rough terrain crane 20tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	20.000	3.000
	2	80.000	--
	self weight W= 200.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 5.700(m) outrigger distance(perpendicular) = 5.700(m) outrigger width = 0.400(m)

4	name : Rough terrain crane 25tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	25.000	3.500
	2	100.000	--
	self weight W= 250.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 6.300(m) outrigger distance(perpendicular) = 6.200(m) outrigger width = 0.400(m)

5	name : Rough terrain crane 40tons		
	wheel distance in perpendicular direction = 2.10 (m)		
		load intensity (1 side)(kN)	wheel distance in moving direction (m)
	1	35.000	4.250
	2	140.000	--
	self weight W= 350.000(kN) lifting load T= 30.000(kN) load distribution ratio Alp.= 0.700 load distribution ratio Beta= 0.150 load distribution ratio Gam= 0.150		outrigger distance(moving) = 7.300(m) outrigger distance(perpendicular) = 6.500(m) outrigger width = 0.500(m)

4 Registered member data export

4.1 Main girder Registered data

No.	Item	Symbol	Value	Item	Symbol	Value
1	name : H 300x300x10x15					
	unit weight	=	912.0 (N/m)	flange section area	Af =	45.00(cm²)
	web section area	Aw =	27.00(cm²)	section modulus	Z =	1350.0(cm³)
	moment of inertia	I =	20200.0(cm⁴)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
2	name : H 350x350x12x19					
	unit weight	=	1324.0 (N/m)	flange section area	Af =	66.50(cm²)
	web section area	Aw =	37.44(cm²)	section modulus	Z =	2280.0(cm³)
	moment of inertia	I =	39800.0(cm⁴)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
3	name : H 400x400x13x21					
	unit weight	=	1687.0 (N/m)	flange section area	Af =	84.00(cm²)
	web section area	Aw =	46.54(cm²)	section modulus	Z =	3330.0(cm³)
	moment of inertia	I =	66600.0(cm⁴)	lateral buckling radius	i =	11.00(cm)
	beam height	h =	40.0(cm)	compressive flange width	b =	40.0(cm)
	web thickness	t1 =	1.30(cm)	compressive flange thickness	t2 =	2.10(cm)
4	name : H 594x302x14x23					
	unit weight	=	1667.0 (N/m)	flange section area	Af =	69.46(cm²)
	web section area	Aw =	76.72(cm²)	section modulus	Z =	4500.0(cm³)
	moment of inertia	I =	134000.0(cm⁴)	lateral buckling radius	i =	7.96(cm)
	beam height	h =	59.4(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.40(cm)	compressive flange thickness	t2 =	2.30(cm)
5	name : H 900x300x16x28					
	unit weight	=	2354.0 (N/m)	flange section area	Af =	84.00(cm²)
	web section area	Aw =	135.04(cm²)	section modulus	Z =	8990.0(cm³)
	moment of inertia	I =	404000.0(cm⁴)	lateral buckling radius	i =	7.68(cm)
	beam height	h =	90.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.60(cm)	compressive flange thickness	t2 =	2.80(cm)
6	name : H 912x302x18x34					
	unit weight	=	2775.0 (N/m)	flange section area	Af =	102.68(cm²)
	web section area	Aw =	151.92(cm²)	section modulus	Z =	10800.0(cm³)
	moment of inertia	I =	491000.0(cm⁴)	lateral buckling radius	i =	7.84(cm)
	beam height	h =	91.2(cm)	compressive flange width	b =	30.2(cm)
	web thickness	t1 =	1.80(cm)	compressive flange thickness	t2 =	3.40(cm)
7	name : H 250x250x9x14					
	unit weight	=	718.0 (N/m)	flange section area	Af =	35.00(cm²)
	web section area	Aw =	19.98(cm²)	section modulus	Z =	860.0(cm³)
	moment of inertia	I =	10700.0(cm⁴)	lateral buckling radius	i =	6.91(cm)
	beam height	h =	25.0(cm)	compressive flange width	b =	25.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.40(cm)

4.2 Beam seat H-Beam registered data

No.	name : H-300x300x10x15			
1	unit weight =	912.0 (N/m)	flange section area Af =	45.00(cm^2)
	web section area Aw =	27.00(cm^2)	section modulus Z =	1350.0(cm^3)
	moment of inertia I =	20200.0(cm^4)	lateral buckling radius i =	8.23(cm)
	beam height h =	30.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness t2 =	1.50(cm)

No.	name : H-350x350x12x19			
2	unit weight =	1324.0 (N/m)	flange section area Af =	66.50(cm^2)
	web section area Aw =	37.44(cm^2)	section modulus Z =	2280.0(cm^3)
	moment of inertia I =	39800.0(cm^4)	lateral buckling radius i =	9.65(cm)
	beam height h =	35.0(cm)	compressive flange width b =	35.0(cm)
	web thickness t1 =	1.20(cm)	compressive flange thickness t2 =	1.90(cm)

No.	name : H-400x400x13x21			
3	unit weight =	1687.0 (N/m)	flange section area Af =	84.00(cm^2)
	web section area Aw =	46.54(cm^2)	section modulus Z =	3330.0(cm^3)
	moment of inertia I =	66600.0(cm^4)	lateral buckling radius i =	11.00(cm)
	beam height h =	40.0(cm)	compressive flange width b =	40.0(cm)
	web thickness t1 =	1.30(cm)	compressive flange thickness t2 =	2.10(cm)

No.	name : H-594x302x14x23			
4	unit weight =	1667.0 (N/m)	flange section area Af =	69.46(cm^2)
	web section area Aw =	76.72(cm^2)	section modulus Z =	4500.0(cm^3)
	moment of inertia I =	134000.0(cm^4)	lateral buckling radius i =	7.96(cm)
	beam height h =	59.4(cm)	compressive flange width b =	30.2(cm)
	web thickness t1 =	1.40(cm)	compressive flange thickness t2 =	2.30(cm)

No.	name : H-900x300x16x28			
5	unit weight =	2354.0 (N/m)	flange section area Af =	84.00(cm^2)
	web section area Aw =	135.04(cm^2)	section modulus Z =	8990.0(cm^3)
	moment of inertia I =	404000.0(cm^4)	lateral buckling radius i =	7.68(cm)
	beam height h =	90.0(cm)	compressive flange width b =	30.0(cm)
	web thickness t1 =	1.60(cm)	compressive flange thickness t2 =	2.80(cm)

No.	name : H-912x302x18x34			
6	unit weight =	2775.0 (N/m)	flange section area Af =	102.68(cm^2)
	web section area Aw =	151.92(cm^2)	section modulus Z =	10800.0(cm^3)
	moment of inertia I =	491000.0(cm^4)	lateral buckling radius i =	7.84(cm)
	beam height h =	91.2(cm)	compressive flange width b =	30.2(cm)
	web thickness t1 =	1.80(cm)	compressive flange thickness t2 =	3.40(cm)

No.	name : H-250x250x9x14			
7	unit weight =	704.0 (N/m)	flange section area Af =	35.00(cm^2)
	web section area Aw =	19.98(cm^2)	section modulus Z =	860.0(cm^3)
	moment of inertia I =	10700.0(cm^4)	lateral buckling radius i =	6.91(cm)
	beam height h =	25.0(cm)	compressive flange width b =	25.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.40(cm)

4.3 Beam seat one side U steel

No.	name : [-250x90x9x13			
1	unit weight =	339.0(N/m)	section area Af =	44.07(cm^2)
	web section area Aw =	20.16(cm^2)	section modulus Z =	335.0(cm^3)
	moment of inertia I =	4180.0(cm^4)	area gyration radius i =	2.58(cm)
	web height h =	25.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

No.	name : [-300x90x9x13			
2	unit weight =	374.0(N/m)	section area Af =	48.57(cm^2)
	web section area Aw =	24.66(cm^2)	section modulus Z =	429.0(cm^3)
	moment of inertia I =	6440.0(cm^4)	area gyration radius i =	2.52(cm)
	web height h =	30.0(cm)	compressive flange width b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness t2 =	1.30(cm)

3	name : [-300x90x10x15.5	
	unit weight = 430.0(N/m)	section area Af = 55.74(cm^2)
	web section area Aw = 26.90(cm^2)	section modulus Z = 494.0(cm^3)
	moment of inertia I = 7410.0(cm^4)	area gyration radius i = 2.54(cm)
	web height h = 30.0(cm)	compressive flange width b = 9.0(cm)
	web thickness t1 = 1.00(cm)	compressive flange thickness t2 = 1.55(cm)

4	name : [-380x100x10.5x16	
	unit weight = 534.0(N/m)	section area Af = 69.39(cm^2)
	web section area Aw = 36.54(cm^2)	section modulus Z = 763.0(cm^3)
	moment of inertia I = 14500.0(cm^4)	area gyration radius i = 2.78(cm)
	web height h = 38.0(cm)	compressive flange width b = 10.0(cm)
	web thickness t1 = 1.05(cm)	compressive flange thickness t2 = 1.60(cm)

5	name : [-380x100x13x20	
	unit weight = 660.0(N/m)	section area Af = 85.71(cm^2)
	web section area Aw = 44.20(cm^2)	section modulus Z = 926.0(cm^3)
	moment of inertia I = 17600.0(cm^4)	area gyration radius i = 2.76(cm)
	web height h = 38.0(cm)	compressive flange width b = 10.0(cm)
	web thickness t1 = 1.30(cm)	compressive flange thickness t2 = 2.00(cm)

4.4 Beam seat L section steel Registered data

1	name : L-65x65x6	
	unit weight = 58.0(N/m)	section area A = 7.527(cm^2)
	area gyration radius iy = 1.98(cm)	
	angle edge width B = 6.5(cm)	thickness t = 0.60(cm)

2	name : L-75x75x6	
	unit weight = 67.2(N/m)	section area A = 8.727(cm^2)
	area gyration radius iy = 2.30(cm)	
	angle edge width B = 7.5(cm)	thickness t = 0.60(cm)

3	name : L-75x75x9	
	unit weight = 97.7(N/m)	section area A = 12.690(cm^2)
	area gyration radius iy = 2.25(cm)	
	angle edge width B = 7.5(cm)	thickness t = 0.90(cm)

4	name : L-90x90x10	
	unit weight = 130.4(N/m)	section area A = 17.000(cm^2)
	area gyration radius iy = 2.71(cm)	
	angle edge width B = 9.0(cm)	thickness t = 1.00(cm)

5	name : L-100x100x10	
	unit weight = 146.1(N/m)	section area A = 19.000(cm^2)
	area gyration radius iy = 3.04(cm)	
	angle edge width B = 10.0(cm)	thickness t = 1.00(cm)

4.5 Support pile Registered data

1	name : H-300x300x10x15(Weak)	
	unit weight = 912.0 (N/m)	section area A = 118.40(cm^2)
	flange section area Af = 45.00(cm^2)	web section area Aw = 27.00(cm^2)
	action direction = weak	area gyration radius iy = 13.10(cm)
	area gyration radius iz = 7.55(cm)	lateral buckling radius i = 8.23(cm)
	beam height h = 30.0(cm)	compressive flange width b = 30.0(cm)
	web thickness t1 = 1.00(cm)	compressive flange thickness t2 = 1.50(cm)
	section modulus Z = 450.0(cm^3)	moment of inertia I = 6750.0(cm^4)
	pile tip area = 900.0(cm^2)	pile circumference = 120.0(cm)
	pile diameter = 30.0(cm)	pile unit weight = 912.0(N/m)

2	name : H-300x300x10x15(Strong)					
	unit weight		912.0 (N/m)	section area	A =	118.40(cm^2)
	flange section area	Af =	45.00(cm^2)	web section area	Aw =	27.00(cm^2)
	action direction		= strong	area gyration radius	iy =	13.10(cm)
	area gyration radius	iz =	7.55(cm)	lateral buckling radius	i =	8.23(cm)
	beam height	h =	30.0(cm)	compressive flange width	b =	30.0(cm)
	web thickness	t1 =	1.00(cm)	compressive flange thickness	t2 =	1.50(cm)
	section modulus	Z =	1350.0(cm^3)	moment of inertia	I =	20200.0(cm^4)
	pile tip area	=	900.0(cm^2)	pile circumference	=	120.0(cm)
	pile diameter	=	30.0(cm)	pile unit weight	=	912.0(N/m)

3	name : H-350x350x12x19(Weak)					
	unit weight	=	1324.0 (N/m)	section area	A =	171.90(cm^2)
	flange section area	Af =	66.50(cm^2)	web section area	Aw =	37.44(cm^2)
	action direction		= weak	area gyration radius	iy =	15.20(cm)
	area gyration radius	iz =	8.89(cm)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
	section modulus	Z =	776.0(cm^3)	moment of inertia	I =	13600.0(cm^4)
	pile tip area	=	1225.0(cm^2)	pile circumference	=	140.0(cm)
	pile diameter	=	35.0(cm)	pile unit weight	=	1323.9(N/m)

4	name : H-350x350x12x19(Strong)					
	unit weight	=	1324.0 (N/m)	section area	A =	171.90(cm^2)
	flange section area	Af =	66.50(cm^2)	web section area	Aw =	37.44(cm^2)
	action direction		= strong	area gyration radius	iy =	15.20(cm)
	area gyration radius	iz =	8.89(cm)	lateral buckling radius	i =	9.65(cm)
	beam height	h =	35.0(cm)	compressive flange width	b =	35.0(cm)
	web thickness	t1 =	1.20(cm)	compressive flange thickness	t2 =	1.90(cm)
	section modulus	Z =	2280.0(cm^3)	moment of inertia	I =	39800.0(cm^4)
	pile tip area	=	1225.0(cm^2)	pile circumference	=	140.0(cm)
	pile diameter	=	35.0(cm)	pile unit weight	=	1323.9(N/m)

4.6 Hori. joint Registered data

1	name : [-150x75x6.5x10					
	unit weight	=	182.0(N/m)	section area	A =	23.71(cm^2)
	area gyration radius	iy =	2.27(cm)			
	web height	h =	15.0(cm)	compressive flange width	b =	7.5(cm)
	web thickness	t1 =	0.65(cm)	compressive flange thickness	t2 =	1.00(cm)

2	name : [-200x90x8x13.5					
	unit weight	=	297.0(N/m)	section area	A =	38.65(cm^2)
	area gyration radius	iy =	2.68(cm)			
	web height	h =	20.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.80(cm)	compressive flange thickness	t2 =	1.35(cm)

3	name : [-250x90x9x13					
	unit weight	=	339.0(N/m)	section area	A =	44.07(cm^2)
	area gyration radius	iy =	2.64(cm)			
	web height	h =	25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness	t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)

4.7 Vert. brace Registered data

1	name : L-65x65x6					
	unit weight	=	58.00(N/m)	section area	A =	7.527(cm^2)
	area gyration radius	iy =	1.98(cm)	min area gyration radius	iv =	1.27(cm)
	angle edge width	B =	6.5(cm)	thickness	t =	0.60(cm)

2	name : L-75x75x6					
	unit weight	=	67.20(N/m)	section area	A =	8.727(cm^2)
	area gyration radius	iy =	2.30(cm)	min area gyration radius	iv =	1.48(cm)
	angle edge width	B =	7.5(cm)	thickness	t =	0.60(cm)

3	name : L-75x75x9					
	unit weight	=	97.70(N/m)	section area	A =	12.690(cm^2)
	area gyration radius	iy =	2.25(cm)	min area gyration radius	iv =	1.45(cm)
	angle edge width	B =	7.5(cm)	thickness	t =	0.90(cm)

No.					
4	name : L-90x90x10				
	unit weight =	130.40(N/m)	section area	A =	17.000(cm²)
	area gyration radius iy =	2.71(cm)	min area gyration radius	iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness	t =	1.00(cm)
5	name : L-100x100x10				
	unit weight =	146.10(N/m)	section area	A =	19.000(cm²)
	area gyration radius iy =	3.04(cm)	min area gyration radius	iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness	t =	1.00(cm)

4.8 Hori. brace Registered data

No.					
1	name : L-65x65x6				
	unit weight =	58.00(N/m)	section area	A =	7.527(cm²)
	moment of inertia iy =	1.98(cm)	min area gyration radius	iv =	1.27(cm)
	angle edge width B =	6.5(cm)	thickness	t =	0.60(cm)
2	name : L-75x75x6				
	unit weight =	67.20(N/m)	section area	A =	8.727(cm²)
	moment of inertia iy =	2.30(cm)	min area gyration radius	iv =	1.48(cm)
	angle edge width B =	7.5(cm)	thickness	t =	0.60(cm)
3	name : L-75x75x9				
	unit weight =	97.70(N/m)	section area	A =	12.690(cm²)
	moment of inertia iy =	2.25(cm)	min area gyration radius	iv =	1.45(cm)
	angle edge width B =	7.5(cm)	thickness	t =	0.90(cm)
4	name : L-90x90x10				
	unit weight =	130.40(N/m)	section area	A =	17.000(cm²)
	moment of inertia iy =	2.71(cm)	min area gyration radius	iv =	1.74(cm)
	angle edge width B =	9.0(cm)	thickness	t =	1.00(cm)
5	name : L-100x100x10				
	unit weight =	146.10(N/m)	section area	A =	19.000(cm²)
	moment of inertia iy =	3.04(cm)	min area gyration radius	iv =	1.95(cm)
	angle edge width B =	10.0(cm)	thickness	t =	1.00(cm)

4.9 Lateral joint member 1 side U steel Registered data

No.					
1	name : [-200x90x8x13.5				
	unit weight =	297.0(N/m)	section area	A =	38.65(cm²)
	area gyration radius iy =	2.68(cm)			
	web height h =	20.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1 =	0.80(cm)	compressive flange thickness	t2 =	1.35(cm)
2	name : [-250x90x9x13				
	unit weight =	339.0(N/m)	section area	A =	44.07(cm²)
	area gyration radius iy =	2.58(cm)			
	web height h =	25.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)
3	name : [-300x90x9x13				
	unit weight =	374.0(N/m)	section area	A =	48.57(cm²)
	area gyration radius iy =	2.52(cm)			
	web height h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1 =	0.90(cm)	compressive flange thickness	t2 =	1.30(cm)
4	name : [-300x90x10x15.5				
	unit weight =	430.0(N/m)	section area	A =	55.74(cm²)
	area gyration radius iy =	2.54(cm)			
	web height h =	30.0(cm)	compressive flange width	b =	9.0(cm)
	web thickness t1 =	1.00(cm)	compressive flange thickness	t2 =	1.55(cm)

4.10 Lateral joint member L section steel Registered data

1
name : L-65x65x6
unit weight = 58.0(N/m) section area A = 7.527(cm²)
area gyration radius iy = 1.98(cm)
angle edge width B = 6.5(cm) thickness t = 0.60(cm)

2
name : L-75x75x6
unit weight = 67.2(N/m) section area A = 8.727(cm²)
area gyration radius iy = 2.30(cm)
angle edge width B = 7.5(cm) thickness t = 0.60(cm)

3
name : L-75x75x9
unit weight = 97.7(N/m) section area A = 12.690(cm²)
area gyration radius iy = 2.25(cm)
angle edge width B = 7.5(cm) thickness t = 0.90(cm)

4
name : L-90x90x10
unit weight = 130.4(N/m) section area A = 17.000(cm²)
area gyration radius iy = 2.71(cm)
angle edge width B = 9.0(cm) thickness t = 1.00(cm)

5
name : L-100x100x10
unit weight = 146.1(N/m) section area A = 19.000(cm²)
area gyration radius iy = 3.04(cm)
angle edge width B = 10.0(cm) thickness t = 1.00(cm)

4.11 Retaining wall Steel sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	II	400	100	48.0	153.00	8740	874
2	III	400	125	60.0	191.00	16800	1340
3	III	400	130	60.0	191.00	17400	1340
4	IV	400	170	76.1	242.50	38600	2270
5	VL	500	200	105.0	267.60	63000	3150
6	IIw	600	130	61.8	131.20	13000	1000
7	IIIw	600	180	81.6	173.20	32400	1800
8	IVw	600	210	106.0	225.50	56700	2700

4.12 Retaining wall soldier lateral sheet pile Registered data

No	steel name	H (mm)	B (mm)	tw (mm)	tf (mm)	A (cm²)	w (kg/m)	Ix (cm⁴)	Zx (cm³)
1	H-100x100x 6x 8	100	100	6.0	8	21.59	16.9	378	76
2	H-125x125x 6x 9	125	125	6.5	9	30.00	23.6	839	134
3	H-150x150x 7x10	150	150	7.0	10	39.65	31.1	1620	216
4	H-175x175x 7x11	175	175	7.5	11	51.42	40.4	2900	331
5	H-200x200x 8x12	200	200	8.0	12	63.53	49.9	4720	472
6	H-250x250x 9x14	250	250	9.0	14	91.43	71.8	10700	860
7	H-300x300x10x15	300	300	10.0	15	118.40	93.0	20200	1350
8	H-350x350x12x19	350	350	12.0	19	171.90	135.0	39800	2280
9	H-400x400x13x21	400	400	13.0	21	218.70	172.0	66600	3330
10	H-400x400x18x28	414	405	18.0	28	295.40	232.0	92800	4480
11	H-400x400x20x35	428	407	20.0	35	360.70	283.0	119000	5570
12	H-400x400x30x50	458	417	30.0	50	528.60	415.0	187000	8170
13	H-400x400x45x70	498	432	45.0	70	770.10	605.0	298000	12000

4.13 Retaining wall Lightweight sheet pile Registered data

No	steel name	w (mm/sheets)	h (mm)	W (kg/m²)	A (cm²/m)	I (cm⁴/m)	Z (cm³/m)
1	TypeA	250	36	14.8	75.40	107	60
2	TypeB	333	51	17.9	68.28	510	144
3	TypeC	333	85	19.3	73.80	2000	272
4	TypeD	333	74	21.6	82.53	636	171
5	TypeE	500	160	33.6	85.70	3620	452