DESIGN CALCULATION COVER SHEET

Project	Detailed Design on Port Reactivation Project in La Union Province	**Project Code**	JC1N004
Section	**Civil**	Calc. File No.	
Sub-Section	**Quaywall**	Calc. Index No.	

Subject: **Passenger Berth**

Calculation Objective:

Cathodic protection

References, Calculation Notes and Comments

Refer to drawings **QW-02-032,QW-02-033**

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

Rev	Prepared		No. of	Checked		Reviewed		Superseded
	by	Date	Pages	by	Date	by	Date	by Calc No.
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References/ Notes

.1. Anode 1

.1.1. Anode to be use

- Model ; ANODE-1
- Dimension ; (230+250) X 240 X 790 (mm)
- Net Mass ; 121.7kg (Exclude core)
- Output Current ; 3.5 amp. (Seawater resistivity = 25 ohm.cm)
- Design Life ; 20 years

.1.2. Design conditions and Performance of Aluminum alloy anode

(1) Performance of Aluminum alloy anode

- Closed circuit potential ; -1050 mV vs. SCE. or more negative
- Driving voltage ; 0.25 V
- Capacity ; 2600 A.hr/kg or more
- Density of Aluminum Alloy ; 2.7g/cm^3

(2) Design conditions

- Seawater resistivity ; 25 ohm.cm
- Current reduction factor of anode ; 50 %
- Design life ; 20 years

.1.3. Calculation

(1) Anode resistance

Anode resistance is calculated by the following formula

When L/D<6,

$R = (0.266 \times p) / (S)^{0.5}$

where,

p ; Seawater resistivity 25(ohm.cm)

S ; Surface area of anode (cm^2)

L ; Anode length 79cm

D ; Equivalent diameter of anode (cm)

A ; Upper base in trapezoid (trapezium) of anode cross section 23.0cm

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			26 / 07 /2002		8 / Aug /2002

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B ; Lower base in trapezoid (trapezium) of anode cross section 25.0cm

C ; Height in trapezoid (trapezium) of anode cross section 24.0cm

$D = [A + B + 2 \times \{C^2 + (B-A)^2/4\}^{0.5}] / 3.14 = 30.6$ cm

$L/D = 2.5$ (<6)

$S=[A + B + 2 \times \{C^2 + (B-A)^2/4\}^{0.5}] \times L + (A+B)/2 \times C \times 2 = 8739.3$ cm^2

$R = (0.266 \times 25) / 8739.3^{0.5} = 0.071$ ohm

(2) Output current

Initial output current of anode is calculated by the following formula

$I = E/R$

where,

I ; Initial output current of anode (A)

E ; Driving voltage 0.25(V)

R ; Anode resistance (ohm)

$I = 0.25 / 0.071 = 3.5$ A

(3) Anode net mass

Anode net mass is calculated by the following formula

$W=(V_A-V_C) \times a \ / 1000$

where,

W ; Anode net mass(kg)

V_A ; Volume of Aluminum alloy , including inside core (cm^3)

$V_A = (A+B) \times C \times 1/2 \times L = 45504.0$ cm^3

V_C ; Volume of inside core 444.4 (cm^3)

a ; Aluminum alloy density 2.7(g/cm^3)

$W=(V_A-V_C) \times a \ / 1000 = (45504.0-444.4) \times 2.7 /1000 = 121.7$ kg

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(4) Design life of anode

Design life of anode is calculated by the following formula

T = (Q X W) / (8760 X I X f)
where,
T ; design life of anode (yr)
Q ; Capacity 2600 A.hr/kg
W ; Anode net mass (kg)
I ; Initial output current of anode 3.5A
f ; current reduction factor of anode 0.5
8760 ; Time per year (hr/year)

T = (2600 X 121.7) / (8760 X 3.5 X 0.5) = 20 year

2. Anode 2

2.1. Anode to be use

- Model ; ANODE-2
- Dimension ; (170+210) X 190 X 1050 (mm)
- Net Mass ; 101.1kg (Exclude core)
- Output Current ; 3.0 amp. (Seawater resistivity = 25 ohm.cm)
- Design Life ; 20 years
- A part of Aluminum alloy surface are coated with tar epoxy

2.2. Design conditions and Performance of Aluminum alloy anode

(1) Performance of Aluminum alloy anode

- Closed circuit potential ; -1050 mV vs. SCE. or more negative
- Driving voltage ; 0.25 V
- Capacity ; 2600 A.hr/kg or more
- Density of Aluminum Alloy ; 2.7g/cm^3

(2) Design conditions

- Seawater resistivity ; 25 ohm.cm
- Current reduction factor of anode ; 50 %
- Design life ; 20 years

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2.3. Calculation

(1) Anode resistance

Anode resistance is calculated by the following formula

When L/D<6,

$R = (0.266 \times p) / (S)^{0.5}$

where,

p ; Seawater resistivity 25 (ohm.cm)

S ; Surface area of anode (cm^2)

L ; Anode length 105.0cm

D ; Equivalent diameter of anode (cm)

A ; Upper base in trapezoid (trapezium) of anode cross section 17.0cm

B ; Lower base in trapezoid (trapezium) of anode cross section 21.0cm

C ; Height in trapezoid (trapezium) of anode cross section 19.0cm

$D = [A + 2 \times \{C^2 + (B-A)^2/4\}^{0.5}] / 3.14 = 17.6$ cm

L/D = 5.9 (<6)

$S=[A + 2 \times \{C^2 + (B-A)^2/4\}^{0.5}] \times L + (A+B)/2 \times C \times 2 = 6519.0\ cm^2$

$R = (0.266 \times 25) / 6519.0^{0.5} = 0.082$ ohm

(2) Output current

Initial output current of anode is calculated by the following formula

I = E/R

where,

I ; Initial output current of anode (A)

E ; Driving voltage 0.25(V)

R ; Anode resistance (ohm)

I = 0.25 / 0.082 = 3.0 A

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References/ Notes

(3) Anode net mass

Anode net mass is calculated by the following formula

$W=(V_A-V_C) X a \ / 1000$

where,

W ; Anode net mass (kg)

V_A ; Volume of Aluminum alloy , including inside core (cm^3)

$V_A = (A+B) X C X 1/2 X L = 37905.0 cm^3$

V_C ; Volume of inside core 462.0 (cm^3)

a ; Aluminum alloy density 2.7(g/cm^3)

$W=(V_A-V_C) X a \ / 1000 = (37905.0-462.0) X 2.7 /1000 =101.1$ kg

(4) Design life of anode

Design life of anode is calculated by the following formula

T = (Q X W) / (8760 X I X f)

where,

T ; design life of anode (yr)

Q ; Capacity 2600 A.hr/kg

W ; Anode net mass (kg)

I ; Initial output current of anode 3.0A

f ; current reduction factor of anode 0.5

8760 ; Time per year (hr/year)

T = (2600 X 101.1) / (8760 X 3.0 X 0.5) = 20 year

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DESIGN CALCULATION COVER SHEET

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Section	**Civil**	Calc. File No.	
Sub-Section	**Quaywall**	Calc. Index No.	

Subject: **Passenger Berth**

Calculation Objective:

Stability of Bitte base

References, Calculation Notes and Comments

Refer to drawings **QW-02-029,QW-02-030**

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

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· Calculation of the gravity-type foundation of a mooring post

1 Design Condition

(1) Tractive Force

Tractive Force : Pm	Pm=	1000	kN
Vertical force by tractive force		500	kN

(2) dimension of foundation of a mooring post

Width : B(m)	Length : L(m)	Height:H(m)
7.10	7.10	2.90

Height of Crown	+5.00
H.W.L	+3.37

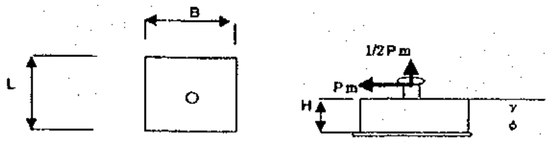

fig. Dimension of foundation of a mooring post

(3) Safety Factor

Sliding	1.2
Overturning	1.2
Bearing Capacity	1.5

2. Stability Calculation

(1) Calculation of Load

1) Calculation of Deadweight

i	Volume				Unit Weight γc(kN/m3)	Weight Wd(kN)	Center of gravity Xd(m)	Resistance moment Wd·Xd(tf·m/m)
	Factor	Width(m)	Height(m)	V(m3)				
1	1.000	7.100	2.900	20.590	22.600	465.334	3.550	1651.936
Total						465.334		1651.936

※) Factor : When form is a triangle =0.5
When form is a quadrangle =1.0

2) Mooring force and its acting point

	Mooring force		Action point		overturning moment (kN·m/m)	
	Pmv(kN/m)	Pmh(kN/m)	Xm(m)	Ym(m)	Mx	My
1	-70.423	140.845	3.550	3.400	-250.000	478.873
Total	-70.423	140.845			-250.000	478.873

3) Calculation of Buoyancy

Water Surface Elevation (Distance from Crown) 1.63 m

i	Volume				Unit Weight γc(kN/m3)	Weight Wd(kN)	Center of gravity Xd(m)	Resistance moment Wd·Xd(tf·m/m)
	Factor	Width(m)	Height(m)	V(m3)				
1	1.000	7.100	1.270	9.017	10.100	-91.072	3.550	-323.305
Total						-91.072		-323.305

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4) Calculation of Active Earth Pressure

- Surcharge : q — q = 10.0 kN/m2
- Unit weight of soil — γ = 18.0 kN/m3
- Submerged unit weight of soil — γ' = 10.0 kN/m3
- Angle of internal friction : φ — φ = 30.0 °
- Angle of friction between backfilling material and backface wall : δ — δ = 15.0 °
- Coefficient of active earth pressure : Ka — Ka = 0.3014
- Water Surface Elevation (Distance from Crown) — 1.63 m

i	Active and Horizontal Earth Pressure : Pah				Action point	Overturning moment
	Height (m)	Upper surface earth pressure (kN/m2)	Lower surface earth pressure (kN/m2)	Earth Pressure (kN/m)	Ya(m)	Pa·Ya (kN·m/m)
1	1.630	2.911	11.454	11.708	1.923	22.519
2	1.270	11.454	15.151	16.894	0.606	10.231
Total				28.602		32.750

i	Active and Vertical Earth Pressure : Pav				Action point	Overturning moment
	Height (m)	Upper surface earth pressure (kN/m2)	Lower surface earth pressure (kN/m2)	Earth Pressure (kN/m)	Xa(m)	Pa·Ya (kN·m/m)
1	2.900	0.780	3.069	5.581	7.100	39.627
Total				5.581		39.627

5) Calculation of Passive Earth Pressure

- Surcharge : q — q = 0.0 tf/m2
- Unit weight of soil — γ = 10.0 tf/m3
- Angle of internal friction : φ — φ = 30.0 °
- Angle of friction between backfilling material and backface wall : δ — δ = -15.0 °
- Coefficient of active earth pressure : Ka — Kp = 4.9765

i	Passive and Horizontal Earth Pressure : Pph				Action point	Overturning moment
	Height (m)	Upper surface earth pressure (kN/m2)	Lower surface earth pressure (kN/m2)	Earth Pressure (kN/m)	Yp(m)	Pph·Yp (tf·m/m)
1	0.900	0.000	43.262	19.468	0.300	5.840
合計				19.468		5.840

i	Passive and Vertical Earth Pressure : Ppv				Action point	Overturning moment
	Height (m)	Upper surface earth pressure (kN/m2)	Lower surface earth pressure (kN/m2)	Earth Pressure (kN/m)	Xp(m)	Ppv·Xp (tf·m/m)
1	0.900	0.000	-11.592	-5.216	0.000	0.000
合計				-5.216		0.000

5) Generalization of Load

	Vertical Load (kN/m)	Moment by vertical load My (kN·m/m)	Horizontal Load (kN/m)	Moment by horizontal load Mh (kN·m/m)
Deadweight:Wd	465.334	1651.936		
Mooring Force:Pm	-70.423	-250.000	140.845	478.873
Buoyancy:U	-91.072	-323.305		
Active Earth Pressure:Pa	5.581	39.627	28.602	32.750
Passive Earth Pressure:Pp	-5.216	0.000	-19.468	-5.840
total	304.205	1118.258	149.979	505.783

(2) Calculation of Safety Factor

Safety Factor of Sliding F = (μ · (Wd+Pmv+Pav) +Pp) / (Pmh+Pah)
Safety Factor of Overturning F = (Wd·Xd+V·Xo+Pav·Xa) / (Pah·Ya+Pp·Yp+Pmh·Ymh)

	Coefficient of Friction	Safety Factor of Sliding	Safety Factor of Overturning
Mooring Condition	0.6	1.22 >1.2 OK	2.21 >1.2 OK

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3. Examination of Bearing Capacity
(1) Bottom Reaction

$e = b/2 - x$
$x = (Mv - Mh)/V$

wher e : eccentricity of resultant force (m)
b : width of bottom (m)
Mv : moment for an observing point by vertical resultant force (kN·m)
Mh : moment for an observing point by horizontal resultant force (kN·m)
V : vertical resultant force (kN)

Mv(kN·m)	Mh(kN·m)	V (kN)	b (m)	x (m)
1118.258	505.783	304.205	7.100	2.013

e (m)	b/6 (m)	shape of distribution
1.537	1.183	Triangle

Since it is "e≧b/6", bottom reaction is shape of triangle.
Bottom reaction is computed by the following formulas.

$p1 = 2/3 * V/(b/2 - e)$
$b' = 3*(b/2 - e)$
where, p1:reaction at the front toe (m)
b':distribution width of bottom reaction

p1(kN/m2)	b'(m)
100.728	6.040

(2)Allowable Bearing Capacity and Examination of Bearing Capacity

Allowable bearing capacity is calculated by the following formula.

$qa = 1/F*(\beta*\gamma 1*B*Nr + \gamma 2*D*Nq) + \gamma 2*D$

where qa : bearing capacity (tf/m2)
B : smallest width of foundation (m)
D : embedded length of foundation (m)
γ1 : unit weight of soil below the level of foundation bottom (kN/m3)
(submerged unit weight if submerged)
γ2 : unit weight of soil above thr level of foundation bottom (kN/m3)
(submerged unit weight if submerged)
Nr, Nq : bearing capacity factors
φ : internal friction angle

φ	Nr	Nq
40°	100.0	80.0

β : shape factor of foundation

	shape factor			
Shape of foundation	Continuous	Square	Circular	Rectangular
β	0.5	0.4	0.3	0.5-0.1(B/L)

※) B : short side length
L : long side length

F : safety factor
The safety factor should not be less than 2.5 as a general rule.

B(m)	D(m)	γ1(kN/m3)	γ2(kN/m3)	β
7.10	0.00	10.00	10.00	0.50

The examination of bearing capacity of foundation on ground is as follows.

F	qa(kN/m2)	q(kN/m2)	Judgment
2.5	1420.000	100.728	OK

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Section	**Civil**	Calc. File No.	
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Subject: **West Rivetment**

Calculation Objective:

Stability of Revetment

References, Calculation Notes and Comments

Refer to drawing **RV-00-001,RV-00_004~RV-00-005**
RV-01-001~RV-01-023

Calculation based on
TECHNICAL STANDERDS AND COMMENTARIES
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WEST REVETMET -9.5m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.378
center of slip circle X = 30.00 (m)
Y = 26.00 (m)
radius of slip circle R = 44.00 (m)
resisting moment M_R = 95853.1 (kN·m)
overturning moment M_D = 69542.4 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	30.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	40.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

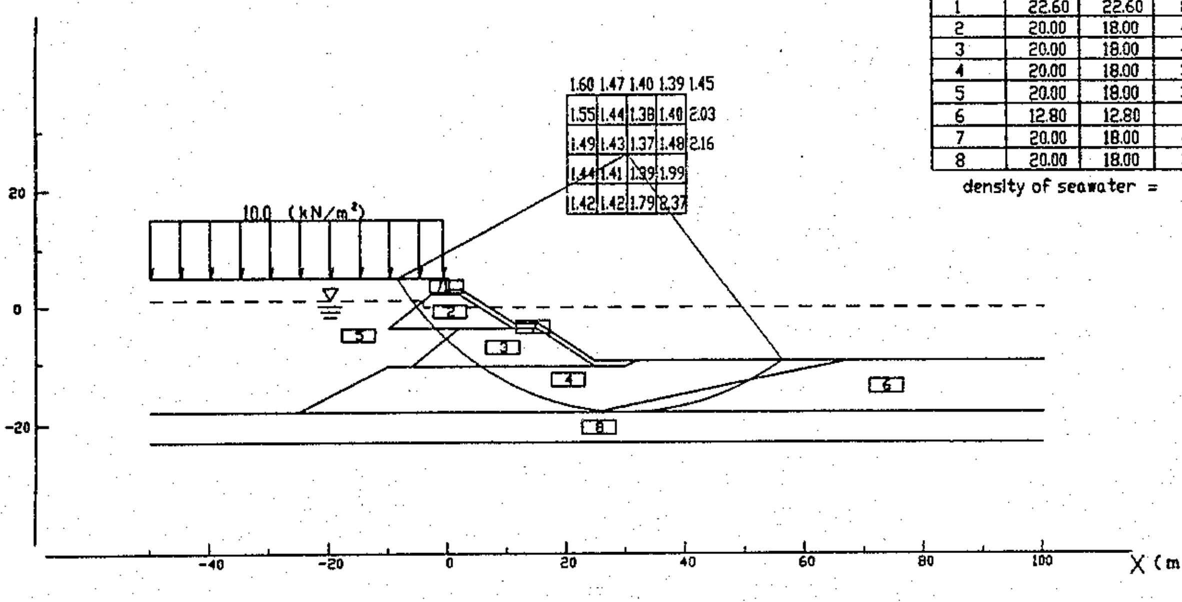

figure of safety factor (ordinary condition)

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WEST REVETMET -8.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.373
center of slip circle X = 30.00 (m)
Y = 22.00 (m)
radius of slip circle R = 39.00 (m)
resisting moment M_R = 73791.8 (kN·m)
overturning moment M_D = 53729.8 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	30.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	40.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

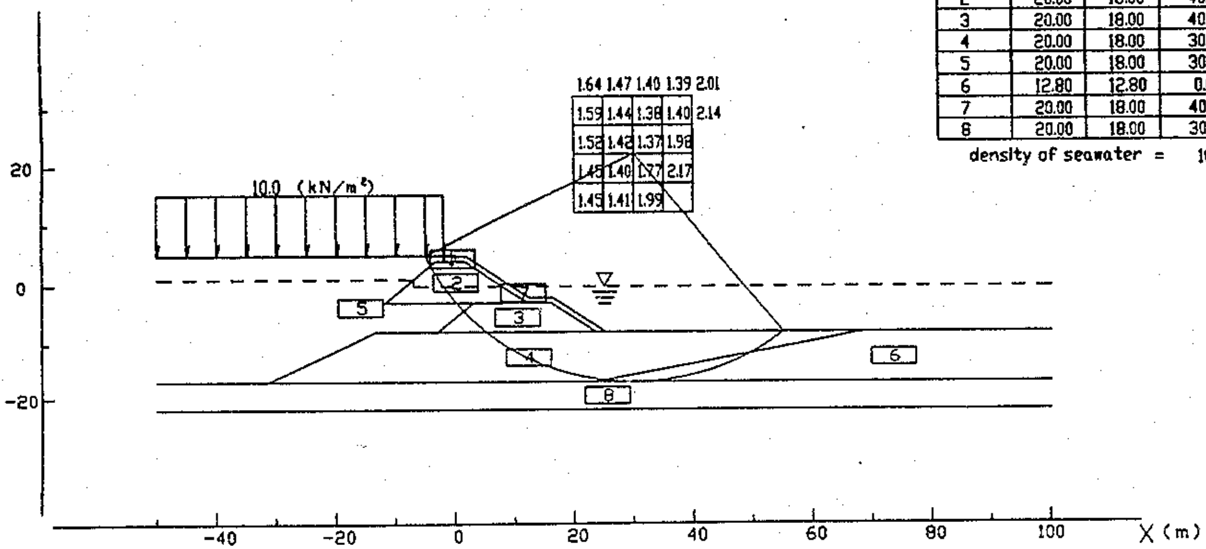

figure of safety factor (ordinary condition)

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WEST REVETMET -6.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.395
center of slip circle X = 25.00 (m)
Y = 19.00 (m)
radius of slip circle R = 33.50 (m)
resisting moment M_R = 54398.0 (kN·m)
overturning moment M_D = 38991.0 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	30.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	40.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

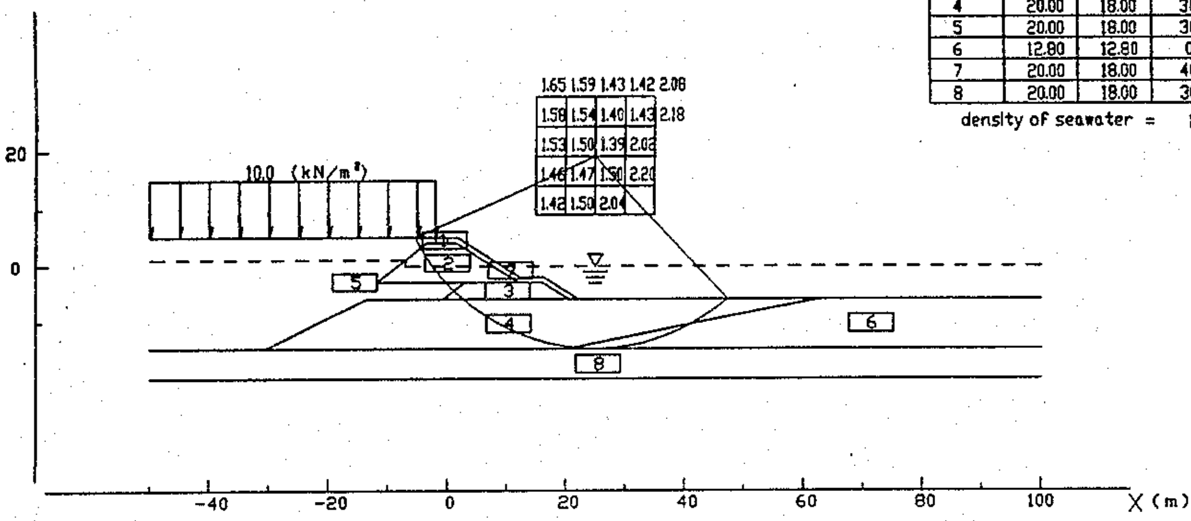

figure of safety factor (ordinary condition)

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	26/07/2002		08/08/2002

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WEST REVETMET -4.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.285
center of slip circle X = 12.00 (m)
Y = 9.00 (m)
radius of slip circle R = 15.00 (m)
resisting moment M_R = 10450.4 (kN・m)
overturning moment M_0 = 8133.7 (kN・m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	30.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

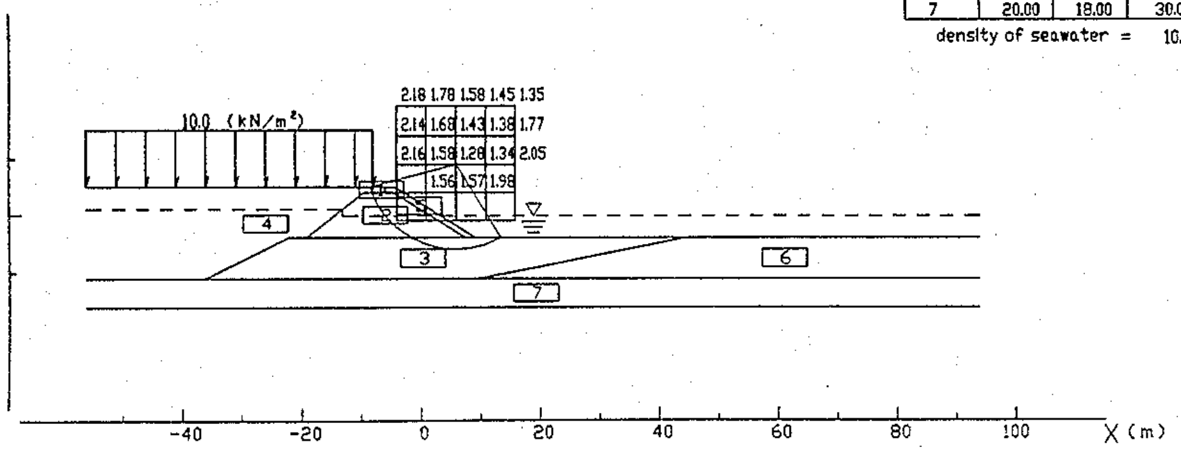


figure of safety factor (ordinary condition)

Prepared by	Y. Ando	Checked by	R. NISHIMURA
	26/ 07 /2002		08 / 08 /2002

DESIGN CALCULATION COVER SHEET

Project	Detailed Design on Port Reactivation Project in La Union Province	**Project Code**	JC1N004
Section	**Civil**	Calc. File No.	
Sub-Section	**Revetmentl**	Calc. Index No.	

Subject: **East Revetment**

Calculation Objective:

Stability of Revetment

References, Calculation Notes and Comments

Refer to drawing **RV-00-001～RV-00-003**

RV-02-001～RV-02-020

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

Rev	Prepared		No. of	Checked		Reviewed		Superseded
	by	Date	Pages	by	Date	by	Date	by Calc No.
O	[illegible]	26/07/02	5	[illegible]	26 July 02	[illegible]	26/08/02	
A								
B								
C								

File in Calc. File

FN : Calculation_Cover_Sheet

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. /	Rev.

EAST REVETMENT -14.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.305
center of slip circle X = -33.00 (m)
Y = 20.00 (m)
radius of slip circle R = 40.00 (m)
resisting moment M_R = 100289.7 (kN·m)
overturning moment M_D = 76871.8 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

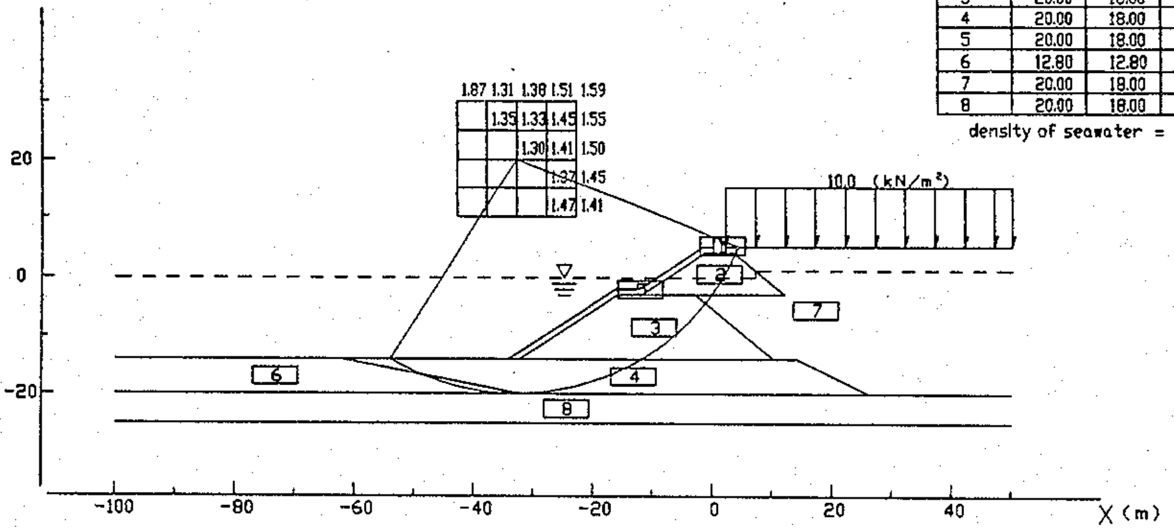


figure of safety factor (ordinary condition)

Prepared by	Y. Ando	Checked by	E. NISHIMURA
	26 / 07 / 2002		08 / 08 / 2002

FN: Calculation_Sheet

EAST REVETMENT -10.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.323
center of slip circle X = -28.00 (m)
Y = 20.00 (m)
radius of slip circle R = 34.00 (m)
resisting moment M_R = 51595.7 (kN·m)
overturning moment M_D = 39001.8 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

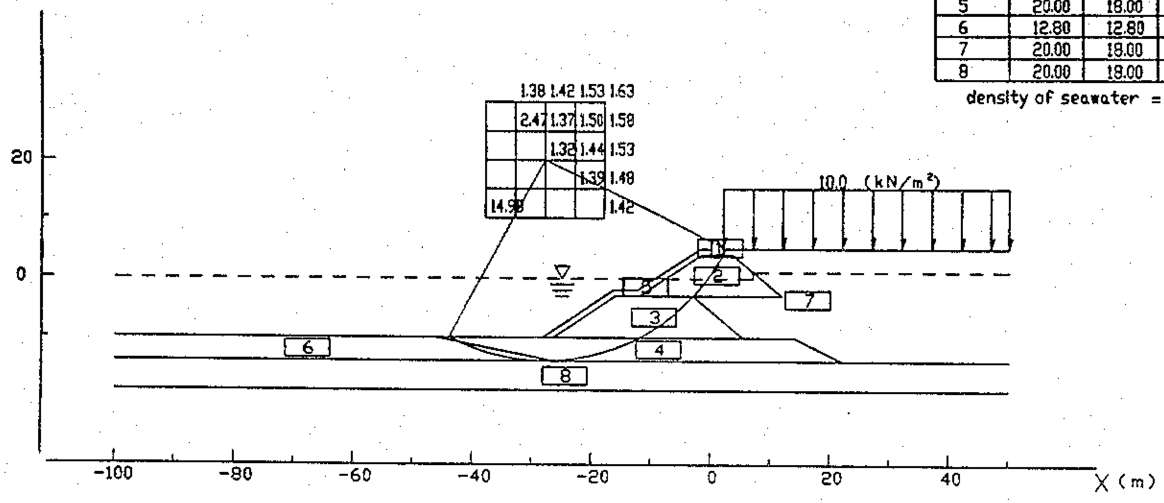


figure of safety factor (ordinary condition)

Prepared by	Y Ando	Checked by	R. NISHIMURA
	26/07/2002		08/08/2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No 3	Rev

EAST REVETMENT -8.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.387
center of slip circle X = -19.00 (m)
Y = 12.00 (m)
radius of slip circle R = 23.00 (m)
resisting moment M_R = 31164.5 (kN·m)
overturning moment M_D = 22462.1 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	First-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

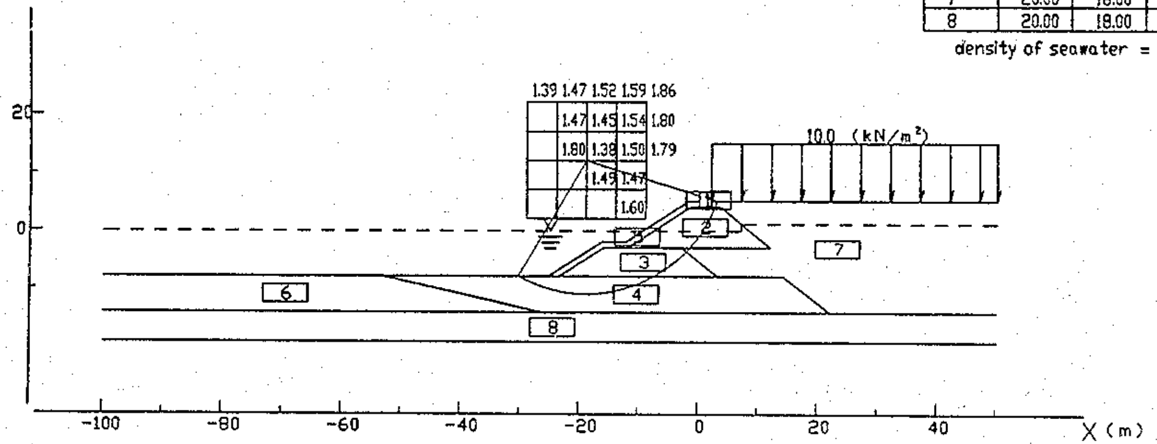


figure of safety factor (ordinary condition)

Prepared by	Y. Ando	Checked by	R. NISHIMURA
	26/07/2002		08/08/2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. 4	Rev.

EAST REVETMENT -6.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.352
center of slip circle X = -25.00 (m)
Y = 16.00 (m)
radius of slip circle R = 30.00 (m)
resisting moment M_R = 41822.0 (kN·m)
overturning moment M_D = 30935.1 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	40.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000
8	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

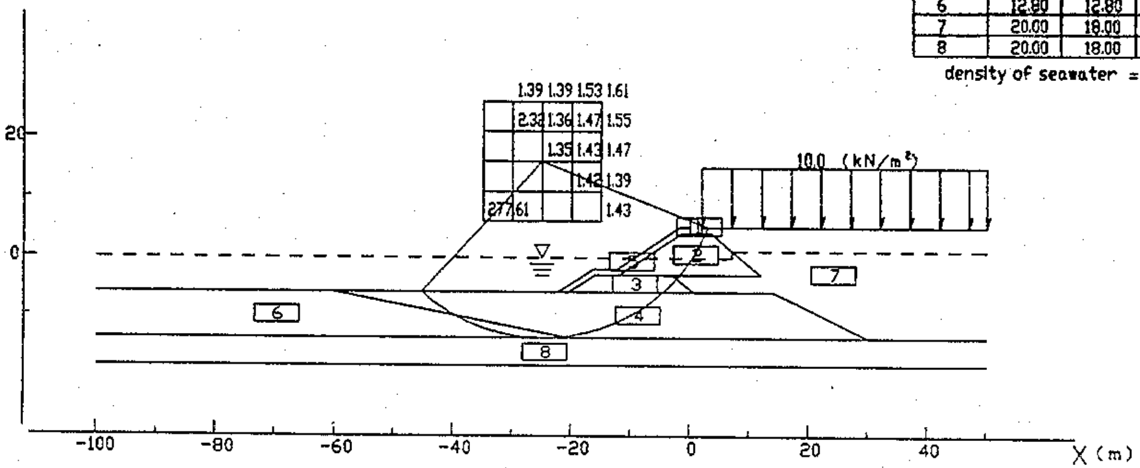


figure of safety factor (ordinary condition)

	Prepared by	Y. Ando	Checked by	K. NISHIMURA
		26/07/2002		08/08/2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. 5	Rev.

EAST REVETMENT -4.0m

scale : 1/ 1000

minimum safety factor F_{smin} = 1.235
center of slip circle X = -12.00 (m)
Y = 9.00 (m)
radius of slip circle R = 15.00 (m)
resisting moment M_R = 11015.0 (kN·m)
overturning moment M_S = 8922.4 (kN·m)

layer No.	saturated unit weight (kN/m³)	wet unit weight (kN/m³)	internal friction angle of soil (°)	cohesion of soil (kN/m²)	first-order coefficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	22.60	22.60	89.00	0.0	0.0	0.000	0.000
2	20.00	18.00	40.00	0.0	0.0	0.000	0.000
3	20.00	18.00	30.00	0.0	0.0	0.000	0.000
4	20.00	18.00	30.00	0.0	0.0	0.000	0.000
5	20.00	18.00	40.00	0.0	0.0	0.000	0.000
6	12.80	12.80	0.00	5.0	0.0	0.000	0.000
7	20.00	18.00	30.00	0.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

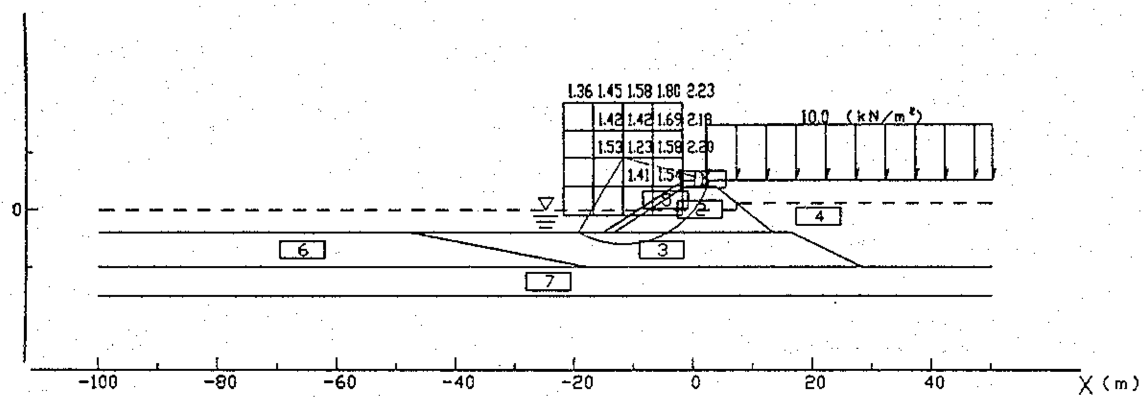


figure of safety factor (ordinary condition)

Prepared by	Y. Ando	Checked by	R. NISHIMURA
	26 / 07 /2002		08 / 08 /2002

DESIGN CALCULATION COVER SHEET

Project	Detailed Design on Port Reactivation Project in La Union Province	Project Code	JC1N004
Section	Civil	Calc. File No.	
Sub-Section	Revetmentl	Calc. Index No.	

Subject: Revetment (EAST & WEST)

Calculation Objective:

Stability of armor stone

References, Calculation Notes and Comments

Refer to drawings RV-00-001～RV-00-008

RV-01-001～RV-01-023

RV-02-001～RV-02-020

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

Rev	Prepared by	Prepared Date	No. of Pages	Checked by	Checked Date	Reviewed by	Reviewed Date	Superseded by Calc No.
O	[signature]	26/07/02	8	[signature]	26 July 02	[signature]	26/08/02	
A								
B								
C								

File in Calc. File

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. /	Rev.

References/
Notes

WAVE HIDCASTING

WAVE HIGHT AT THE FRONT OF EAST REVETMENT

Dumping Area A (West) 前面の発生波高

	オペレーション時	10年確率	50年確率	
WIND VELOCITY U (m/s)	15	23.217	29.7	27.8
FETCH (m)	7,625	7,625	7,625	7,625
H 1/3 (m)	0.904	1.450	1.883	1.756
T 1/3 (sec)	3.111	3.741	4.134	4.026

	F (km)	θ1 − θ	Δθ	cos(θ1 − θ)Δθ	
	6.8	31	39	33.430	194.852
MAIN DIRECTION	10.6	0	17	17.000	180.200
	9.4	10.5	10	9.833	90.878
	8.8	20.5	15	14.050	115.811
	6.8	35	9.0	7.372	41.066
			90	81.685	622.807

VALID FETCH 7.625 km

Dumping Area A (North) & Dumping Area B 前面の発生波高

	オペレーション時	10年確率	50年確率	
風速 U (m/s)	15	23.217	29.7	27.8
吹送距離 (m)	10,133	10,133	10,133	10,133
H 1/3 (m)	1.026	1.655	2.153	2.007
T 1/3 (sec)	3.370	4.066	4.500	4.381

	F (km)	θ1 − θ	Δθ	cos(θ1 − θ)Δθ	
	14.8	16.2	8.3	7.970	113.279
	10.8	8.5	4.6	4.549	48.595
主方向	17.2	0	12.8	12.800	220.160
	7.2	26.5	38.0	34.008	219.128
			63.7	59.327	601.162

有効フェッチ 10.133 km

		Prepared by	Y. Ando	Checked by	R. NISHIMURA
			26/07/2002		08/08/2002

FN: Calculation_Sheet

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. 2	Rev.

References/ Notes

WEIGHT OF ARMOR STONE

CALCURATION FORMULA (Hudson's Formula)

$$M = \frac{\rho r * H3}{NS3(Sr-1)3}$$

Where

M :minimum mass of rubble stones

ρr : density of armor stones (t/m3)

H : wave height used in the stability calculation (m)

Ns : stability number

Sr : specific gravity of rubble stones relative to sea water

Return Period	Rp	10年	50年	10年	50年
Coefficient of disaster	D_N	1%	10%		
Density of armor stone	Gs	2.60			
Density of sea water	γw	1.03 tf/m3			
	K_D	4.0	4.9		
Wave height	$H_{1/3}$	1.655	2.153	1.45	1.883

Gs=2.60 の場合

Dumping Area "A"

Temporary Revetment A-North

Damage ratio		Return Period 10years	50years
0%~5%	K_D=4.0	0.49	1.09
5%~10%	K_D=4.9	0.40	0.89

Temporary Revetment A-West

Damage ratio		Return Period 10years	50years
0%~5%	K_D=4.0	0.33	0.73
5%~10%	K_D=4.9	0.27	0.59

Dumping Area "B"

Temporary Revetment B

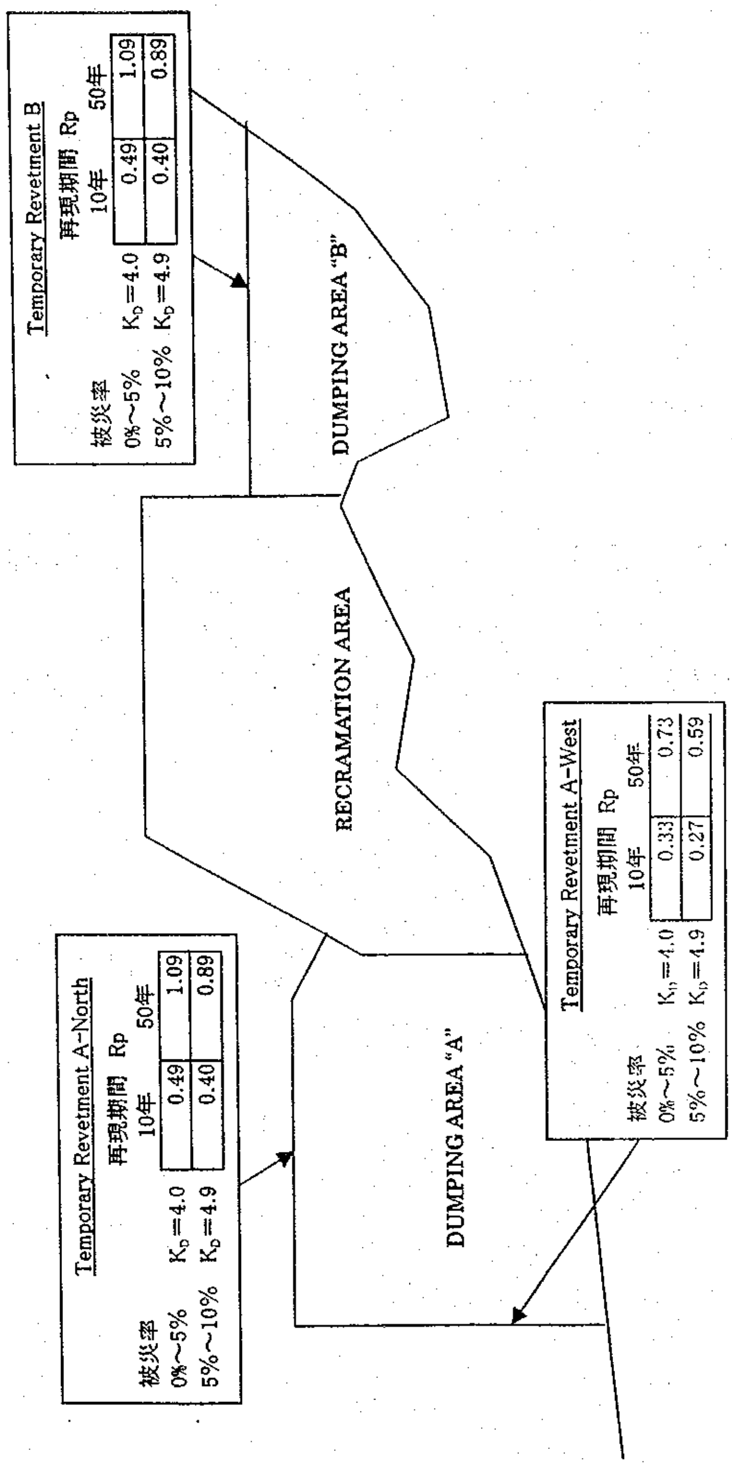
Damage ratio		Return Period 10years	50years
0%~5%	K_D=4.0	0.49	1.09
5%~10%	K_D=4.9	0.40	0.89

Prepared by	Y. Ando	Checked by	R. NISHIMURA
	26 / 07 /2002		08 / 08 /2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. 3	Rev.

References/ Notes

Calculation Result of Armor Stone



		Prepared by	Y. Ando	Checked by	R. NISHIMURA
			26/07/2002		08/08/2002

DESIGN CALCULATION COVER SHEET

Project	Detailed Design on Port Reactivation Project in La Union Province	**Project Code**	JC1N004
Section	**Civil**	Calc. File No.	
Sub-Section	**Revetmentl**	Calc. Index No.	

Subject: **Transitional part**

Calculation Objective:

Stability of Concrete Block Wall

References, Calculation Notes and Comments

Refer to drawings **RV-03-001,RV-03-002**

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

Rev	Prepared		No. of	Checked		Reviewed		Superseded
	by	Date	Pages	by	Date	by	Date	by Calc No.
O	[signature]	26/07/02	44	[signature]	26 July 02	[signature]	26/08/02	
A								
B								
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File in Calc. File

FN : Calculation_Cover_Sheet

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. /	Rev.

References/ Notes

1. Design Conditions

1-1. Form and Dimensions

Crown Height	5.000 (m)
Bottom Height	-3.000 (m)

1-2. Tide Level

H.W.L	3.370 (m)
L.W.L	-0.130 (m)

1-3. Residual Water Height

R.W.L	1.033 (m)

1-4. Surcharge

	Normal Condition (kN/m²)	Seismic Condition (kN/m²)
	19.600	9.800

1-5. Seismic Coefficient

For Earth Pressure	0.200
For Inertia Force	0.200

1-6. Safety Factor

	Normal condition	Seismic condition
: Sliding	1.200	1.000
Overturning	1.200	1.100
Bearing Capacity (Sandy Soil)	2.500	2.500
Bearing Capacity (Cohesive Soil)	1.500	1.500

	Prepared by Y. Ando		Checked by R. NISHIMURA
		26/07/2002	08/08/2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
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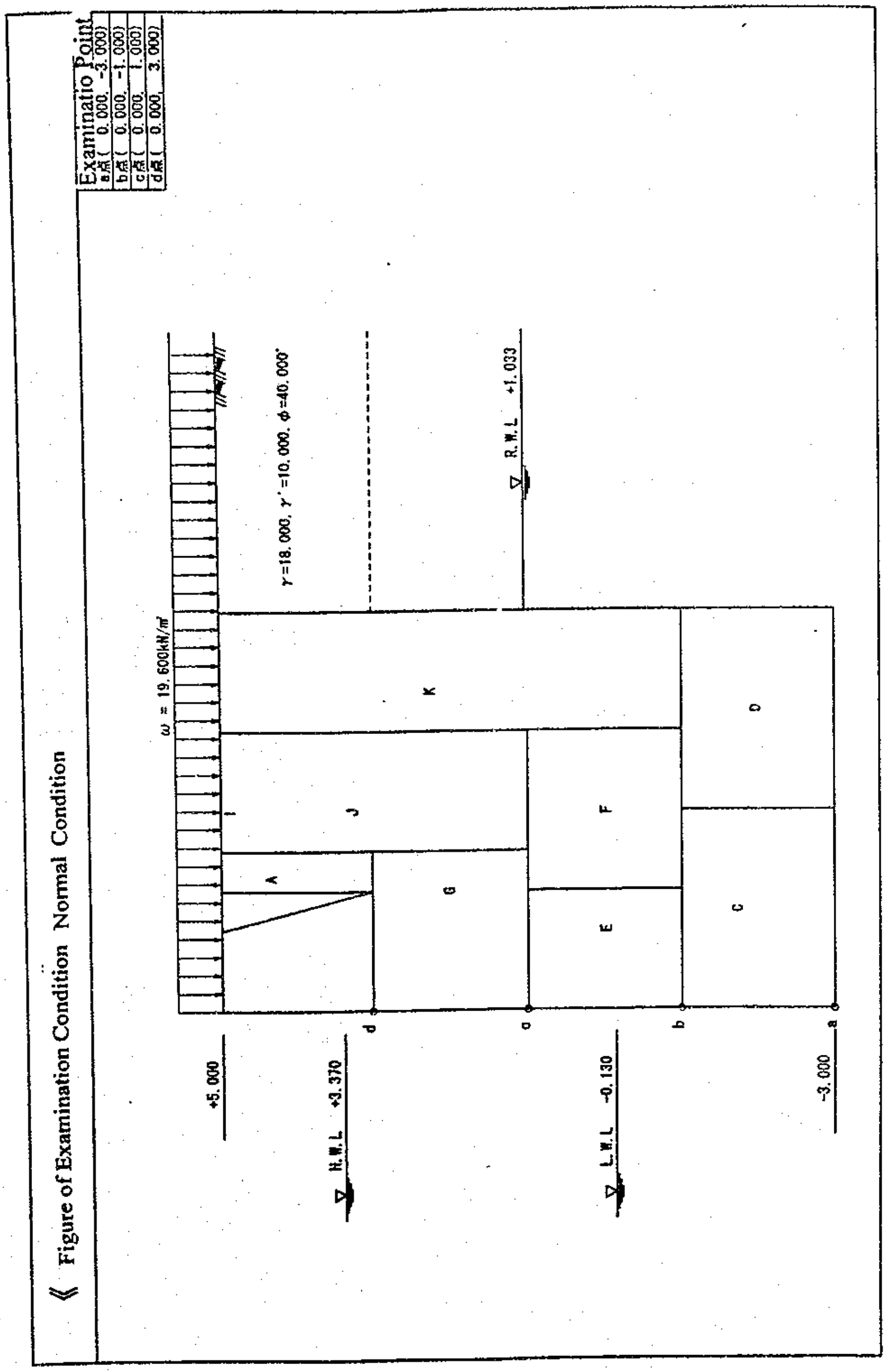
References/ Notes



《 Figure of Examination Condition Normal Condition

	Prepared by Y. Ando		Checked by R. NISHIMURA
	26 / 07 /2002		08 / 08 /2002

2. Stability in Normal Condition

2-1. : Earth Pressure and Water Pressure

[1] Coefficient of earth Pressure

$$K_a = \frac{\cos^2(\phi-\psi)}{\cos^2\psi\cdot\cos(\delta+\psi)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\cdot\sin(\phi-\beta)}{\cos(\delta+\psi)\cdot\cos(\psi-\beta)}}\right]^2}$$

K_a : Coefficient of active earth pressure
ϕ : 背面土内部摩擦角 (度) angle of internal friction
β : 地表面が水平となす角 (度)
ψ : 壁面が鉛直となす角 (度)
δ : 壁面摩擦角 (度)

Point
A < -3.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	K_a
5.000～ 1.033	0.0	40.0	15.0	0.0	0.2011
1.033～ -3.000	0.0	40.0	15.0	0.0	0.2011

Point
B < -1.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	K_a
-1.000～ 5.000	0.0	40.0	15.0	180.0	-0.2011

Point
C < 1.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	K_a
1.000～ 5.000	0.0	40.0	15.0	180.0	-0.2011

Point
D < 3.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	K_a
5.000～ 3.000	0.0	40.0	15.0	0.0	0.2011

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. [illegible] Rev.	

References/ Notes

[2] Intensity of Earth Pressure

$$P_a = \left[\Sigma \gamma \cdot h + \frac{\omega \cdot \cos\psi}{\cos(\psi-\beta)} \right] \cdot K_a$$

P_a : Intensity of active earth pressure (kN/m²)
γ : Unit weight of soil (kN/m³)
h : Thickness of soil layer (m)
ω : Surcharge (kN/m²)
ψ : Angle of the wall surface to vertical (degree)
β : Angle of the ground surface to horizontal (degree)
K_a : Coefficient of active earth pressure

Point
A < -3.000m >

Point of Action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
5.000	0.000	0.000	0.000	0.0	19.600	0.1942	3.806
1.033	3.967	71.406	71.406	0.0	19.600	0.1942	17.673
1.033	3.967	71.406	71.406	0.0	19.600	0.1942	17.673
-3.000	4.033	40.330	111.736	0.0	19.600	0.1942	25.505

Point
B < -1.000m >

Point of Action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
-1.000	0.000	0.000	0.000	180.0	19.600	0.1942	3.806
5.000	-6.000	-108.000	-108.000	180.0	19.600	0.1942	-17.167

Point
C < 1.000m >

Point of Action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
1.000	0.000	0.000	0.000	180.0	19.600	0.1942	3.806
5.000	-4.000	-72.000	-72.000	180.0	19.600	0.1942	-10.176

Point
D < 3.000m >

Point of Action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
5.000	0.000	0.000	0.000	0.0	19.600	0.1942	3.806
3.000	2.000	36.000	36.000	0.0	19.600	0.1942	10.798

		Prepared by	Y. Ando	Checked by	E. NISHIMURA
			26 / 07 /2002		08 / 08 /2002

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
Section	Civil	Calc. Index No.	
Subject	Revetment	Page No. 5	Rev.

References/ Notes

[3] Earth Pressure

$$P_E = \frac{1}{2} \cdot P_a \cdot h$$

P_E : Earth pressure (kN/m)
h : Thickness of Soil (m)
P_a : Intensity of active earth pressure

Point
A < -3.000m >

No.	Formula				P_a (kN/m²)		h (m)	P_E (kN/m)
1	1/2	x	3.806	x	3.967	7.549
2	1/2	x	17.673	x	3.967	35.054
3	1/2	x	17.673	x	4.033	35.638
4	1/2	x	25.505	x	4.033	51.431

Point
B < -1.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_E (kN/m)
1	1/2	x	3.806	x	-6.000	-11.418
2	1/2	x	-17.167	x	-6.000	51.501

Point
C < 1.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_E (kN/m)
1	1/2	x	3.806	x	-4.000	-7.612
2	1/2	x	-10.176	x	-4.000	20.352

Point
D < 3.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_E (kN/m)
1	1/2	x	3.806	x	2.000	3.806
2	1/2	x	10.798	x	2.000	10.798

		Prepared by	Y. Ando	Checked by	R. NISHIMURA
			26 / 07 /2002		08 / 08 /2002

FN: Calculation_Sheet

[4] Horizontal Earth Pressure and Moment

Point
A < -3.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal Force MPH(kN·m/m)
1	7.549	6.678	50.412
2	35.054	5.355	187.714
3	35.638	2.689	95.831
4	51.431	1.344	69.123
Total	129.672		403.080

Point
B < -1.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal Force MPH(kN·m/m)
1	-11.418	2.000	-22.836
2	51.501	4.000	206.004
Total	40.083		183.168

Point
C < 1.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal Force MPH(kN·m/m)
1	-7.612	1.333	-10.147
2	20.352	2.667	54.279
Total	12.740		44.132

D < 3.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal Force MPH(kN·m/m)
1	3.806	1.333	5.073
2	10.798	0.667	7.202
Total	14.604		12.275

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References/ Notes

[5] Vertical Earth Pressure and Moment

Point
A < -3.000m >

Vertical Factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	tan(ψ+δ)	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	7.549	0.268	2.023	5.000	10.115
2	35.054	0.268	9.394	5.000	46.970
3	35.638	0.268	9.551	5.000	47.755
4	51.431	0.268	13.784	5.000	68.920
Total			34.752		173.760

Point
B < -1.000m >

Vertical Factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	tan(ψ+δ)	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	-11.418	0.268	-3.060	4.000	-12.240
2	51.501	0.268	13.802	4.000	55.208
Total			10.742		42.968

Point
C < 1.000m >

Vertical Factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	tan(ψ+δ)	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	-7.612	0.268	-2.040	2.500	-5.100
2	20.352	0.268	5.454	2.500	13.635
Total			3.414		8.535

Point
D < 3.000m >

Vertical Factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	tan(ψ+δ)	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	3.806	0.268	1.020	1.500	1.530
2	10.798	0.268	2.894	1.500	4.341
Total			3.914		5.871

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[6] Water Pressure and Moment

$$P_w = \frac{1}{2} \cdot h_w \cdot p_w + h \cdot p_w$$

$$p_w = h_w \cdot \gamma_w$$

P_w : Residual Water Pressure (kN/m)
p_w : Intensity of Residual Water Pressure (under L.W.L.).
h_w : Distance from R.W.L. to L.W.L. (m)
h : Depth from wall bottom to L.W.L. (m)
γ_w : Unit Weight of Water (kN/m³)

Point
A < -3.000m >

No.	p_w h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1 2	1/2 x 11.746x 1.163 11.746x 2.870	6.830 33.711	3.258 1.435	22.252 48.375
Total		40.541		70.627

Point
B < -1.000m >

No.	p_w h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1 2	1/2 x 11.746x 1.163 11.746x 0.870	6.830 10.219	1.258 0.435	8.592 4.445
Total		17.049		13.037

Point
C < 1.000m >

No.	p_w h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1	1/2 x 0.333x 0.033	0.005	0.011	0.000
Total		0.005		0.000

Point
D < 3.000m >
No. Residual water pressure at this point

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2-2. Weight of Wall

[1] Weight and Center of Gravity of Each Block

Back filling

No	BaseXHeight x γ W(kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1/2x 0.500x 2.000x18.000 = 9.000	1.333	4.333	11.997	38.997
Total	9.000	* 1.333	* 4.333	11.997	38.997

(Coordinate of Gravity Center: x, y)

Back filling D1

No	BaseXHeight x γ W(kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	2.500x 2.000x23.000 = 115.000	1.250	-2.000	143.750	-230.000
Total	115.000	* 1.250	* -2.000	143.750	-230.000

(Coordinate of Gravity Center: x, y)

Back filling D2

No	BaseXHeight x γ W(kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	2.500x 2.000x23.000 = 115.000	3.750	-2.000	431.250	-230.000
Total	115.000	* 3.750	* -2.000	431.250	-230.000

(Coordinate of Gravity Center: x, y)

Back filling C1

No	BaseXHeight γ W(kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.500x 2.000x23.000 = 69.000	0.750	0.000	51.750	0.000
Total	69.000	* 0.750	* 0.000	51.750	0.000

(Coordinate of Gravity Center: x, y)

Back filling C2

No	BaseXHeight x γ W(kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	2.000x 2.000x23.000 = 92.000	2.500	0.000	230.000	0.000
Total	92.000	* 2.500	* 0.000	230.000	0.000

(Coordinate of Gravity Center: x, y)

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Back filling B1 — Coordinate of Gravity Center

No	Base×Height x γ W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	2.000x 1.967x23.000 = 90.482	1.000	2.016	90.482	182.412
2	2.000x 0.033x23.000 = 1.518	1.000	1.016	1.518	1.542
Total	92.000	* 1.000	* 2.000	92.000	183.954

Back filling A1 — Coordinate of Gravity Center

No	Base×Height x γ W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.000x 2.000x23.000 = 46.000	0.500	4.000	23.000	184.000
2	1/2x 0.500x 2.000x23.000 = 11.500	1.167	3.667	13.420	42.170
Total	57.500	* 0.633	* 3.933	36.420	226.170

Back filling AS — Coordinate of Gravity Center

No	Base×Height x γ W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	0.500x 2.000x20.000 = 20.000	1.750	4.000	35.000	80.000
Total	20.000	* 1.750	* 4.000	35.000	80.000

Back filling BS — Coordinate of Gravity Center

No	Base×Height x γ W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.500x 3.967x20.000 = 119.010	2.750	3.016	327.278	358.934
2	1.500x 0.033x20.000 = 0.990	2.750	1.016	2.722	1.006
Total	120.000	* 2.750	* 3.000	330.000	359.940

Back filling CS — Coordinate of Gravity Center

No	Base×Height x γ W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.500x 3.967x20.000 = 119.010	4.250	3.016	505.792	358.934
2	1.500x 2.033x20.000 = 60.990	4.250	0.016	259.208	0.976
Total	180.000	* 4.250	* 2.000	765.000	359.910

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* Coordinate of Gravity Center

$$x = \frac{\Sigma W \cdot x}{\Sigma W} \qquad y = \frac{\Sigma W \cdot y}{\Sigma W}$$

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[7] Vertical Force of Wall and Moment

Point A < -3.000m >

No	Name of Block	Weight	W, (kN/m)	Arm lenght x (m)	M_{v} (kN·m/m)
1	Back filling		9.000	1.333	11.997
2	D1		115.000	1.250	143.750
3	D2		115.000	3.750	431.250
4	C1		69.000	0.750	51.750
5	C2		92.000	2.500	230.000
6	B1		92.000	1.000	92.000
7	A1		57.500	0.633	36.398
8	AS		20.000	1.750	35.000
9	BS		120.000	2.750	330.000
10	CS		180.000	4.250	765.000
	Total		869.500		2127.145

Point B < -1.000m >

No	Name of Block	Weight	W, (kN/m)	Arm lenght x (m)	M_{v} (kN·m/m)
1	Back filling		9.000	1.333	11.997
2	C1		69.000	0.750	51.750
3	C2		92.000	2.500	230.000
4	B1		92.000	1.000	92.000
5	A1		57.500	0.633	36.398
6	AS		20.000	1.750	35.000
7	BS		120.000	2.750	330.000
	Total		459.500		787.145

Point C < 1.000m >

No	Name of Block	Weight	W, (kN/m)	Arm lenght x (m)	M_{v} (kN·m/m)
1	Back filling		9.000	1.333	11.997
2	B1		92.000	1.000	92.000
3	A1		57.500	0.633	36.398
4	AS		20.000	1.750	35.000
	Total		178.500		175.395

Point D < 3.000m >

No	Name of Block	Weight	W, (kN/m)	Arm lenght x (m)	M_{v} (kN·m/m)
1	Back filling		9.000	1.333	11.997
2	A1		57.500	0.633	36.398
	Total		66.500		48.395

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[3] Weight and Gravity Center of Each Block (Under R.W.L.)

Backfilling No Buoyancy

《D1》

No	BasexHeight x γ-γ' W(kN/m)	x (m)	y (m)	W・x (kN・m/m)	W・y (kN・m/m)
1	2.500x 2.000x10.000 = 50.000	1.250	-2.000	62.500	-100.000
Total	50.000	* 1.250	* -2.000	62.500	-100.000

《D2》

No	BasexHeight x γ-γ' W(kN/m)	x (m)	y (m)	W・x (kN・m/m)	W・y (kN・m/m)
1	2.500x 2.000x10.000 = 50.000	3.750	-2.000	187.500	-100.000
Total	50.000	* 3.750	* -2.000	187.500	-100.000

《C1》

No	BasexHeight x γ-γ' W(kN/m)	x (m)	y (m)	W・x (kN・m/m)	W・y (kN・m/m)
1	1.500x 2.000x10.000 = 30.000	0.750	0.000	22.500	0.000
Total	30.000	* 0.750	* 0.000	22.500	0.000

《C2》

No	BasexHeight x γ-γ' W(kN/m)	x (m)	y (m)	W・x (kN・m/m)	W・y (kN・m/m)
1	2.000x 2.000x10.000 = 40.000	2.500	0.000	100.000	0.000
Total	40.000	* 2.500	* 0.000	100.000	0.000

《B1》

No	BasexHeight x γ-γ' W(kN/m)	x (m)	y (m)	W・x (kN・m/m)	W・y (kN・m/m)
1	2.000x 0.033x10.000 = 0.660	1.000	1.016	0.660	0.671
Total	0.660	* 1.000	* 1.016	0.660	0.671

(Coordination of Gravity Center: x, y)

《A1》 No Buoyancy

《AS》 No Buoyancy

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(BS)

Coordination of Gravity Center

No	Base x Height x γ−γ' W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.500x 0.033x10.000 = 0.495	2.750	1.016	1.361	0.503
Total	0.495	* 2.750	* 1.016	1.361	0.503

(CS)

Coordination of Gravity Center

No	Base x Height : x γ−γ' W (kN/m)	x (m)	y (m)	W·x (kN·m/m)	W·y (kN·m/m)
1	1.500x 2.033x10.000 = 30.495	4.250	0.016	129.604	0.488
Total	30.495	* 4.250	* 0.016	129.604	0.488

* Coordination of Gravity Center

$$x = \frac{\Sigma W\cdot x}{\Sigma W} \qquad y = \frac{\Sigma W\cdot y}{\Sigma W}$$

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[4] Buoyancy and Moment

Point
A < -3.000m >

No	Name	Weight	Wv (kN/m)	Arm Lenght x (m)	Mwv (kN·m/m)
1	D1		50.000	1.250	62.500
2	D2		50.000	3.750	187.500
3	C1		30.000	0.750	22.500
4	C2		40.000	2.500	100.000
5	B1		0.660	1.000	0.660
6	BS		0.495	2.750	1.361
7	CS		30.495	4.250	129.604
	Total		201.650		504.125

Point
B < -1.000m >

No	Name	Weight	Wv (kN/m)	Arm Lenght x (m)	Mwv (kN·m/m)
1	C1		30.000	0.750	22.500
2	C2		40.000	2.500	100.000
3	B1		0.660	1.000	0.660
4	BS		0.495	2.750	1.361
	Total		71.155		124.521

Point
C < 1.000m >

No	Name	Weight	Wv (kN/m)	Arm Lenght x (m)	Mwv (kN·m/m)
1	B1		0.660	1.000	0.660
	Total		0.660		0.660

Point
D < 3.000m >
No Buoyancy at this Point

2-3. Other Force

No other force

		Prepared by	Y. Ando	Checked by	R. NISHIHURA
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2-4. Stability of Wall

[1] Sliding

$$F = \frac{\mu \cdot V}{H}$$

[2] Overturning

$$F = \frac{M_R}{M_D}$$

V : Total Vertical Force (kN/m)
H : Total Horizontal Force (kN/m)
μ : Coefficient of Friction
M_R : Moment of Total Vertical Force (kN·m/m)
M_D : Moment of Total Horizontal Force (kN·m/m)

Point
A < -3.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	34.752	129.672	173.760	403.080
Residual Water Pressure	—	40.541	—	70.627
Weight of wall	869.500	—	2127.145	—
Buoyancy	-201.650	—	-504.125	—
Total	702.602	170.213	1796.780	473.707

Sliding			Overturning		
Safety Factor F		Allowable Values	Safety Factor F		Allowable Values
0.600 x 702.602 / 170.213	2.476	≧1.20	1796.780 / 473.707	3.793	≧1.20

Point
B < -1.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	10.742	40.083	42.968	183.168
Residual Water Pressure	—	17.049	—	13.037
Weight of wall	459.500	—	787.145	—
Buoyancy	-71.155	—	-124.521	—
Total	399.087	57.132	705.592	196.205

Sliding			Overturning		
Safety Factor F		Allowable Values	Safety Factor F		Allowable Values
0.500 x 399.087 / 57.132	3.492	≧1.20	705.592 / 196.205	3.596	≧1.20

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Point
C < 1.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_O (kN·m/m)
Earth Pressure	3.414	12.740	8.535	44.132
Residual Water Pressure	—	0.005	—	0.000
Weight of wall	178.500	—	175.395	—
Buoyancy	-0.660	—	-0.660	—
Total	181.254	12.745	183.270	44.132

Sliding			Overturning		
Safety Factor F		Allowable Values	Safety Factor F		Allowable Values
$\frac{0.500 \times 181.254}{12.745}$	7.110	≧1.20	$\frac{183.270}{44.132}$	4.152	≧1.20

Point
D < 3.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_O (kN·m/m)
Earth Pressure	3.914	14.604	5.871	12.275
Residual Water Pressure	—	0.000	—	0.000
Weight of wall	66.500	—	48.395	—
Buoyancy	0.000	—	0.000	—
Total	70.414	14.604	54.266	12.275

Sliding			Overturning		
Safety Factor F		Allowable Values	Safety Factor F		Allowable Values
$\frac{0.500 \times 70.414}{14.604}$	2.410	≧1.20	$\frac{54.266}{12.275}$	4.420	≧1.20

Prepared by	Y. Ando	Checked by	T. NISHIMURA
	26/07/2002		08/08/2002

FN: Calculation_Sheet

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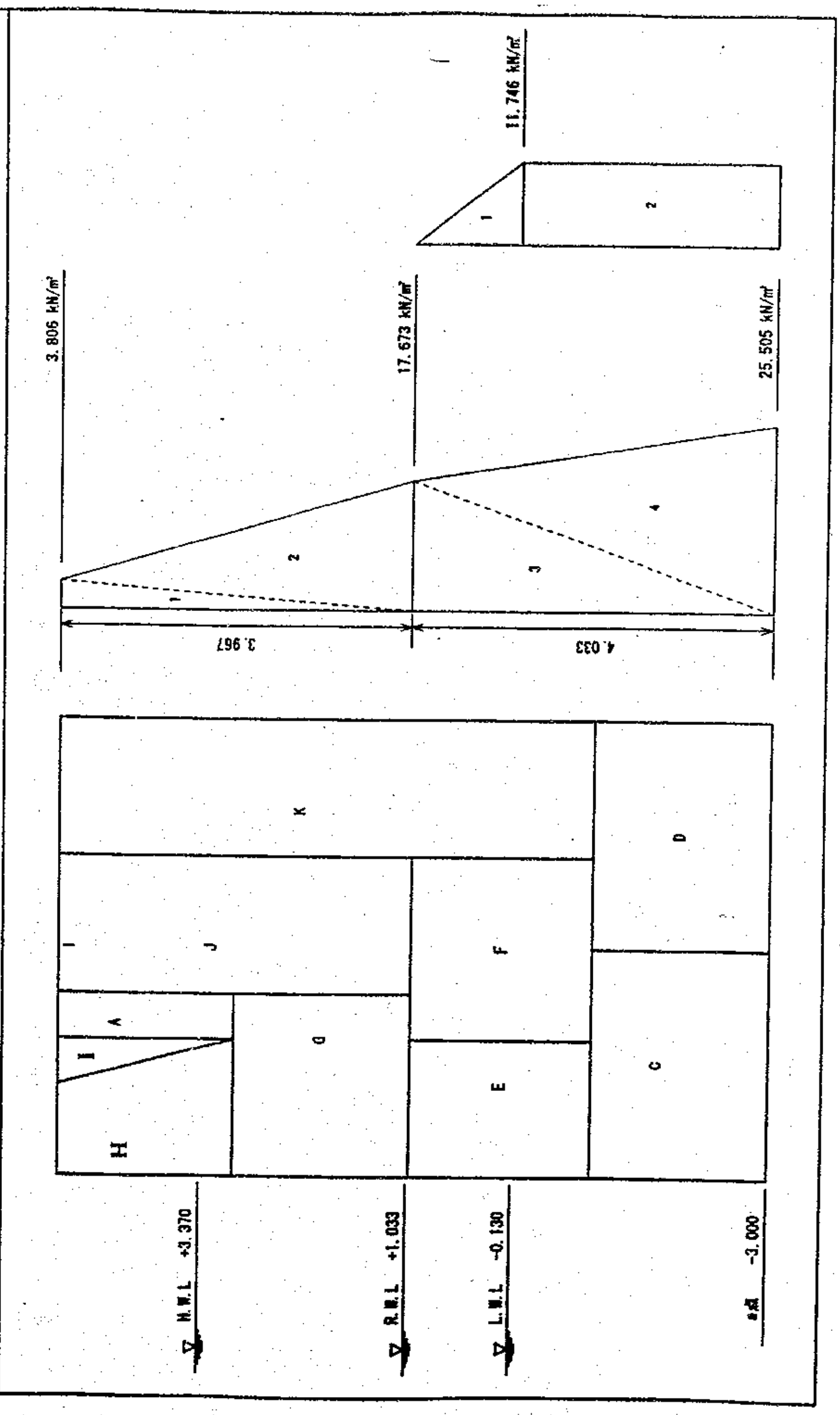
《 Figure of Total Force 》 Normal Condition 〈 a point -3.000 m 〉



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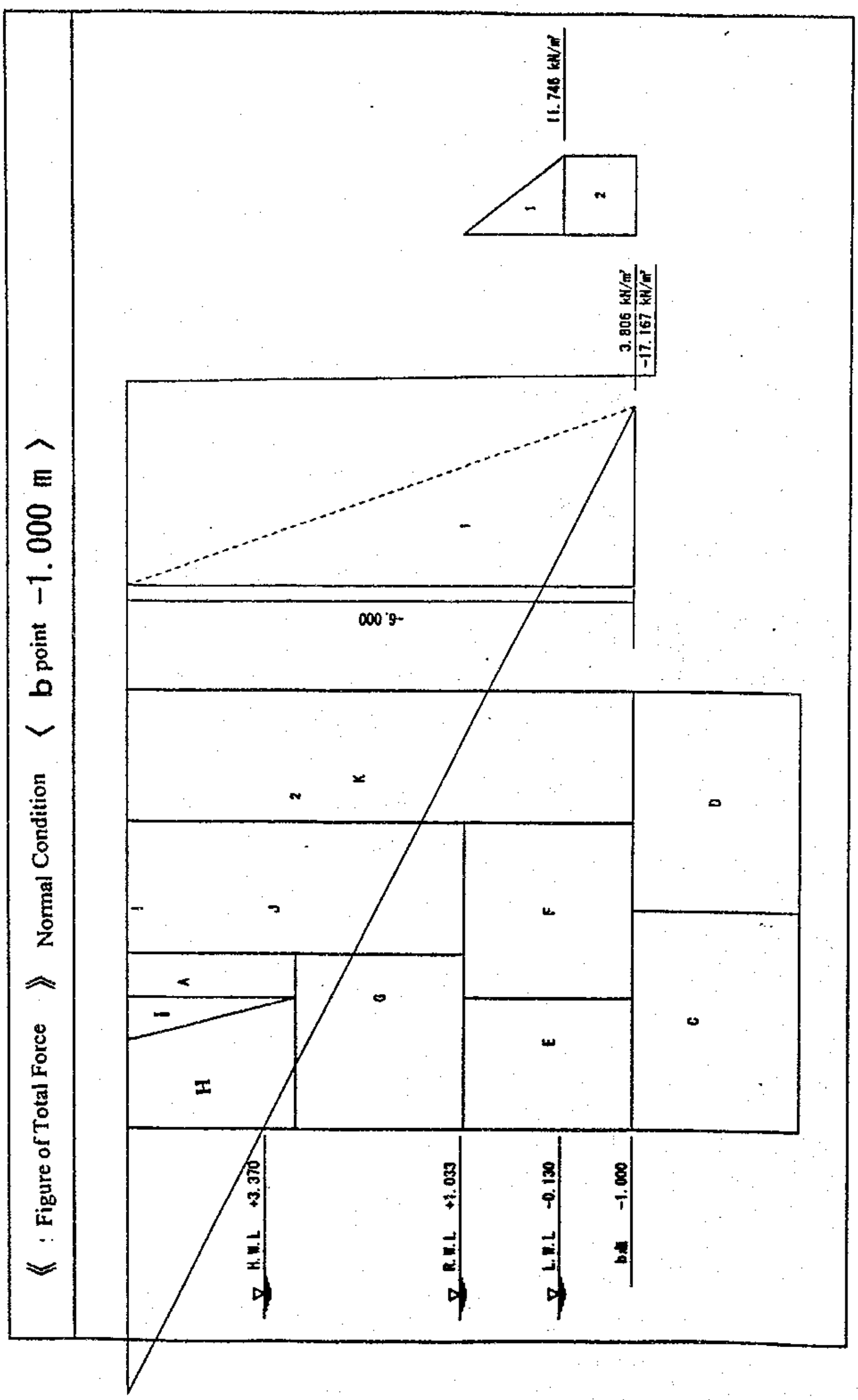

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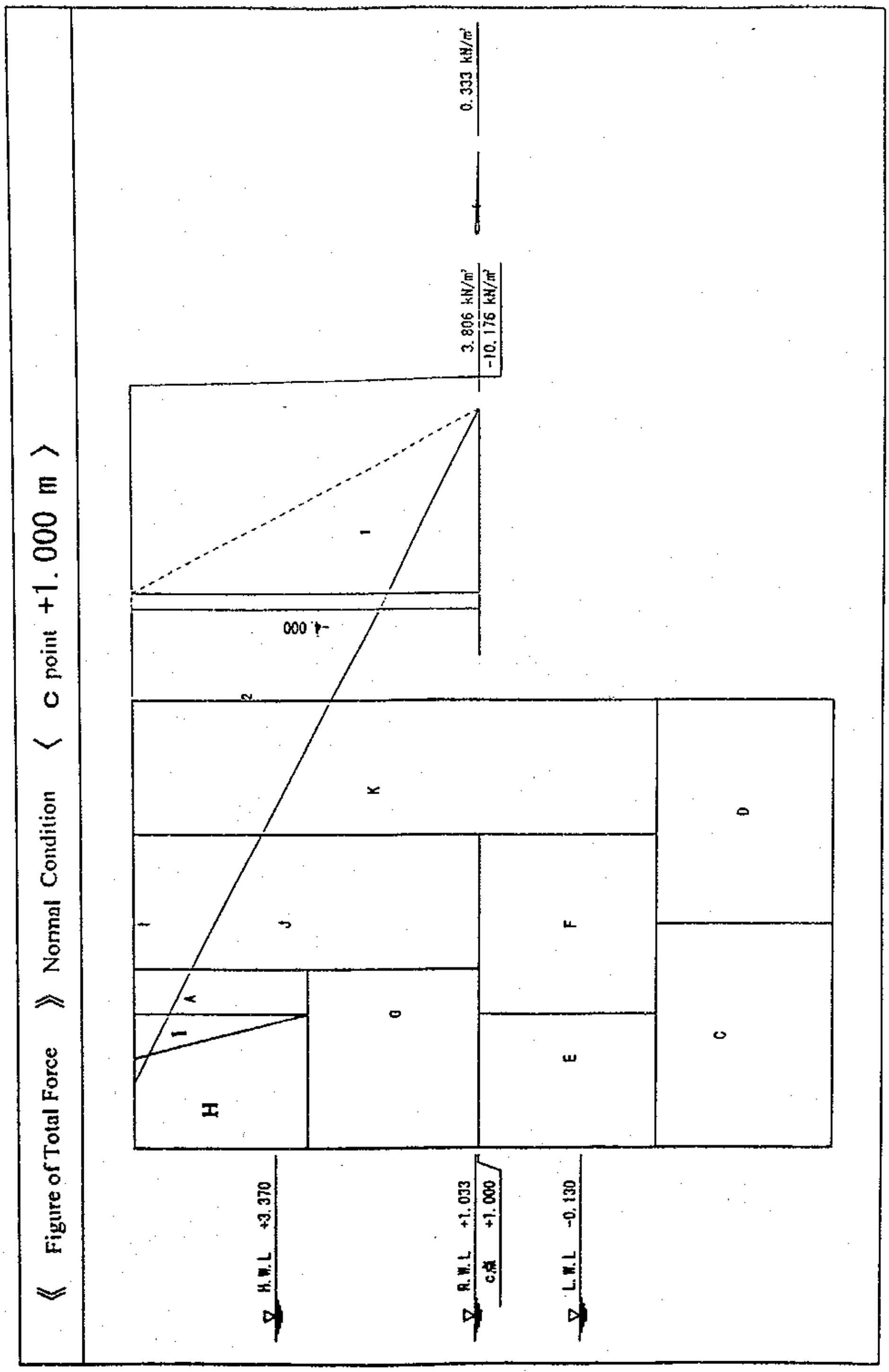

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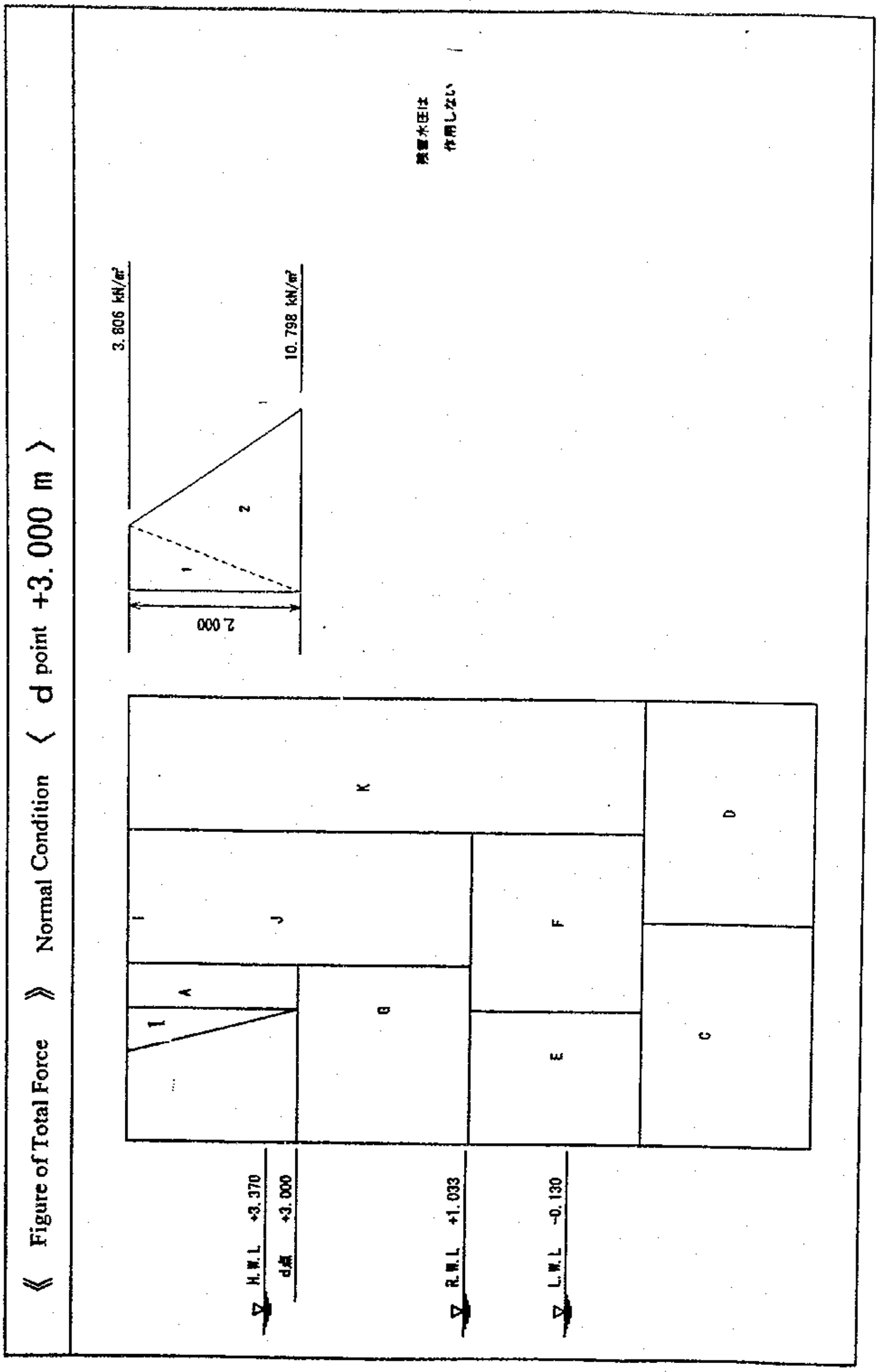

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2-5. Bearing Capacity

[1]. Reaction of Bottom Surface of Caisson

a) $0 < e \leqq b/6$ Case

$$p_1 = \left(1 + \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b}$$

$$p_2 = \left(1 - \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b}$$

b) $e > b/6$ Case

$$p_1 = \frac{2}{3} \cdot \frac{V}{x}$$

$$p_2 = 0$$

$$b' = 3 \cdot x$$

c) $e < 0$ Case

$$p = \frac{V}{b}$$

Distribution Load

ただし

$$x = \frac{M_R - M_D}{V} \qquad e = \frac{b}{2} - x$$

p_1 : MaximumReaction Force (kN/m²)
p_2 : MinimumReaction Force (kN/m²)
b : Width of Wall (m)
V : Vertical resultant force act on wall (kN/m)
b' : Distribution width of bottom reactions in case e>b/6
M_R : Moment of Vertical force act on wall (kN·m/m)
M_D : Moment of Horizontal force act o wall (kN·m/m)
e : Eccentricity of resultant force of Vertical and Horizontal

$$x = \frac{M_R - M_D}{V} = \frac{54.266 - 12.275}{70.414} = 0.596 \text{ (m)}$$

$$e = \frac{b}{2} - x = \frac{1.500}{2} - 0.596 = 0.154 \text{ (m)}$$

a) $0 < e \leqq b/6$ の Case

$$p_1 = \left(1 + \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b} = \left(1 + \frac{6 \times 0.154}{1.500}\right) \times \frac{70.414}{1.500} = 75.860 \text{ (kN/m}^2\text{)}$$

$$p_2 = \left(1 - \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b} = \left(1 - \frac{6 \times 0.154}{1.500}\right) \times \frac{70.414}{1.500} = 18.026 \text{ (kN/m}^2\text{)}$$

Maximum Reaction Force ≦ Allowable Bearing Capacity of Rubble Mound O K.

75.860 (kN/m²) ≦ 600.000 (kN/m²) .... OK

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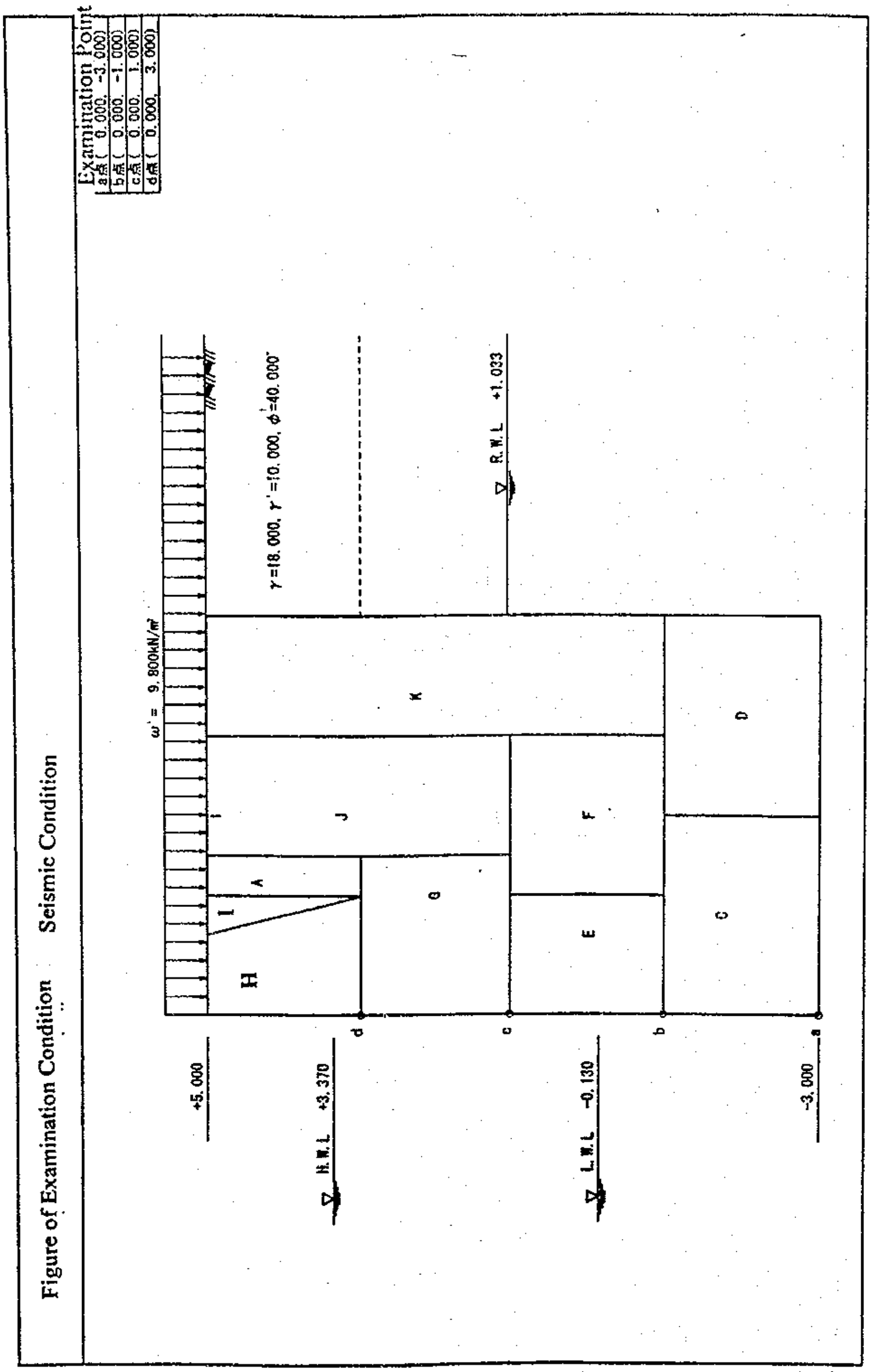

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3. Stability in Seismic Condition

3-1. Earth Pressure and Water Pressure

[1] Coefficient of Earth Pressure

$$K_a = \frac{\cos^2(\phi-\psi-\theta)}{\cos\theta\cdot\cos^2\psi\cdot\cos(\delta+\psi+\theta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\cdot\sin(\phi-\beta-\theta)}{\cos(\delta+\psi+\theta)\cdot\cos(\psi-\beta)}}\right]^2}$$

K_a : Coefficient of active earth pressure
ϕ : Angle of Internal friction of Soil
β : Angle of the ground surface to horizontal
ψ : Angle of the wall surface to vertical
δ : Angle of wall friction
θ :
k Seismic Coefficient
k' : Apparent seismic coefficient by following formula
Composite seismic angle which is defined as angle by following formula $\tan^{-1}K$ or $\tan^{-1}K'$

$$k' = \frac{\Sigma\gamma\cdot h + \gamma_w\cdot h_w + \omega}{\Sigma\gamma\cdot h + \omega}\cdot k$$

γ : Unit Weight of Soil (kN/m³)
γ_w : Unit Weight of Water (kN/m³)
h : Thickness of layer (under water) (m)
h_w : 土層の海水につかっている深さ (m)
ω : Surcharge (kN/m²)

Point
A < -3.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	k or k'	θ (°)	K_a
5.000~ 1.033	0.0	40.0	15.0	0.0	0.20	11.31	0.3168
1.033~ -3.000	0.0	40.0	15.0	0.0	0.20 0.27	11.31 15.11	0.3168 0.3702

Point
B. < -1.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	k or k'	θ (°)	K_a
-1.000~ 5.000	0.0	40.0	15.0	180.0	0.20	11.31	-0.3168

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Point
C < 1.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	k or k'	θ (°)	K
1.000～ 5.000	0.0	40.0	15.0	180.0	0.20	11.31	-0.3168

Point
D < 3.000m >

Point of action Level (m)	β (°)	φ (°)	δ (°)	ψ (°)	k or k'	θ (°)	K
5.000～ 3.000	0.0	40.0	15.0	0.0	0.20	11.31	0.3168

References/ Notes

[2] Intesity of Earth Pressure

$$P_a = \left[\Sigma\gamma \cdot h + \frac{\omega \cdot \cos\psi}{\cos(\psi-\beta)} \right] \cdot K_a$$

P_a : Intensity of active earth pressure (kN/m²)
γ : Unit Weight of Soil (kN/m³)
h : Thickness of Soil Layer (m)
ω : Surcharge (kN/m²)
ψ : Angle of the wall surface to vertical (°)
β : Angle of the ground surface to horizontal (°)
K_a : Coefficient of active earth pressure

Point
A < -3.000m >

Point of action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
5.000	0.000	0.000	0.000	0.0	9.800	0.3060	2.999
1.033	3.967	71.406	71.406	0.0	9.800	0.3060	24.849
1.033	3.967	71.406	71.406	0.0	9.800	0.3060	24.849
-3.000	4.033	40.330	111.736	0.0	9.800	0.3576	43.461

Point
B < -1.000m >

Point of action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
-1.000	0.000	0.000	0.000	180.0	9.800	0.3060	2.999
5.000	-6.000	-108.000	-108.000	180.0	9.800	0.3060	-30.049

Point
C < 1.000m >

Point of action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
1.000	0.000	0.000	0.000	180.0	9.800	0.3060	2.999
5.000	-4.000	-72.000	-72.000	180.0	9.800	0.3060	-19.033

Point
D < 3.000m >

Point of action Level (m)	h (m)	γh (kN/m²)	Σγh (kN/m²)	ψ (°)	ω·cosψ / cos(ψ−β)	Kacos(δ+ψ)	P_a (kN/m²)
5.000	0.000	0.000	0.000	0.0	9.800	0.3060	2.999
3.000	2.000	36.000	36.000	0.0	9.800	0.3060	14.015

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[3] Earth Pressure

$$P_6 = \frac{1}{2} \cdot P_a \cdot h$$

P_6 : Earth Pressure (kN/m)
h : Thickness of Soil (m)
P_a : Intensity of active earth pressure

Point
A < -3.000m >

No.	Formula				P_a (kN/m²)		h (m)	P_6 (kN/m)
1	1/2	x	2.999	x	3.967	5.949
2	1/2	x	24.849	x	3.967	49.288
3	1/2	x	24.849	x	4.033	50.108
4	1/2	x	43.461	x	4.033	87.639

Point
B < -1.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_6 (kN/m)
1	1/2	x	2.999	x	-6.000	-8.997
2	1/2	x	-30.049	x	-6.000	90.147

Point
C < 1.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_6 (kN/m)
1	1/2	x	2.999	x	-4.000	-5.998
2	1/2	x	-19.033	x	-4.000	38.066

Point
D < 3.000m >

No.	Formula		P_a (kN/m²)		h (m)	P_6 (kN/m)
1	1/2	x	2.999	x	2.000	2.999
2	1/2	x	14.015	x	2.000	14.015

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[4] Horizontal Earth Pressure and Moment

Point

A < -3.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal force MPH(kN·m/m)
1	5.949	6.678	39.727
2	49.288	5.355	263.937
3	50.108	2.689	134.740
4	87.639	1.344	117.787
Total	192.984		556.191

Point

B < -1.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal force MPH(kN·m/m)
1	-8.997	2.000	-17.994
2	90.147	4.000	360.588
Total	81.150		342.594

Point

C < 1.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal force MPH(kN·m/m)
1	-5.998	1.333	-7.995
2	38.066	2.667	101.522
Total	32.068		93.527

Point

D < 3.000m > Horizontal Earth Pressure

No.	PH (kN/m)	Arm lenght (m)	Moment of Horizontal force MPH(kN·m/m)
1	2.999	1.333	3.998
2	14.015	0.667	9.348
Total	17.014		13.346

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[5] Vertical Earth Pressure and Moment

Point

A < -3.000m . >

Vertical factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	$\tan(\psi+\delta)$	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	5.949	0.268	1.594	5.000	7.970
2	49.288	0.268	13.209	5.000	66.045
3	50.108	0.268	13.429	5.000	67.145
4	87.639	0.268	23.487	5.000	117.435
Total			51.719		258.595

Point

B < -1.000m . >

Vertical factor of earth Pressure

No.	Earth Pressure P_E (kN/m)	$\tan(\psi+\delta)$	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	-8.997	0.268	-2.411	4.000	-9.644
2	90.147	0.268	24.159	4.000	96.636
Total			21.748		86.992

Point

C < 1.000m >

Vertical factor of earth Pressure

No.	Earth Pressure P_E (kN/m)	$\tan(\psi+\delta)$	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	-5.998	0.268	-1.607	2.500	-4.018
2	38.066	0.268	10.202	2.500	25.505
Total			8.595		21.487

Point

D < 3.000m >

Vertical factor of Earth Pressure

No.	Earth Pressure P_E (kN/m)	$\tan(\psi+\delta)$	P_V (kN/m)	Arm lenght (m)	Moment of Vertical Force M_{PV} (kN·m/m)
1	2.999	0.268	0.804	1.500	1.206
2	14.015	0.268	3.756	1.500	5.634
Total			4.560		6.840

References/
Notes

[6] Water Pressure and Moment

$$P_w = \frac{1}{2} \cdot h_w \cdot p_w + h \cdot p_w$$

$$p_w = h_w \cdot \gamma_w$$

P_w : Residual Water Pressure (kN/m)
p_w : Intensity of Residual water Pressure (under L.W.L.)
h_w Distance from R.W.L. to L.W.L. (m)
h : Depth from wall bottom to L.W.L. (m)
γ_w : Unit Weight of water (kN/m³)

Point
A < -3.000m >

No.	p_w	h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1	1/2 x 11.746x	1.163	6.830	3.258	22.252
2	11.746x	2.870	33.711	1.435	48.375
Total			40.541		70.627

Point
B < -1.000m >

No.	p_w	h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1	1/2 x 11.746x	1.163	6.830	1.258	8.592
2	11.746x	0.870	10.219	0.435	4.445
Total			17.049		13.037

Point
C < 1.000m >

No.	p_w	h	P_w (kN/m)	y	M_{Pw} (kN·m/m)
1	1/2 x 0.333x	0.033	0.005	0.011	0.000
Total			0.005		0.000

D点 < 3.000m 面 >
No Residual Water Pressure at this point

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3-2. Dynamic Water Pressure

[1] Dynamic Water Pressure

$$p_{dw} = \frac{7}{8} \cdot k \cdot \gamma_w \cdot \sqrt{H \cdot y}$$

p_{dw} :	Dynamic Water Pressure		(kN/m²)
k :	Seismic Coefficient	0.200	
γ_w :	Unit weight of water	10.100	(kN/m³)
H :	Depth of water	2.870	(m)
y :	Depth from water surface to examination point		(m)

[2] Total force of Dynamic Water Pressure and Acting Point

$$P_{dw} = \frac{7}{12} \cdot k \cdot \gamma_w \cdot \sqrt{H} \cdot y^{3/2}$$

$$h_{dw} = \frac{2}{5} \cdot y$$

P_{dw} :	Total force of Dynamic Water Pressure	(kN/m)
h_{dw} :	Depth from examination point to force acting point	(m)

[3] Total force of Dynamic Water Pressure and Moment

Point

A . < -3.000m >

$$p_{dw} = \frac{7}{8} \times 0.200 \times 10.100 \times \sqrt{2.870 \times 2.870} = 5.073 \ (kN/m^2)$$

$$P_{dw} = \frac{7}{12} \times 0.200 \times 10.100 \times \sqrt{2.870} \times 2.870^{3/2} = 9.706 \ (kN/m)$$

$$h_{dw} = \frac{2}{5} \times 2.870 = 1.148 \ (m)$$

$$M_D = 9.706 \times 1.148 = 11.142 \ (kN \cdot m/m)$$

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Point
B. < -1.000m >

$$P_{d*} = \frac{7}{8} \times 0.200 \times 10.100 \times \sqrt{2.870 \times 0.870} = 2.793 \ (kN/m^2)$$

$$P_{d*} = \frac{7}{12} \times 0.200 \times 10.100 \times \sqrt{2.870} \times 0.870^{3/2} = 1.620 \ (kN/m)$$

$$h_{d*} = \frac{2}{5} \times 0.870 = 0.348 \ (m)$$

$$M_D = 1.620 \times 0.348 = 0.564 \ (kN \cdot m/m)$$

Point
C. < 1.000m >
No Dinamic Water Pressure at this Point

Point
D. < 3.000m >
No Dinamic Water Pressure at this Point

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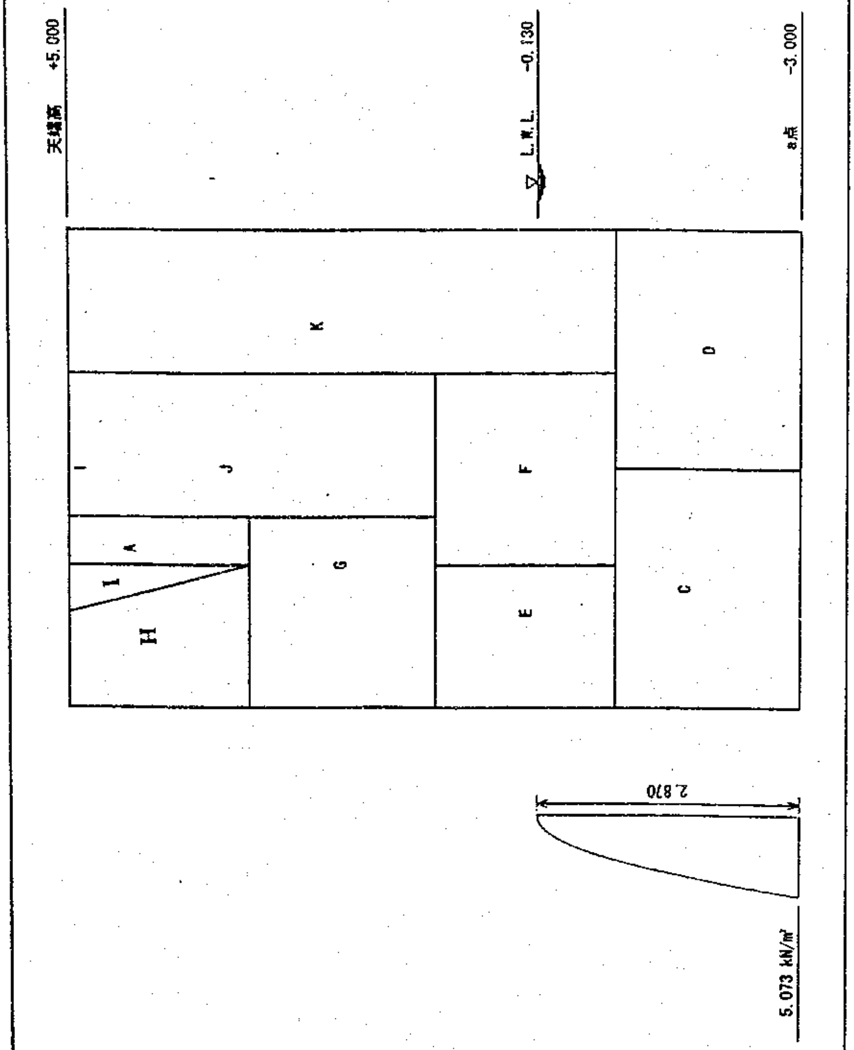

Figure of Dynamic Water Pressure ＜a Point(-3.000m)＞

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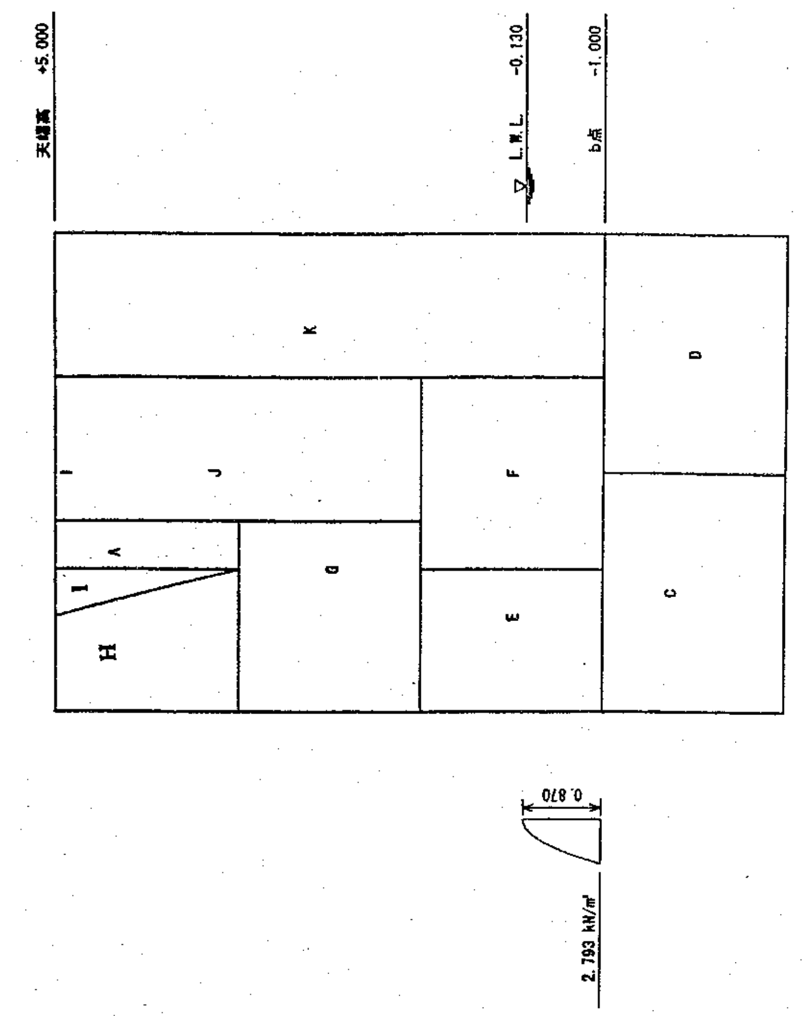

Figure of Dynamic Water Pressure (bPoint −1.000m)

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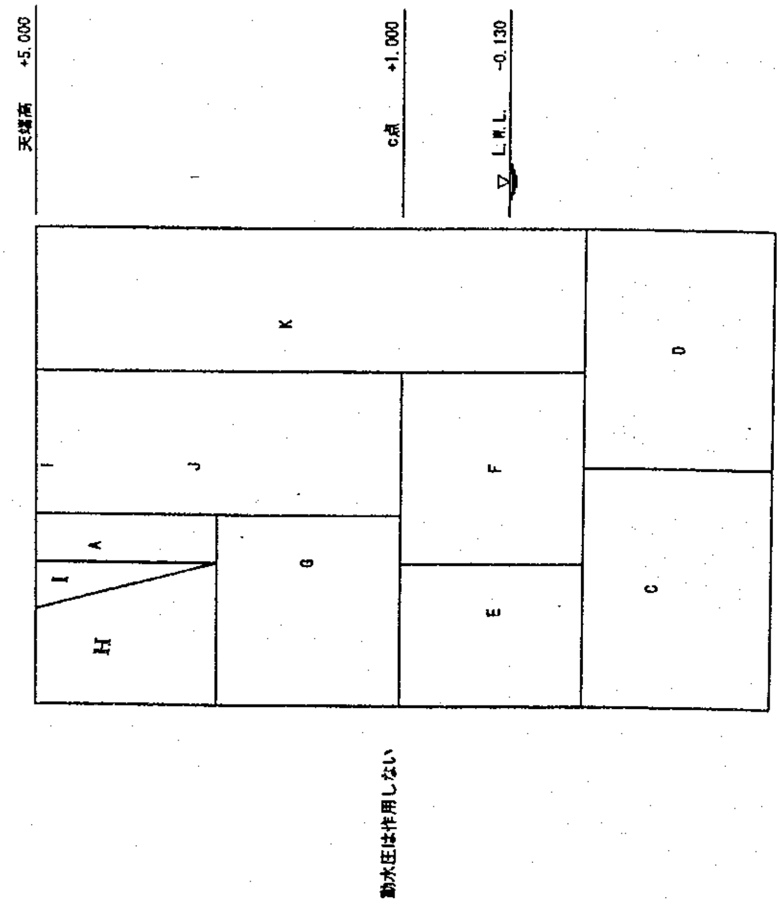

Figure of Dynamic Water Pressure ⟨ c Point +1.000m⟩

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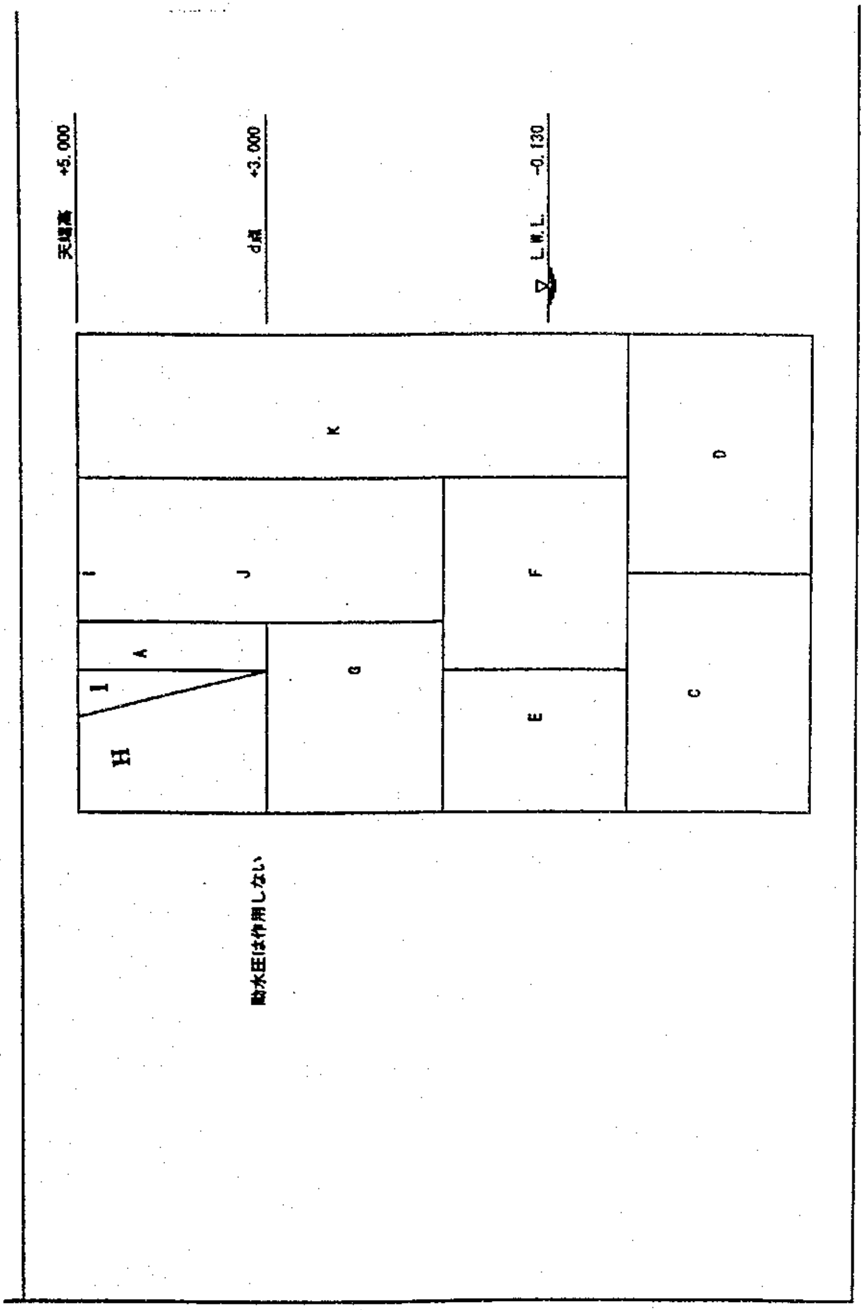

Figure of Dynamic Water Pressure 〈dPoint +3.000m〉

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3-3. Weight of Wall

[1] Horizontal Seismic Force and Moment

Point A < -3.000m >

No	Name	W (kN/m)	K_h	W_h (kN/m)	y (m)	M_{wh} (kN·m/m)
1	Back filling	9.000	0.200	1.800	7.333	13.199
2	D1	115.000	0.200	23.000	1.000	23.000
3	D2	115.000	0.200	23.000	1.000	23.000
4	C1	69.000	0.200	13.800	3.000	41.400
5	C2	92.000	0.200	18.400	3.000	55.200
6	B1	92.000	0.200	18.400	5.000	92.000
7	A1	57.500	0.200	11.500	6.933	79.730
8	AS	20.000	0.200	4.000	7.000	28.000
9	BS	120.000	0.200	24.000	6.000	144.000
10	CS	180.000	0.200	36.000	5.000	180.000
	Total			173.900		679.529

Point B < -1.000m >

No	Name	W (kN/m)	K_h	W_h (kN/m)	y (m)	M_{wh} (kN·m/m)
1	Backfilling	9.000	0.200	1.800	5.333	9.599
2	C1	69.000	0.200	13.800	1.000	13.800
3	C2	92.000	0.200	18.400	1.000	18.400
4	B1	92.000	0.200	18.400	3.000	55.200
5	A1	57.500	0.200	11.500	4.933	56.730
6	AS	20.000	0.200	4.000	5.000	20.000
7	BS	120.000	0.200	24.000	4.000	96.000
	Total			91.900		269.729

Point C < 1.000m >

No	Name	W (kN/m)	K_h	W_h (kN/m)	y (m)	M_{wh} (kN·m/m)
1	Backfilling	9.000	0.200	1.800	3.333	5.999
2	B1	92.000	0.200	18.400	1.000	18.400
3	A1	57.500	0.200	11.500	2.933	33.730
4	AS	20.000	0.200	4.000	3.000	12.000
	Total			35.700		70.129

Point D < 3.000m >

No	Name	W (kN/m)	K_h	W_h (kN/m)	y (m)	M_{wh} (kN·m/m)
1	Backfilling	9.000	0.200	1.800	1.333	2.399
2	A1	57.500	0.200	11.500	0.933	10.730
	Total			13.300		13.129

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3-4. Other Force

No Other Forc

3-5. Stability of Wall

[1] Sliding

$$F = \frac{\mu \cdot V}{H}$$

[2] Overturning

$$F = \frac{M_R}{M_D}$$

V : Total Vertical Force (kN/m)
H : Total Horizontal Force (kN/m)
μ : Coefficient of Friction
M_R : Moment of Total Vertical Force (kN·m/m)
M_D : Moment of Total Horizontal Force (kN·m/m)

Point
A < -3.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	51.719	192.984	258.595	556.191
Residual Water Pressure	—	40.541	—	70.627
Weight of Wall	869.500	173.900	2127.145	679.529
Buoyancy	-201.650	—	-504.125	—
Dynamic Water Pressure	—	9.706	—	11.142
Total	719.569	417.131	1881.615	1317.489

Sliding			Overturning		
Safety Factor F		Allowable Value	Safety Factor F		Allowable Value
$\frac{0.600 \times 719.569}{417.131}$	1.035	≧1.00	$\frac{1881.615}{1317.489}$	1.428	≧1.10

Point
B_I < -1.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	21.748	81.150	86.992	342.594
Residual Water Pressure	—	17.049	—	13.037
Weight of Wall	459.500	91.900	787.145	269.729
Buoyancy	-71.155	—	-124.521	—
Dynamic Water Pressure	—	1.620	—	0.564
Total	410.093	191.719	749.616	625.924

Sliding			Overturning		
Safety Factor F		Allowable Value	Safety Factor F		Allowable Value
$\frac{0.500 \times 410.093}{191.719}$	1.069	≧1.00	$\frac{749.616}{625.924}$	1.197	≧1.10

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Point
C < 1.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	8.595	32.068	21.487	93.527
Residual Water Pressure	—	0.005	—	0.000
Weight of Wall	178.500	35.700	175.395	70.129
Buoyancy	-0.660	—	-0.660	—
Dynamic Water Pressure	—	0.000	—	0.000
Total	186.435	67.773	196.222	163.656

Sliding			Overturning		
Safety Factor F		Allowable Value	Safety Factor F		Allowable Value
0.500 x 186.435 / 67.773	1.375	≧1.00	196.222 / 163.656	1.198	≧1.10

Point
D < 3.000m >

	V (kN/m)	H (kN/m)	M_R (kN·m/m)	M_D (kN·m/m)
Earth Pressure	4.560	17.014	6.840	13.346
Residual Water Pressure	—	0.000	—	0.000
Weight of Wall	66.500	13.300	48.395	13.129
Buoyancy	0.000	—	0.000	—
Dynamic Water Pressure	—	0.000	—	0.000
Total	71.060	30.314	55.235	26.475

Sliding			Overturning		
Safety Factor F		Allowable Value	Safety Factor F		Allowable Value
0.500 x 71.060 / 30.314	1.172	≧1.00	55.235 / 26.475	2.086	≧1.10

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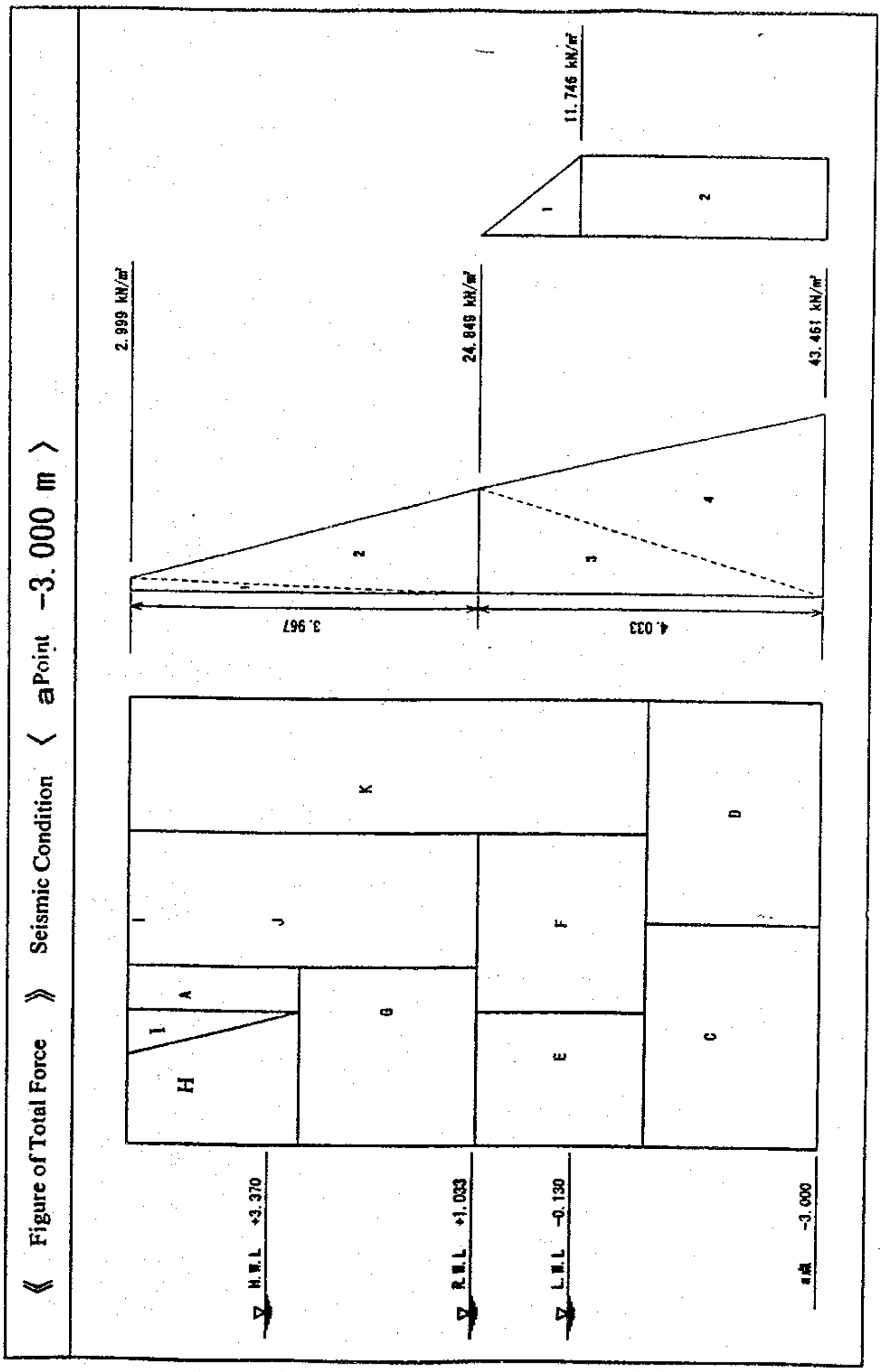

		Prepared by	Y. Ando	Checked by	E. NISHIMURA
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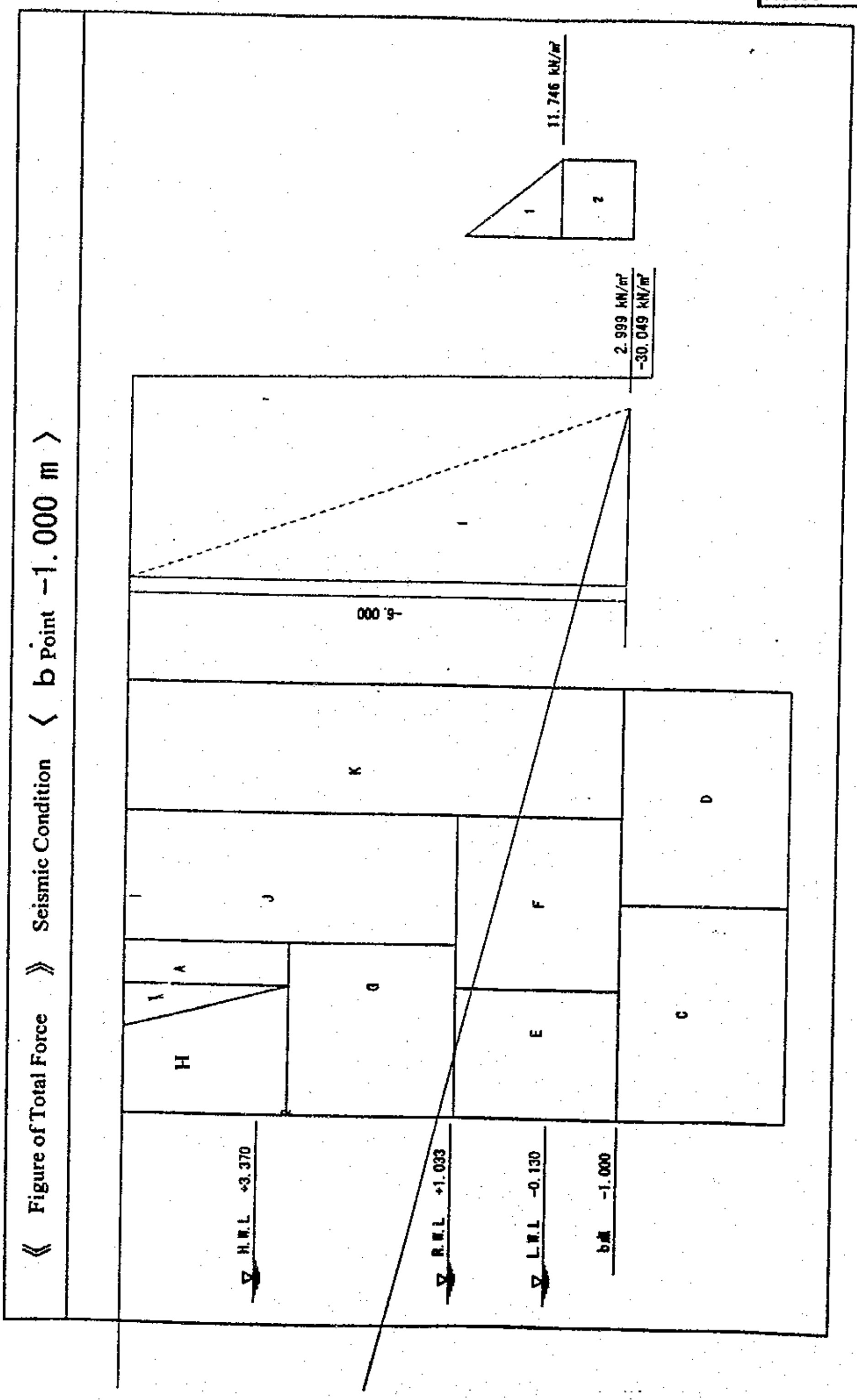

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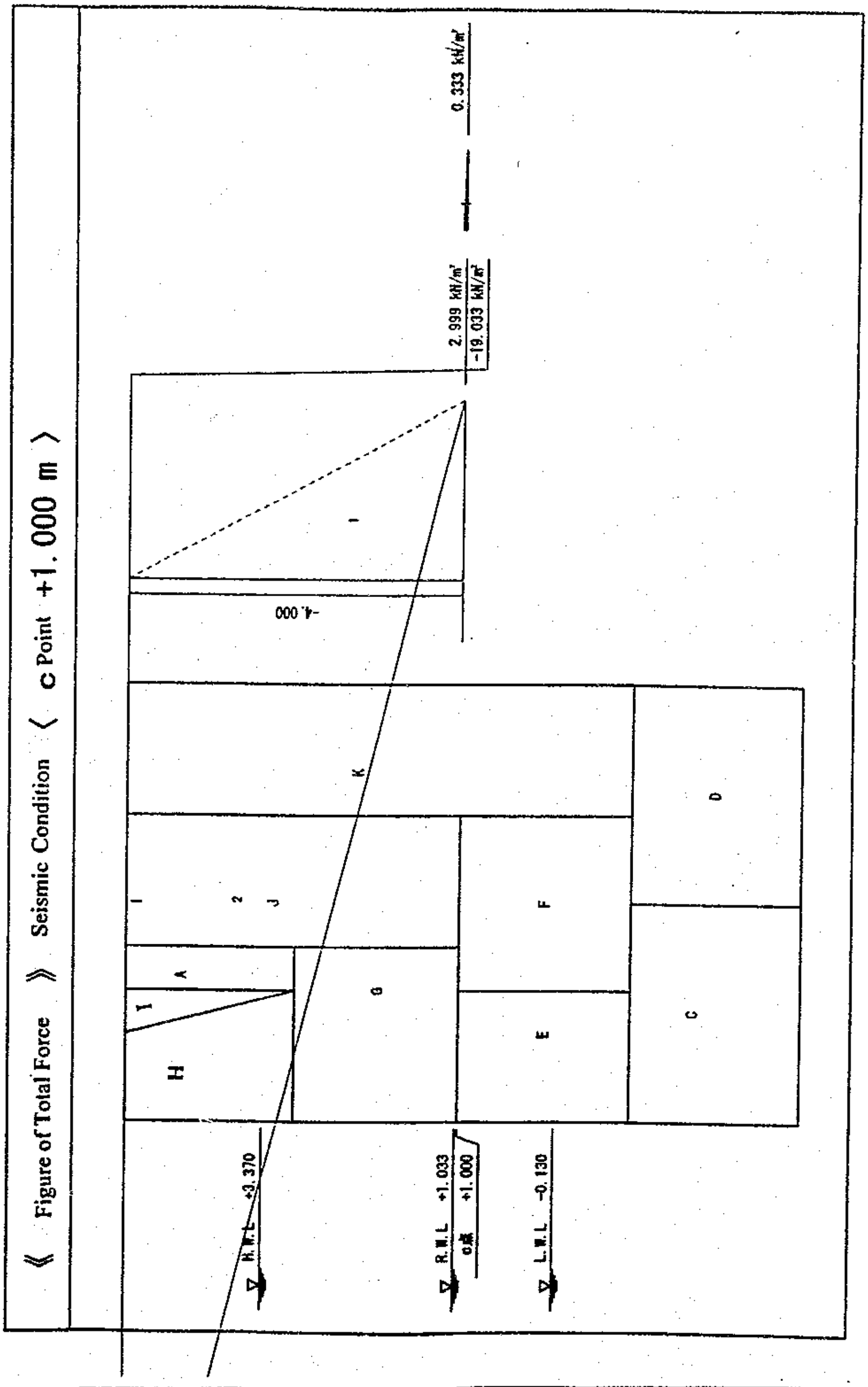

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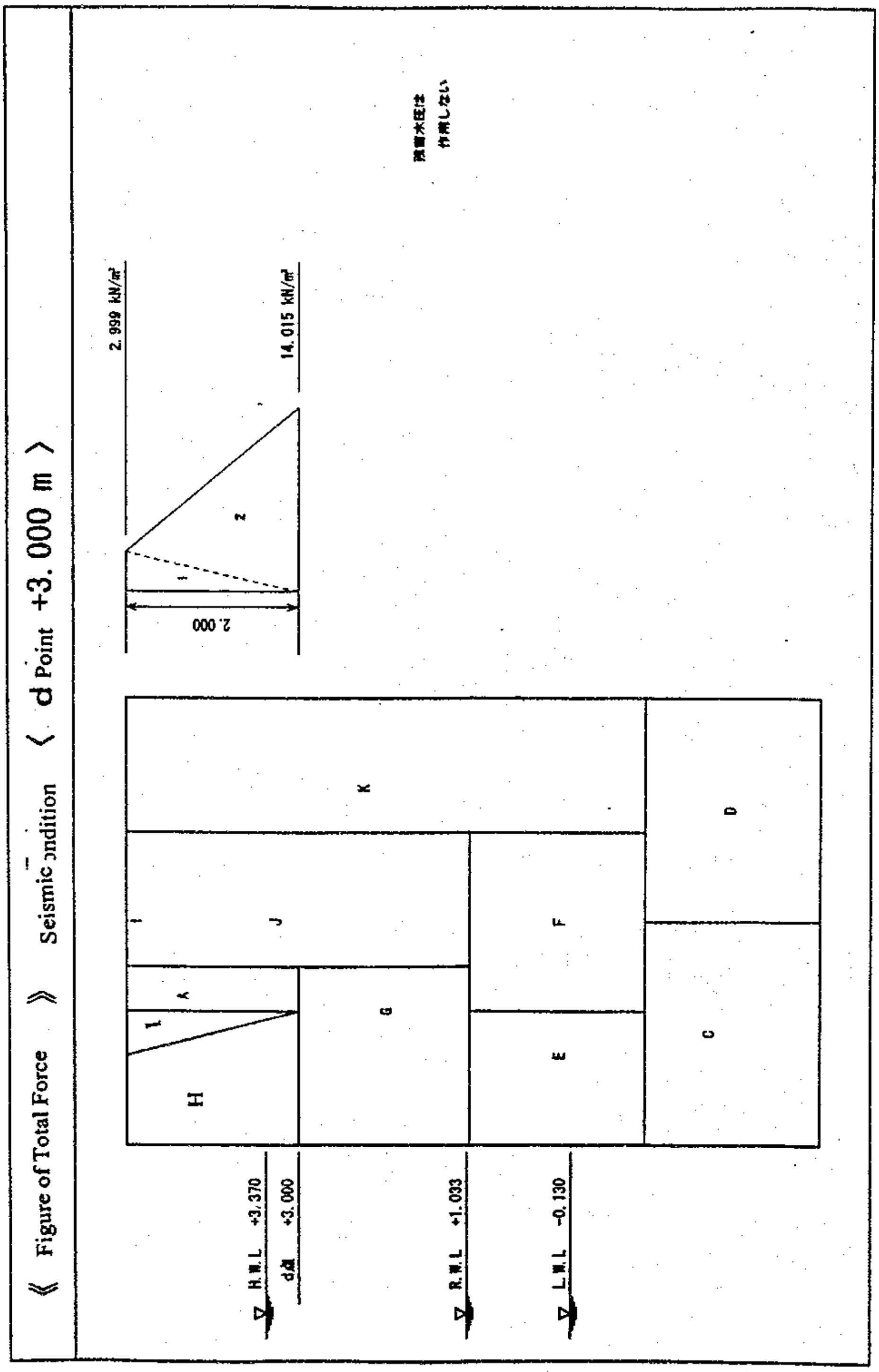

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3-6. Bearing Capacity

[1]. Reaction of Bottom Surface of Caisson

a) $0 < e \leqq b/6$ Case

$$p_1 = \left(1 + \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b}$$

$$p_2 = \left(1 - \frac{6 \cdot e}{b}\right) \cdot \frac{V}{b}$$

b) $e > b/6$ Case

$$p_1 = \frac{2}{3} \cdot \frac{V}{x}$$

$$p_2 = 0$$

$$b' = 3 \cdot x$$

c) $e < 0$ Case

$$p = \frac{V}{b}$$

Distibution Load

ただし

$$x = \frac{M_R - M_D}{V} \qquad e = \frac{b}{2} - x$$

p_1 : Maximum Reaction Force (kN/m²)
p_2 : Minimum Reaction Force (kN/m²)
b : Width of Wall (m)
V : Vertical resultant force act on wall (kN/m)
b' : Distribution width of bottom reactions in case e> b/6
M_R : Moment of vertical force act on wall (kN·m/m)
M_D : Moment of horizontal force act on wall (kN·m/m)
e : Eccentricity of resultant force of vertical and horizontal

$$x = \frac{M_R - M_D}{V} = \frac{55.235 - 26.475}{71.060} = 0.405 \text{ (m)}$$

$$e = \frac{b}{2} - x = \frac{1.500}{2} - 0.405 = 0.345 \text{ (m)}$$

b) $e > b/6$ Case

$$p_1 = \frac{2 \cdot V}{3 \cdot x} = \frac{2\text{x } 71.060}{3\text{x } 0.405} = 116.972 \text{ (kN/m}^2\text{)}$$

$$b' = 3 \cdot x = 3\text{x } 0.405 = 1.215 \text{ (m)}$$

$$p_2 = 0$$

Maximum Reaction Force ≦ Allowable Bearing Capacity of Rubble Mound O.K.

116.972 (kN/m²) ≦ 600.000 (kN/m²) ………… OK

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		26 / 07 /2002		08 / 08 /2002