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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
COMISION EJECUTIVA PORTUARIA AUTONOMA (CEPA)

THE DETAILED DESIGN ON PORT REACTIVATION PROJECT IN LA UNION PROVINCE OF THE REPUBLIC OF EL SALVADOR

FINAL REPORT

DESIGN CALCULATION REPORT

Civil Works (1/2)

OCTOBER 2002

NIPPON KOEI CO., LTD.

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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: **Container and Multi-Purpose Berth**
Passennger Berth

Calculation Objective:

Desigin Conditions

References, Calculation Notes and Comments

Refer toDrawing **GE-00-001,GE-00-003**
SI-01-001～SI-01-007
SI-02-001～GE-02-014

Rev	Prepared by	Prepared Date	No. of Pages	Checked by	Checked Date	Reviewed by	Reviewed Date	Superseded by Calc No.
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1. Design Condition

This examination is performed based on [TECHNICAL STANDARDS AND COMMENTARIES FOR PORT AND HARBOUR FACILITIES IN JAPAN]

1) Plan and Usage Conditions

(1) Plan Conditions

①Container Berth

Planned Water Depth	:	-14.00 m
Design Water Depth	:	-14.50 m
Crown Height of Berth	:	+5.0 m
Length	:	340.0 m

②Bulk Berth

Planned Water Depth	:	-14.00 m
Design Water Depth	:	-14.50 m
Crown Height of Berth	:	+5.0 m
Length	:	220.0 m

③Passenger Berth

Planned Water Depth	:	- 9.5 m
Design Water Depth	:	- 10.0 m
Crown Height of Berth	:	+5.0 m
Length	:	240.0 m (Piers(30.0m)、Dolphins 2sets)

(2) Usage Conditions

a) Dimensions of the Target Vessel

①Container Berth

Target Vessel : Container ships 55,000DWT=0.88DWT =48,400GT

Length overall : 294.00 m

Molded breadth : 32.20 m

Full load draft : 13.10 m

②Bulk Berth

Target Vessel : Bulk ships 43,000～50,000DWT=0.541DWT =23,260～27,050GT

Length overall : 185.00 m

Molded breadth : 32.20 m

Full load draft : 12.00 m

		Prepared by	Y. Ando	Checked by	R. NISHIMURA
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③Passenger Berth

Target Vessel	: Passenger ships	25,000GT	Car carriers	25,000DWT
Length overall	: Passenger ships	195.0 m	Car carriers	200.0m
Molded breadth	: Passenger ships	27.0m	Car carriers	32.20 m
Full load draft	: Passenger ships	8.5m	Car carriers	8.5m
				(No full load)

b) Berthing Velocity and Tractive force

Berthing Velocity : V = 0.10 m/sec

Bollard	Container Berth	1,000 k N
	Bulk Berth	1,000 k N
	Passenger Berth	1,000 k N
	(Breasting Dolphin)	

(3) Lifetime and Corrosion Control

a) Lifetime : 50 years

b) Corrosion Rates

L.W.L-1.0m～seabed : 0.2mm/year

Under seabed : 0.03mm/year

c) Corrosion Control

Above L.W.L-1.0m : Coating Method (Corrosion control rate : 100%)

Below L.W.L-1.0m : Cathodic Protection Method

(Corrosion control rate : 90%)

(4) Allowable Limit of Displacement

Berthing Condition	5.0 cm
Earthquake Condition	10.0 cm

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2) Natural Condition

(1) Design Water Level

H.W.L : +3.37 m

L.W.L : -0.13 m

(2) Wind Velocity v=31.0 m/s (Extraordinary Conditions)

(Out of Service of Container Crane : V=60,0m/sec)

(3) Soil Condition

①Container Berth

case I

-11.00 m

Silty Clay N = 1

γ = 14 kN/m^3 、 γ' = 4 kN/m^3

c = 5.0 kN/m^2

-20.00 m

Gravel Sand N =30(50 Gravel portion)

γ = 18.0 kN/m^3 、 γ' = 10 kN/m^3

ϕ = 35°

-26.00 m

Rock N > 50

γ = 18 kN/m^3 、 γ' = 10 kN/m^3

case II

-11.00 m

Silty Clay N = 1

γ = 14 kN/m^3 、 γ' = 4 kN/m^3

c = 5.0 kN/m^2

-12.00 m

Gravel Sand N =30(50 Gravel Portion)

γ = 18.0 kN/m^3 、 γ' = 10 kN/m^3

ϕ = 35°

-26.00 m

Rock N > 50

γ = 18 kN/m^3 、 γ' = 10 kN/m^3

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②Bulk Berth

case I

-10.00 m

Silty Clay N = 1

γ = 14 kN/m³ 、 γ' = 4 kN/m³

c = 5.0 kN/m²

-20.00 m

Gravel Sand N =30(50)

γ = 18.0 kN/m³ 、 γ' = 10 kN/m³

ϕ = 35°

-28.00m

Rock N > 50

γ = 18.0 kN/m³ 、 γ' = 10.0 kN/m³

②Passenger Berth

case I

-10.00 m

Silty Clay N = 1

γ = 12.8 kN/m³ 、 γ' = 2.8 kN/m³

c = 5.0 kN/m²

-19.00 m

Gravel Sand N = 30 (50)

γ = 18.0 kN/m³ 、 γ' = 10.0 kN/m³

ϕ = 35°

-26.00 m

Rock N > 50

γ = 18.0 kN/m³ 、 γ' = 100 kN/m³

Silty Clay is replaced to sand or stone.

Material Container and Bulk Berth : stone (ϕ =35°)

Passenger Berth : sand (ϕ =35°)

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(4) Coefficient of Horizontal Subgrade Reaction

Coefficient of Horizontal Subgrade Reaction (kh) is calculated by means of the following formula.

$kh = 1.5 \times N$ (N/cm^3)

Coefficient of Horizontal Subgrade Reaction (Kh) of Rubble Rock is set to $3.5 N/cm^3$.

(see in TECHNICAL STANDARDS AND COMMENTARIES FOR PORT AND HARBOUR FACILITIES IN JAPAN)

(5) Design Seismic Coefficient

kh = 0.20

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3) Material Coefficient

(1) Concrete

Unit Weight : (Reinforced Concrete) 24.0 kN/m^3 (Plain Concrete) 22.6 kN/m^3

Modulus of elasticty : 2.5×10^7 kN/m^2

(2) Steel

a) Steel Pipe Pile

Unit Weight : 77.00 kN/m^3

Modulus of elasticty : 2.0×10^8 kN/m^2

Design Yield Strength : SKK400 ; 235 N/mm^2 、 SKK490 ; 315 N/mm^2

Allowable Stresses

(Units : N/mm^2)

Type of stress \ Type of steel	SKK400 SHK400 SHK400M SKY400	SKK490 SHK490M SKY490
Axial tensile stress (per net cross-sectional area)	140	185
Axial compressive stress (per gross cross-sectional area)	140; $\frac{\ell}{r}\leqq 18$ $140-0.82\left(\frac{\ell}{r}-18\right)$; $18<\frac{\ell}{r}\leqq 92$ $\frac{1,200,000}{6,700+\left(\frac{\ell}{r}\right)^2}$; $92<\frac{\ell}{r}$	185 ; $\frac{\ell}{r}\leqq 16$ $185-1.2\left(\frac{\ell}{r}-16\right)$; $16<\frac{\ell}{r}\leqq 79$ $\frac{1,200,000}{5,000+\left(\frac{\ell}{r}\right)^2}$; $79<\frac{\ell}{r}$
Bending tensile stress (per net cross-sectional area)	140	185
Bending compressive stress (per gross cross-sectional area)	140	185
Examination of members simultaneously subject to axial force and bending moment	(1) In case of the axial tensile stress $\sigma_t+\sigma_{bt}\leqq\sigma_{ta}$ and $-\sigma_t+\sigma_{bc}\leqq\sigma_{ba}$ (2) In case of the axial compressive stress $\frac{\sigma_c}{\sigma_{ca}}+\frac{\sigma_{bc}}{\sigma_{ba}}\leqq 1.0$	
Shearing stress (per gross cross-sectional area)	80	150

where

ℓ : effective buckling length of member (cm)

r : radius of gyration of area for the gross cross-sectional area of the member (cm)

σ_t , σ_c : tensile stress due to axial tensile force and compressive stress due to axial compressive force acting on the section, respectively (N/mm^2)

σ_{bt} , σ_{bc} : maximum tensile stress and maximum compressive stress due to bending moment acting on the section, respectively (N/mm^2)

σ_{ta} , σ_{ca} : allowable tensile stress and allowable axial compressive stress relating to smallest moment of inertia, respectively (N/mm^2)

σ_{ba} : allowable bending compressive stress (N/mm^2)

b) Reinforcing Bar

SD 345

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References/Notes

(3) Reclaimed Material

γ=18kN/m3 γ'=10kN/m3 ϕ=30°

(4) Backfilling Stone

γ=18kN/m3 γ'=10kN/m3 ϕ=40°

(5) Rubble Mound

γ=18kN/m3 γ'=10kn/m3 ϕ=40°

(Examination of Bearing Capacity for Eccentric and Inclined Loads

ϕ=35° 、 c=20.0 kN/m^2)

(6) Sand Filling

γ sat = 19.00 kN/m^3

(7) Coefficient of Friction

μ=0.60 (Concrete against Rubble)

0.70 (Asphalt Mat against Rubble)

4) Load Condition

(1) Examination Case and Action Load

a) Container Berth

Case	Vertical Forces			Horizontal Forces				Condition	Premium coefficient
	Dead weight	Surcharge	Wheel loads (crane)	Wheel loads (crane)	Reaction force of thefender	Tractive force	Earthquake force		
In service	○	○	○	○	—	—	—	Ordinary	1.00
In service	○	○	—	—	—	—	—	Ordinary	1.00
Berthing	○	○	—	—	○	—	—	Ordinary	1.00
Mooring	○	○	—	—	—	○	—	Extraordinary	1.50
Earthquake	○	○	—	—	—	—	○	Extraordinary	1.50
Earthquake	○	○	○	○	—	—	○	Extraordinary	1.50

b) Passenger Berth

Case	Vertical Forces		Horizontal Forces			Condition	Premium coefficient
	Deadweight	Surcharge	Reaction force of thefender	Tractive force	Earthquake force		
Berthing	○	○	○	—	—	Ordinary	1.00
Mooring	○	○	—	○	—	Extraordinary	1.50
Earthquake	○	○	—	—	○	Extraordinary	1.50

(2) Load Value

a) Surcharge

(i) Container Berth and Bulk Berth

On Pier (From the Wharf face line to less than 40m)

Ordinary Condition : w=20.0 k N/m2

Earthquake Condition : w=10.0 k N/m2

On the Yard of the back of a Pier (It is 40m beyond from Wharf face line)

Ordinary Condition : w = 40.0 kN/m²

Earthquake Condition : w = 20.0 kN/m²

(ii) Passenger Berth

On Platform : (Ordinary Condition) w=20.0 kN/m²

(Earthquake Condition) w=10.0kN/m²

Vehicle Load : T-25

On Breasting Dolphin : Nothing

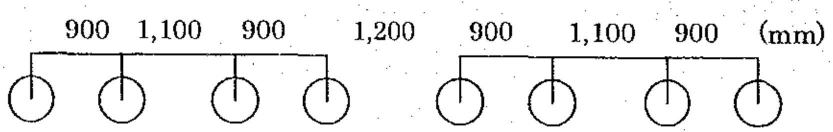
b) Crane Load

	Wheel Load (kNWheel)					
	Water Side (kN/Wheel)		Land Side (kN/wheel)		Pulling (kN/corner)	Remarks
	Vertical	Lateral	Vertical	Lateral		
In service	385	23	310	19		Action direction
Out of service	500	12	580	12	590	・right-angled direction to Rail
Earthquake	580	55	510	50		・Both directions

Total Weight : 790 kN (External electric power)、 Wheel Base : 17.2m

Number : 8 wheel / corner

Wheel Arrengrment



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c) Reaction Force of the Fender

Fender shall use the thing of the 70% of the Max Deflection of Rubber Fender. Product tolerance is expected in selection. The energy absorption characteristics lower by 10% from the catalog value and to use the reaction force characteristics raise by 10% from the catalog value. A calculation result is shown in the following tables.

	Container Berth	Multi-purpose Berth	Passenger Berth	
1.Displacement tonnage: Ms Design Ship Type	Container Ship	Bulk Carrier	Passenger Ship	Car carrier
DWT(ton)	55,000	43,000 ~ 50,000	25,000 GT	25,000
Length : LOA(m)	294	185	195	200
: Lpp (m)	278	173	173	187
Breadth : B (m)	32.2	32.2	27.0	32.3
Draft: D(m)	13.1	11.8	8.0	8.5
Displacement Ms(ton)	76,300	63,000	18,200	37,000
2.Effective Berthing energy: E V=0.1m/sec	380 kN-m	259 kN-m	103 kN-m	154 kN-m
3.Fender Energy absoption Reaction force (cell type fender)	393 kN-m Max 870 kN	285 kN-m Max 700 kN	110 kN-m Max 340 kN	162 kN-m Max 450 kN

[Note: Energy absorption is 90% of catalog value, reaction force is 110% of catalog value]

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d) Tractive Force of Vessel

1,000 kN／set

e) Other Condition

○Passenger Berth

①The Berthing Force of a vessel does not act on a Platform.
(The front of a Platform is lowered 2m from the face line.)

②The face line of a Passenger Berth appears above 25m from the face line of Revetment. Structual type is considered as a Dolphin type.

③It does not moor at the time of a storm.

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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: **Container and Multi-purpose Berth**

Calculation Objective:

Stability of Quaywall

References, Calculation Notes and Comments

Refer to Deawings

QW-01-001～QW-01-006

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

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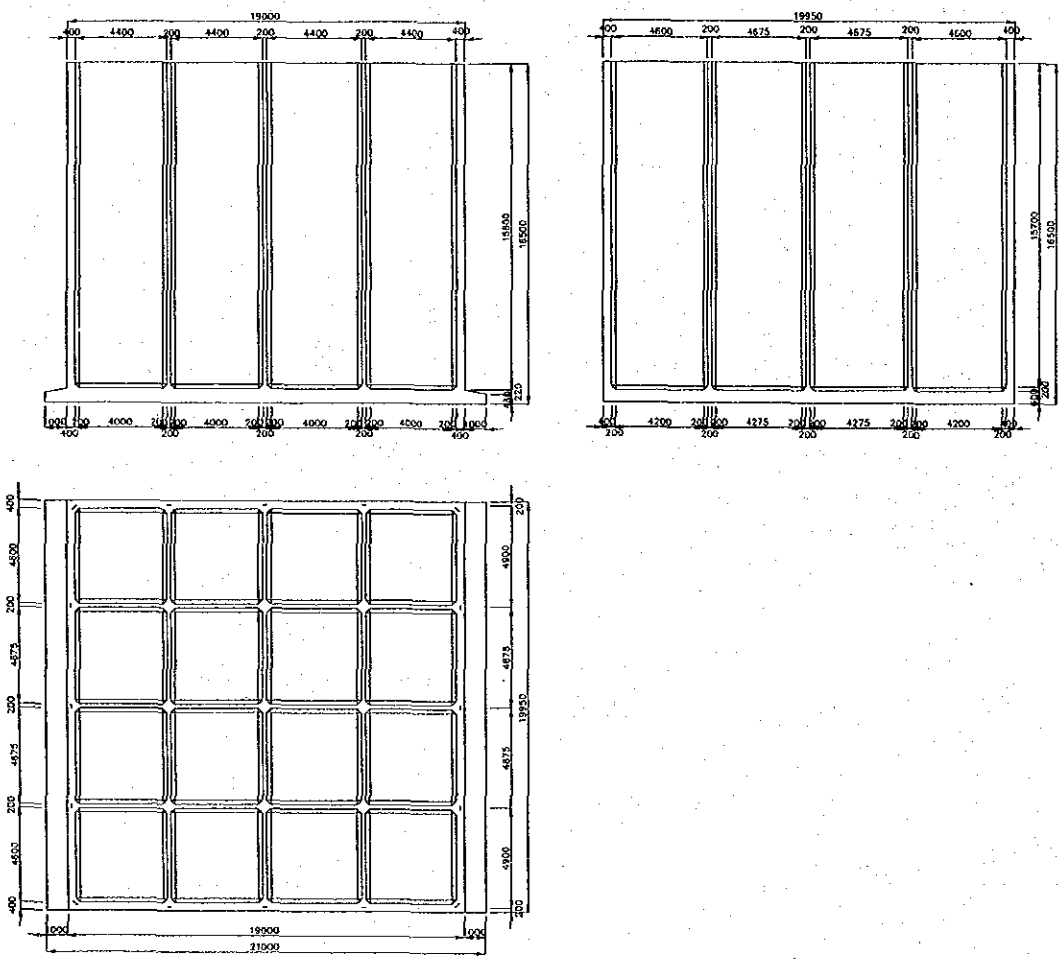
2. Basic Design of Container Berth

1) Dimensions and Weight of Caisson During Suspension

・Dimension of Caisson



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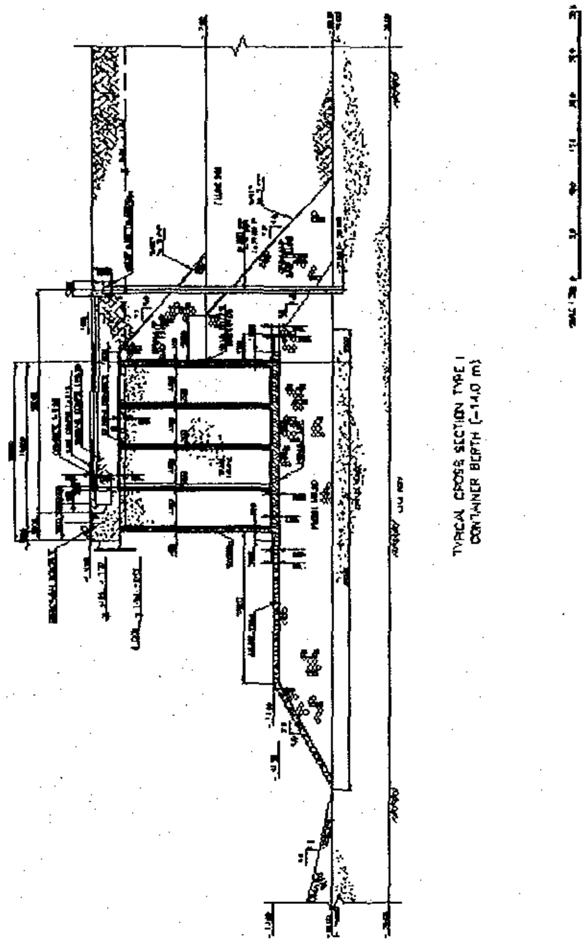

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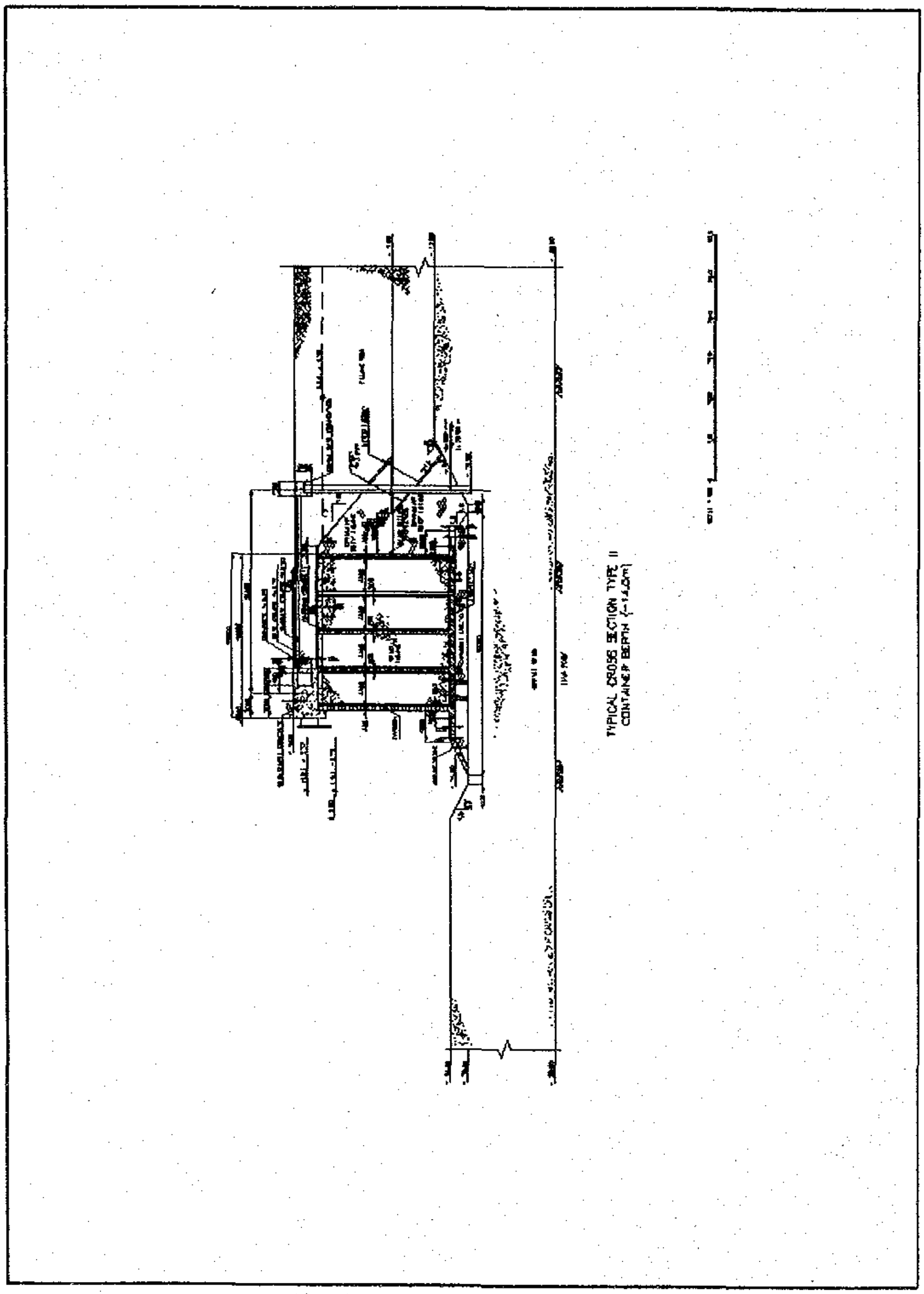

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Shape and Dimensions of Caisson

- Height : 16.50 m
- Width : 19.00 m
- Length : 19.95 m
- Sidewall Thickness : 0.40 m
- Bottom Slab Thickness : 0.60 m
- Partition Wall Thickness : 0.20 m
- Haunch Size : 0.20 m
- Width of Footing : 1.00 m
- Height of Footing : 0.50 m
- Haunch Size(Footing) : 0.20 m
- Number of Chambers
  - (Parallel directions to face line) : 4
  - (Vertical directions to face line) : 4

Weight and Center of Gravity for Caisson

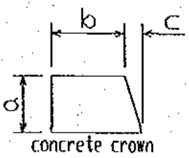
	Formula (m)	Volume V (m^3)	Weight W (kN)	Center of gravity position y(m)	W・y (kN・m/m)
Bottom Slab	19.95*19.00*0.60	227.43	5,458.32	0.30	1,637.50
Side Wall	0.40*(19.95+(19.00-2*0.40)) *(16.50-0.60)*2	485.27	11,646.43	8.55	99,576.99
Partition Wall	0.20*(((19.95-2*0.40)*3)+((19.00-2*0.40-3*0.20)*3))*(16.50-0.60)	350.59	8,414.28	8.55	71,942.09
Vertical Haunch	0.20^2*0.5*(16.50-0.60)*4*16	20.35	488.45	8.55	4,176.23
Horizontal Haunch	0.20^2*0.5*{((4.00+4.20)*2*8) +((4.00+4.275)*2*8)}	5.27	126.53	0.67	84.77
Concave Section	0.2^3/3*4*16	0.17	4.10	0.68	2.79
Footing	1.00*0.50*19.95*2	19.95	478.80	0.25	119.70
Haunch of Footing	0.20*1.00*0.5*19.95*2	3.99	95.76	0.57	54.58
Total		1,113.03	26,712.66	6.65	177,594.66

References/ Notes

Shape and Dimensions of Concrete Crown and Concrete Lid

○Concrete Crown

- Size a (Thickness) : 3.00 m
- Size b (Crown Width) : 4.00 m
- Size c : 1.00 m



○Concrete Lid

- Thickness : 0.50 m

Weight and Center of Gravity for wall

	Formula (m)	Volume V (m^3/m)	Weight W (kNt/m)	Center of gravity position x(m)	Center of gravity position y(m)	W・x (kN・m/m)	W・y (kN・m/m)
Caisson	1,113.03/19.95	55.79	1,338.98	10.50	6.65	14,059.29	8,901.95
Concrete Crown	(4.00+5.00)*3.00/2	13.50	305.10	3.26	17.94	994.40	5,474.85
Concrete Lid	{(4.40*4.60)*8+(4.40*4.675)*8-0.20²*0.5*4*16}*0.50/19.95	8.15	184.20	10.50	16.26	1,934.08	2,993.23
Filling Sand	{[(4.40*4.60)*8+(4.40*4.675)*8]*(16.5-0.60-0.50)-20.35-5.27-0.17}/19.95	250.76	4,764.42	10.50	8.31	50,026.38	39,584.22
Backfilling Soil	14.0*3.0+1.0*3.0*0.5+18.8*1.0+1.0*0.2*0.5	62.40	1,156.18	15.25	15.38	17,631.40	17,780.58
Total			7,748.88	10.92	9.64	84,645.55	74,734.82

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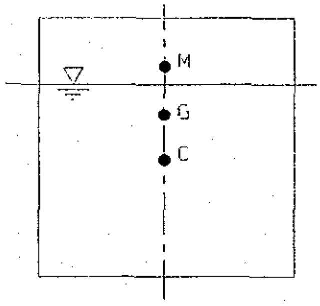
2)

Examination during Buoyancy

The following formula must be satisfied in order to insure the stability of the caisson during floating.

$I/V - \overline{CG} = \overline{GM} \geqq 0.05$



V ; Displacement(m^3)

I ; Moment of inertia of area for the long axis at the draft elevation(m^4)

C ; Center of buoyancy

G ; Center of gravity

M ; Metacenter

・Draft of Caisson

Draft of caisson "d" is calculated by the following formula.

$$d = \frac{W - V_f \rho_0 g}{B L \rho_0 g}$$

W ; Weight of caisson(t)

V_f ; Volume of footing(m^3)

$\rho_0 g$; Unit weight of sea water(t/m^3)

B ; Width of caisson(m)

L ; Length of caisson(m)

$d = (26{,}712.66 - 23.94 \times 10.1) / (19.00 \times 19.95 \times 10.1) = 6.91$ m

・Displacement $V = B \times L \times d + V_f = 19.00 \times 19.95 \times 6.91 + 23.94 = 2{,}644.82\ m^3$

・Primary Moment of Displacement

$Vy = B\,L\,d^2/2 + V_f y = 19.00 \times 19.95 \times 6.91^2/2 + 7.25 = 9{,}056.71\ m^4$

$V_f y$ is Primary moment of displacement for footing.

・Center of Buoyancy $C = Vy / V = 9{,}056.71 / 2{,}644.82 = 3.43$ cm

・Moment of Inertia of Area for Caisson

$I = L \times B^2 / 12 = 19.95 \times 19.00^3 / 12 = 11{,}403.09\ m^4$

・Stability Examination for Caisson

$GM = I/V - GC = 11{,}403.09 / 2{,}644.82 - (6.65 - 3.43)$

$= 1.09\ m \geqq 0.05 \times d = 0.05 \times 6.91 = 0.35\ m$

Accordingly, it is stable during buoyancy.

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			26 / 07 /2002		08 / 08 /2002

3) Calculation of External Forces

(1) Earth Pressure

Calculation results of earth pressure are shown below.

a) Ordinary Condition

Layer	Elevation (m)	Load (kN/m^2)	Coefficient of EarthPressure	Intensity of Earth Pressure (kN/m^2)	Earth Pressure (kN/m)
1	+5.00	20.000	0.3014	6.028	42.500
	+2.00	74.000	0.3014	22.305	
2	+2.00	74.000	0.2011	14.878	15.950
	+1.04	91.280	0.2011	18.352	
3	+1.04	91.280	0.2011	18.352	527.948
	-14.50	246.680	0.2011	49.595	

・Horizontal Earth Pressure

Layer	Earth Pressure (kN/m)	cos(ψ+δ)	Horizontal Earth Pressure (kN/m)	Action Height (m)	Moment (kN・m/m)
1	42.500	0.966	41.052	17.713	727.138
2	15.950	0.966	15.407	16.003	246.558
3	527.948	0.966	509.959	6.579	3,355.057
Total			566.417		4,328.752

・Vertical Earth Pressure

Layer	Earth Pressure (kN/m)	cos(ψ+δ)	Vertical Earth Pressure (kN/m)	Action Height (m)	Moment (kN・m/m)
1	42.500	0.259	11.000	21.000	230.995
2	15.950	0.259	4.128	21.000	86.693
3	527.948	0.259	136.643	21.000	2,869.505
Total			151.771		3,187.192

b) Earthquake Condition

Layer	Elevation (m)	Load (kN/m²)	Seismic Coefficient	Coefficient of EarthPressure	Intensity of Earth Pressure (kN/m²)	Earth Pressure (kN/m)
1	+5.00	10.000	0.200	0.4520	4.520	50.176
	+2.00	64.000	0.200	0.4520	28.930	
2	+2.00	64.000	0.200	0.3168	20.276	22.092
	+1.04	81.280	0.200	0.3168	25.750	
3	+1.04	81.280	0.298	0.3938	32.011	972.992
	-14.50	236.680	0.298	0.3938	93.213	

・Horizontal Earth Pressure

Layer	Earth Pressure (kN/m)	$\cos(\psi+\delta)$	Horizontal Earth Pressure (kN/m)	Action Height (m)	Moment (kN・m/m)
1	50.176	0.966	48.466	17.635	854.703
2	22.092	0.966	21.340	16.001	341.455
3	972.992	0.966	939.838	6.504	6,112.860
Total			1,009.644		7,309.018

・Vertical Earth Pressure

Layer	Earth Pressure (kN/m)	$\cos(\psi+\delta)$	Vertical Earth Pressure (kN/m)	Action Height (m)	Moment (kN・m/m)
1	50.176	0.259	12.986	21.000	272.714
2	22.092	0.259	5.718	21.000	120.077
3	972.992	0.259	251.829	21.000	5,288.408
Total			270.533		5,681.199

(3) Buoyancy

F = {[(14.50+1.04)×20.00] + (0.50×1.00) + (0.20×1.00/2)}×10.1

= (310.80 + 0.50+0.10)×10.1

= 3,145.14 kN/m

M = {[310.80×10.1×(20.00/2+1.00)]

+[0.50×10.1×(1.00/2)] + [0.10×10.1×(1.00×2/3)]}

= 34,533.08 kN・m/m

(4) Earthquake Force

F = 7,748.88×0.20 = 1,549.78 kN/m

M = 1,549.78×9.64 = 14,946.96 kN・m

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(5) Residual Water Pressure

Elevation	Intensity of Water Pressure (kN/m²)	Residual Water Pressure (kN/m)	Action Height (m)	Moment (kN・m/m)
1.04	0.00	6.91	14.76	102.04
-0.13	11.82			
-0.13	11.82	169.81	7.19	1,220.09
-14.50	11.82			
Total		176.72		1,322.12

(6) Dynamic Water Pressure (Earthquake Condition)

Dynamic water pressure acts only on the front of caisson.

$Pw = (7/12) \times 10.1 \times 0.2 \times (14.50-0.13)^2 = 243.32$ kN/m

$h = (2/5) \times (14.50-0.13) = 5.75$ m

$Mw = 243.32 \times 5.748 = 1{,}399.09$ kN・m/m

(7) Crane Load

On a container berth, only a seaside is loaded among the crane wheel loads shown in Design Condition.

It loads 16 wheels per a caisson. Load point of crane is the part 3.0m away from the front of concrete crown. (From the front of footing to 4.0m)

a) During Work

- Vertical Load 385.0 kN/wheel
  - All wheel load per a caisson $P = 385.0 \times 16 = 6{,}160$ kN
  - Wheel load per 1m $p = 6{,}160 / 19.95 = 308.77$ kN/m
- Horizontal Load 23.0 kN/wheel
  - All wheel load per a caisson $P = 23.0 \times 16 = 368.0$ kN
  - Wheel load per 1m $p = 368.0 / 19.95 = 18.45$ kN/m

b) Earthquake Condition

- Vertical Load 580.0 kN/wheel
  - All wheel load per a caisson $P = 580.0 \times 16 = 9{,}280$ kN
  - Wheel load per 1m $p = 9{,}280 / 19.95 = 465.16$ kN/m
- Horizontal Load 55.0 kN/wheel
  - All wheel load per a caisson $P = 55.0 \times 16 = 880.0$ kN
  - Wheel load per 1m $p = 880.0 / 19.95 = 44.11$ kN/m

(8) Reaction Force of Fender

The action direction of reaction force of the fender that generated by berthing is mutually offset in earth pressure and the opposite direction.
Therefore, examination of berthing condition is omitted.

(9) Tractive Force

On a container berth, mooring posts are arranged every 20.0m (1 per a caisson).
P = 1,000 kN / 20.0 m = 50.0 kN /m

(10) Surcharge

On a container berth (less than 40m from a quaywall face line), surcharge of 20kN/m² (ordinary condition) and 10kN/m² (earthquake condition) is considered.

Ordinary Condition : W' = 20.0×(19.00+1.00) = 400.00kN/m
Mw' = 400.00×(1.00+20.00/2) = 4400.00 kN・m/m

Earthquake Condition : W' = 10.0×(19.00+1.00) = 200.00kN/m
Mw' = 200.00×(1.00+20.00/2) = 2200.00 kN・m/m

(11) Generalization of Load

Examination consider as eight cases those with crane load or without, and with surcharge or without, in case of ordinary condition and earthquake condition.
Moreover, since it is small enough compared with seismic force, tractive force does not examine.

a) Ordinary Condition 「With Crane Load・With Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	151.77	3,187.19	566.42	4,328.75
Residual Water Pressure			176.72	1,322.12
Crane Load	308.77	1,235.08	18.45	359.78
Surcharge	400.00	4,400.00		
Total	5,464.28	58,934.75	761.59	6,010.65

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b) Ordinary Condition 「With Crane Load・Without Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	151.77	3,187.19	566.42	4,328.75
Residual Water Pressure			176.72	1,322.12
Crane Load	308.77	1,235.08	18.45	359.78
Total	5,064.28	54,534.75	761.59	6,010.65

c) Ordinary Condition 「Without Crane Load・With Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	151.77	3,187.19	566.42	4,328.75
Residual Water Pressure			176.72	1,322.12
Surcharge	400.00	4,400.00		
Total	5,155.51	57,699.67	743.14	5,650.87

d) Ordinary Condition 「Without Crane Load・Without Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	151.77	3,187.19	566.42	4,328.75
Residual Water Pressure			176.72	1,322.12
Total	4,755.51	53,299.67	743.14	5,650.87

e) Earthquake Condition 「With Crane Load・With Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	270.53	5,681.20	1,009.64	7,309.02
Residual Water Pressure			176.72	1,322.12
Crane Load	465.16	1,860.64	44.11	860.15
Surcharge	200.00	2,200.00		
Seismic Force			1,549.78	14,946.96
Dynamic Water Pressure			243.32	1,399.09
Total	5,539.43	59,854.32	3,023.57	25,837.34

f) Earthquake Condition 「With Crane Load・Without Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	270.53	5,681.20	1,009.64	7,309.02
Residual Water Pressure			176.72	1,322.12
Crane Load	465.16	1,860.64	44.11	860.15
Seismic Force			1,549.78	14,946.96
Dynamic Water Pressure			243.32	1,399.09
Total	5,339.43	57,654.32	3,023.57	25,837.34

g) Earthquake Condition 「Without Crane Load・With Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	270.53	5,681.20	1,009.64	7,309.02
Residual Water Pressure			176.72	1,322.12
Surcharge	200.00	2,200.00		
Seismic Force			1,549.78	14,946.96
Dynamic Water Pressure			243.32	1,399.09
Total	5,074.27	57,993.68	2,979.46	24,977.20

h) Earthquake Condition 「Without Crane Load・Without Surcharge」

	Vertical Force V (kN/m)	Resistance Moment Mx (kN・m/m)	Horizontal Force H (kN/m)	Starting Moment My (kN・m/m)
Weight of the Wall	7,748.88	84,645.55		
Floating Force	-3,145.14	-34,533.08		
Earth Pressure	270.53	5,681.20	1,009.64	7,309.02
Residual Water Pressure			176.72	1,322.12
Seismic Force			1,549.78	14,946.96
Dynamic Water Pressure			243.32	1,399.09
Total	4,874.27	55,793.68	2,979.46	24,977.20

References/ Notes

4) Examination of Stability

(1) Examination of Sliding

It checks satisfying the formula shown below as stability examination of sliding.

$F = \mu \times V / H \geqq F'$

F' : Safety Factor (Ordinary Condition 1.20、Earthquake Condition 1.00)

a) Ordinary Condition 「With Crane Load・With Surcharge」

$F = 0.70 \times 5{,}464.28 / 761.59 = 5.02 \geqq 1.20$ O.K

b) Ordinary Condition 「With Crane Load・Without Surcharge」

$F = 0.70 \times 5{,}064.28 / 761.59 = 4.65 \geqq 1.20$ O.K

c) Ordinary Condition 「Without Crane Load・With Surcharge」

$F = 0.70 \times 5{,}155.51 / 743.14 = 4.86 \geqq 1.20$ O.K

d) Ordinary Condition 「Without Crane Load・Without Surcharge」

$F = 0.70 \times 4{,}755.51 / 743.14 = 4.48 \geqq 1.20$ O.K

e) Earthquake Condition 「With Crane Load・With Surcharge」

$F = 0.70 \times 5{,}539.43 / 3{,}023.57 = 1.28 \geqq 1.00$ O.K

f) Earthquake Condition 「With Crane Load・Without Surcharge」

$F = 0.70 \times 5{,}339.43 / 3{,}023.57 = 1.24 \geqq 1.00$ O.K

g) Earthquake Condition 「Without Crane Load・With Surcharge」

$F = 0.70 \times 5{,}074.27 / 2{,}979.46 = 1.19 \geqq 1.00$ O.K

h) Earthquake Condition 「Without Crane Load・Without Surcharge」

$F = 0.70 \times 4{,}874.27 / 2{,}979.46 = 1.15 \geqq 1.00$ O.K

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(2) Examination of Overturning

It checks satisfying the formula shown below as stability examination of overturning.

F = Mx / My ≧ F'

F' : Safety Factor (Ordinary Condition 1.20、 Earthquake Condition 1.00)

a) Ordinary Condition 「With Crane Load・With Surcharge」

F = 58,934.75 / 6,010.65 = 9.81 ≧ 1.20 O.K

b) Ordinary Condition 「With Crane Load・Without Surcharge」

F = 54,534.75 / 6,010.65 = 9.07 ≧ 1.20 O.K

c) Ordinary Condition 「Without Crane Load・With Surcharge」

F = 57,699.67 / 5,650.87 = 10.21 ≧ 1.20 O.K

d) Ordinary Condition 「Without Crane Load・Without Surcharge」

F = 53,299.67 / 5,650.87 = 9.43 ≧ 1.20 O.K

e) Earthquake Condition 「With Crane Load・With Surcharge」

F = 59,854.32 / 25,837.34 = 2.32 ≧ 1.10 O.K

f) Earthquake Condition 「With Crane Load・Without Surcharge」

F = 57,654.32 / 25,837.34 = 2.23 ≧ 1.10 O.K

g) Earthquake Condition 「Without Crane Load・With Surcharge」

F = 57,993.68 / 24,977.20 = 2.32 ≧ 1.10 O.K

h) Earthquake Condition 「Without Crane Load・Without Surcharge」

F = 55,793.68 / 24,977.20 = 2.23 ≧ 1.10 O.K

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

References/ Notes

(3) Examination of Eccentric and Inclined Loads

a) Examination of Subgrade Reaction at the Bottom Surface of the Wall

Subgrade reaction is calculated by the following formula (per 1m).

Eccentric volume of loads $e = (B/2) - (Mx - My)/V$ (m) B : Wall width (m)

If it is $e \leqq B/6$, subgrade reaction is a trapezoidal distribution.

If it is $e > B/6$, subgrade reaction is a triangular distribution.

Subgrade reaction (Trapezoidal distribution)

$p_1 = (1 + 6 \times e / B) \times V / B$ (kN/m²)

$p_2 = (1 - 6 \times e / B) \times V / B$ (kN/m²)

Subgrade reaction (Triangular distribution)

$p_1 = (2/3) \times V / ((B/2) - e)$ (kN/m²)

Distribution width $b' = 3 \times ((B/2) - e)$ (m)

(i) Ordinary Condition 「With Crane Load・With Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (58{,}934.75 - 6{,}010.65) / 5{,}464.28 = 0.81$ m

B/6=3.50m $e \leqq B/6$ According to the subgrade reaction of trapezoidal distribution.

Subgrade reaction $p_1 = (1+6 \times 0.81 / 21.0) \times 5{,}464.28 / 21.0 = 320.76$ kN/m²

$p_2 = (1-6 \times 0.81 / 21.0) \times 5{,}464.28 / 21.0 = 199.65$ kN/m²

(ii) Ordinary Condition 「With Crane Load・Without Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (54{,}534.75 - 6{,}010.65) / 5{,}064.28 = 0.92$ m

B/6=3.50m $e \leqq B/6$ According to the subgrade reaction of trapezoidal distribution.

Subgrade reaction $p_1 = (1+6 \times 0.92 / 21.0) \times 5{,}064.28 / 21.0 = 304.43$ kN/m²

$p_2 = (1-6 \times 0.92 / 21.0) \times 5{,}064.28 / 21.0 = 177.88$ kN/m²

(iii) Ordinary Condition 「Without Crane Load・With Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (57{,}699.67 - 5{,}650.87) / 5{,}155.51 = 0.40$ m

B/6=3.50m $e \leqq B/6$ According to the subgrade reaction of trapezoidal distribution.

Subgrade reaction $p_1 = (1+6 \times 0.40 / 21.0) \times 5{,}155.51 / 21.0 = 273.85$ kN/m²

$p_2 = (1-6 \times 0.40 / 21.0) \times 5{,}155.51 / 21.0 = 217.15$ kN/m²

(iv) Ordinary Condition 「Without Crane Load・Without Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (53{,}299.67 - 5{,}650.87) / 4{,}755.51 = 0.48$ m

B/6=3.50m $e \leqq B/6$ According to the subgrade reaction of trapezoidal distribution.

Subgrade reaction $p_1 = (1+6 \times 0.48 / 21.0) \times 4{,}755.51 / 21.0 = 257.53$ kN/m²

$p_2 = (1-6 \times 0.48 / 21.0) \times 4{,}755.51 / 21.0 = 195.38$ kN/m²

		Prepared by	Y. Ando	Checked by	R. NISHIMURA
			26/07/2002		06/08/2002

(v) Earthquake Condition 「With Crane Load・With Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (59,854.32 - 25,837.34) / 5,539.43 = 4.36$ m

B/6=3.50m $e > B/6$ According to the subgrade reaction of triangular distribution.

Subgrade reaction $p_1 = (2/3) \times 5,539.43 / ((21.0 / 2) - 4.36) = 601.37$ kN/m^2

Distribution width $b' = 3 \times ((21.0 / 2) - 4.36) = 18.42$ m

(vi) Earthquake Condition 「With Crane Load・Without Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (57,654.32 - 25,837.34) / 5,339.43 = 4.54$ m

B/6=3.50m $e > B/6$ According to the subgrade reaction of triangular distribution.

Subgrade reaction $p_1 = (2/3) \times 5,339.43 / ((21.0 / 2) - 4.54) = 597.37$ kN/m^2

Distribution width $b' = 3 \times ((21.0 / 2) - 4.54) = 17.88$ m

(vii) Earthquake Condition 「Without Crane Load・With Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (57,993.68 - 24,977.20) / 5,074.27 = 3.99$ m

B/6=3.50m $e > B/6$ According to the subgrade reaction of triangular distribution.

Subgrade reaction $p_1 = (2/3) \times 5,074.27 / ((21.0 / 2) - 3.99) = 519.91$ kN/m^2

Distribution width $b' = 3 \times ((21.0 / 2) - 3.99) = 19.52$ m

(viii) Earthquake Condition 「Without Crane Load・Without Surcharge」

Eccentric volume of loads $e = (21.0 / 2) - (55,793.68 - 24,977.20) / 4,874.27 = 4.18$ m

B/6=3.50m $e > B/6$ According to the subgrade reaction of triangular distribution.

Subgrade reaction $p_1 = (2/3) \times 4,874.27 / ((21.0 / 2) - 4.18) = 513.98$ kN/m^2

Distribution width $b' = 3 \times ((21.0 / 2) - 4.18) = 18.97$ m

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

References/ Notes

b) Examination by the Circular Slip Analysis Based on Bishop Method

Stability examination of the foundation is calculated by the circular slip analysis bishop method. The input data of calculation by bishop method is calculated using the following formulas.

Load width $B' = ((B/2) - e) \times 2$ (m)

Uniform load

Subgrade reaction is a trapezoidal distribution $q = ((p_1 + p_2)/(2 \times B')) \times B$ (kN/m²)

Subgrade reaction is a triangular distribution $q = p_1 \times b / (2 \times B')$ (kN/m²)

(i) Ordinary Condition 「With Crane Load・With Surcharge」

Load width $B' = ((21.0 / 2) - 0.81) \times 2 = 19.37$ m

Uniform load $q = ((320.76 + 199.65)/(2 \times 19.37)) \times 21.00 = 282.09$ kN/m²

Horizontal load P = 761.59 kN /m

(ii) Ordinary Condition 「With Crane Load・Without Surcharge」

Load width $B' = ((21.0 / 2) - 0.92) \times 2 = 19.16$ m

Uniform load $q = ((304.43 + 177.88)/(2 \times 19.16)) \times 21.00 = 264.27$ kN/m²

Horizontal load P = 761.59 kN /m

(iii) Ordinary Condition 「Without Crane Load・With Surcharge」

Load width $B' = ((21.0 / 2) - 0.40) \times 2 = 20.19$ m

Uniform load $q = ((273.85 + 217.15)/(2 \times 20.19)) \times 21.00 = 255.33$ kN/m²

Horizontal load P = 743.14 kN /m

(iv) Ordinary Condition 「Without Crane Load・Without Surcharge」

Load width $B' = ((21.0 / 2) - 0.48) \times 2 = 20.04$ m

Uniform load $q = ((257.53 + 195.38)/(2 \times 20.04)) \times 21.00 = 237.31$ kN/m²

Horizontal load P = 743.14 kN /m

(v) Earthquake Condition 「With Crane Load・With Surcharge」

Load width $B' = ((21.0 / 2) - 4.36) \times 2 = 12.28$ m

Uniform load $q = 601.37 \times 18.42 / (2 \times 12.28) = 451.03$ kN/m²

Horizontal load P = 3,023.57 kN /m

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(vi) Earthquake Condition 「With Crane Load・Without Surcharge」

Load width B' = ((21.0 / 2) - 4.54) × 2 = 11.92 m

Uniform load q = 597.37 × 17.88 / (2 × 11.92) = 448.02 kN/m²

Horizontal load P = 3,023.57 kN /m

(vii) Earthquake Condition 「Without Crane Load・With Surcharge」

Load width B' = ((21.0 / 2) - 3.99) × 2 = 13.01 m

Uniform load q = 519.91 × 19.52 / (2 × 13.01) = 389.93 kN/m²

Horizontal load P = 2,979.46 kN /m

(viii) Earthquake Condition 「Without Crane Load・Without Surcharge」

Load width B' = ((21.0 / 2) - 4.18) × 2 = 12.64 m

Uniform load q = 513.98 × 18.97 / (2 × 12.64) = 385.48 kN/m²

Horizontal load P = 2,979.46 kN /m

In addition, about allowable safety factor, it carries out as follows.

Ordinary Condition : F = 1.20 Earthquake Condition : F = 1.00

Stability examination result is shown in the following table. Any case satisfies allowable value. Moreover, rubble width of the front of wall becomes as follows.

With Silty CLAY Layer at the bottom L = 16.00m (Distance from footing)

Without Silty CLAY Layer at the bottom L = 3.00m (Distance from footing)

	Case	Crane Load	Surcharge	Uniform Load q (kN/m²)	Distribution Width B' (m)	Horizontal Load P(kN/m)	Safety Factor F
Without Silty CLAY Layer at the bottom	Ordinary Condition	With	With	282.09	19.37	761.59	3.06
			Without	264.27	19.16	761.59	3.05
		Without	With	255.33	20.19	743.14	3.19
			Without	237.31	20.04	743.14	3.19
	Earthquake Condition	With	With	451.03	12.28	3,023.57	1.10
			Without	448.02	11.92	3,023.57	1.06
		Without	With	389.93	13.01	2,979.46	1.06
			Without	385.48	12.64	2,979.46	1.02
With Silty CLAY Layer at the bottom	Ordinary Condition	With	With	282.09	19.37	761.59	2.47
			Without	264.27	19.16	761.59	2.45
		Without	With	255.33	20.19	743.14	2.56
			Without	237.31	20.04	743.14	2.55
	Earthquake Condition	With	With	451.03	12.28	3,023.57	1.04
			Without	448.02	11.92	3,023.57	1.02
		Without	With	389.93	13.01	2,979.46	1.04
			Without	385.48	12.64	2,979.46	1.02

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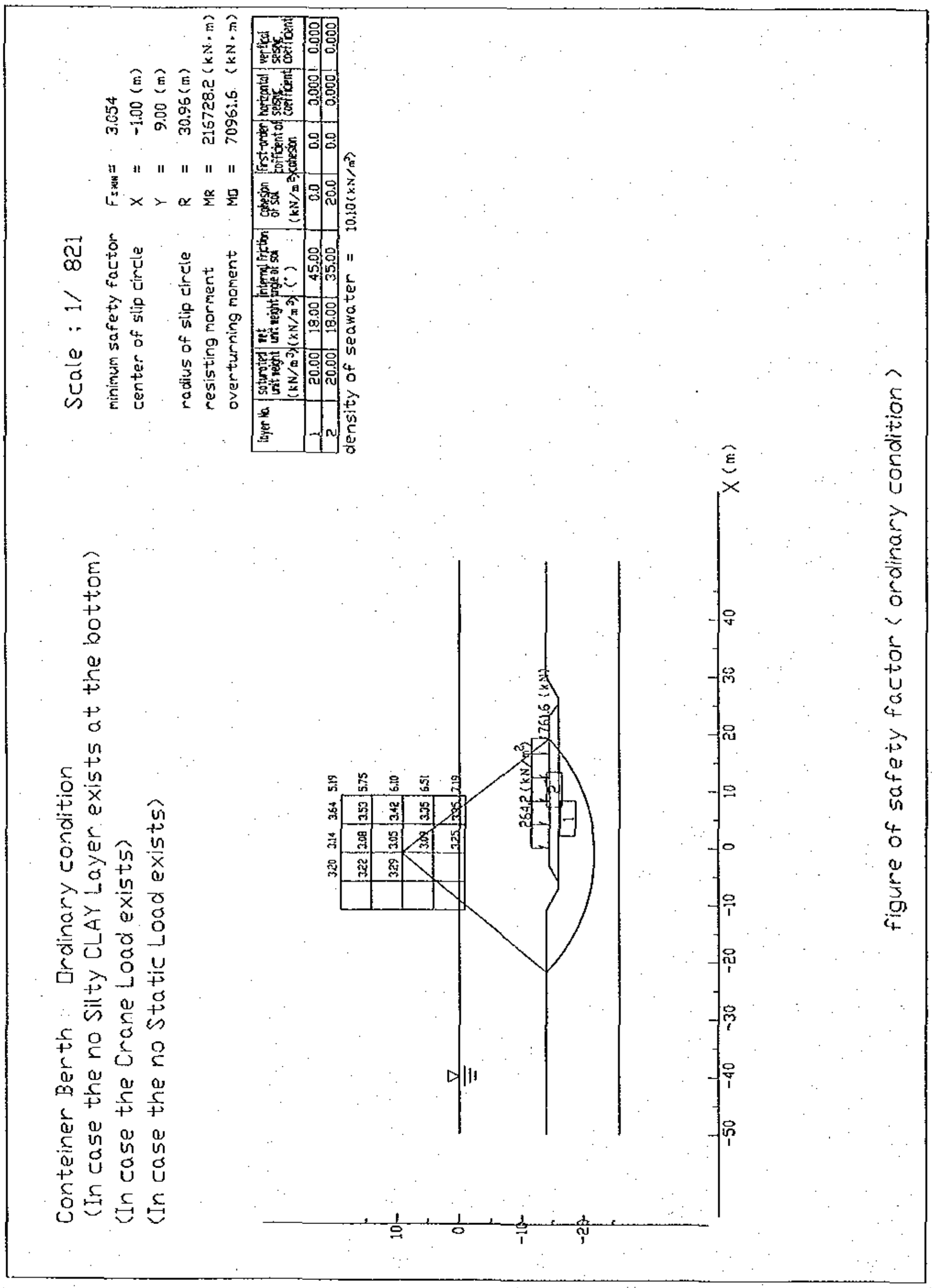
In case the no Silty CLAY Layer exists at the bottom

Ordinary condition



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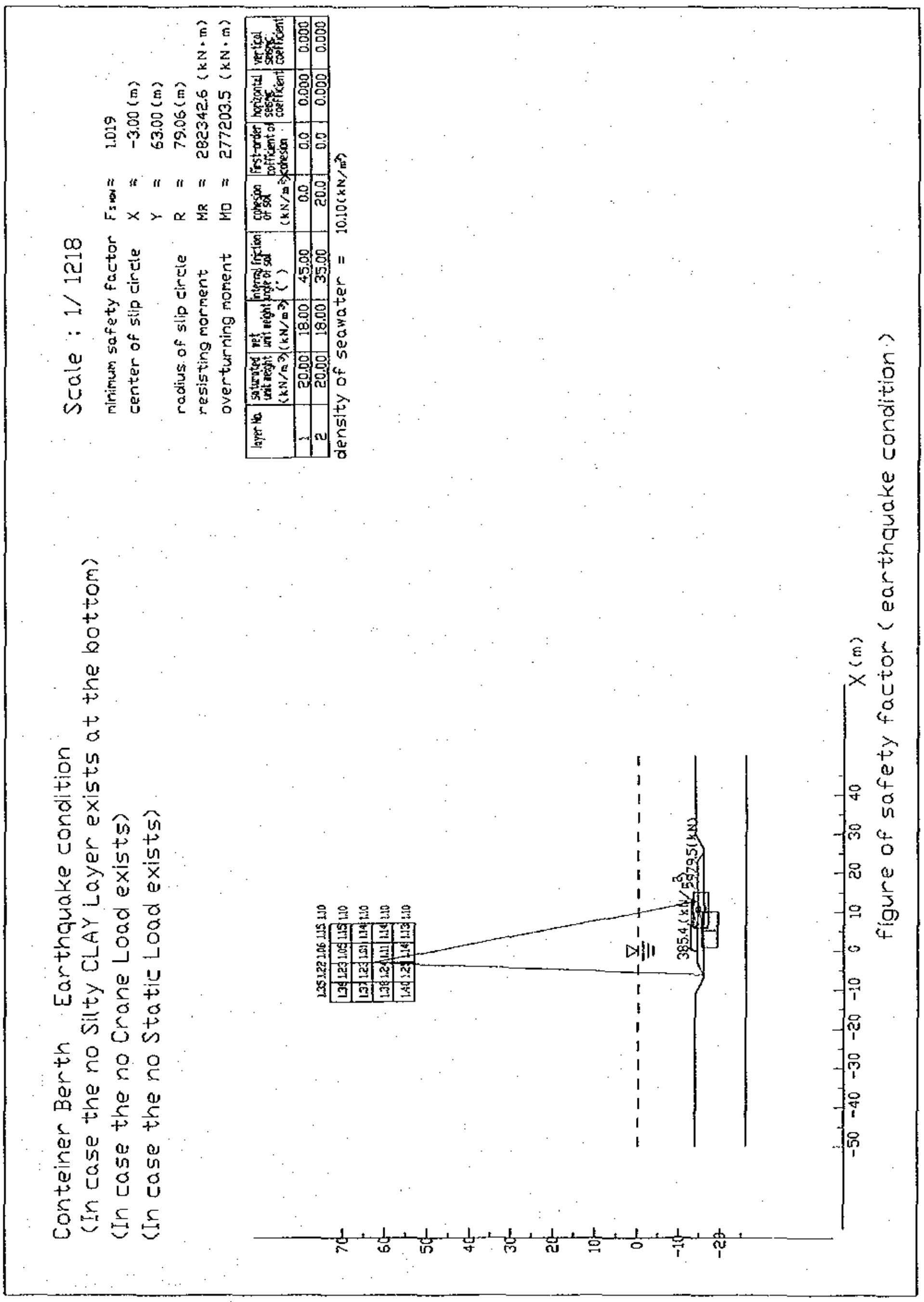
In case the no Silty CLAY Layer exists at the bottom

Earthquake condition



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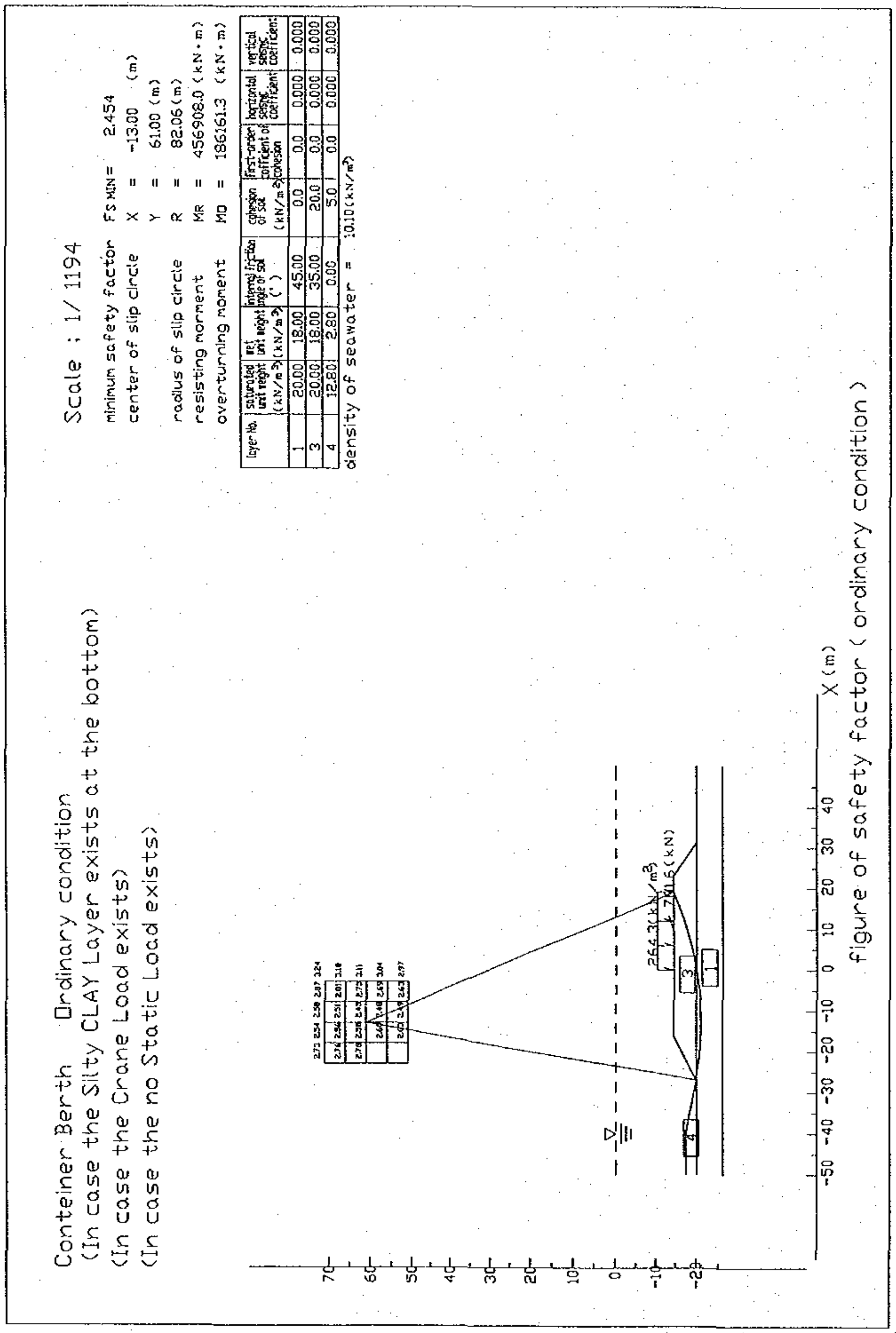
References/ Notes

・In case the Silty CLAY Layer exists at the bottom

Ordinary condition



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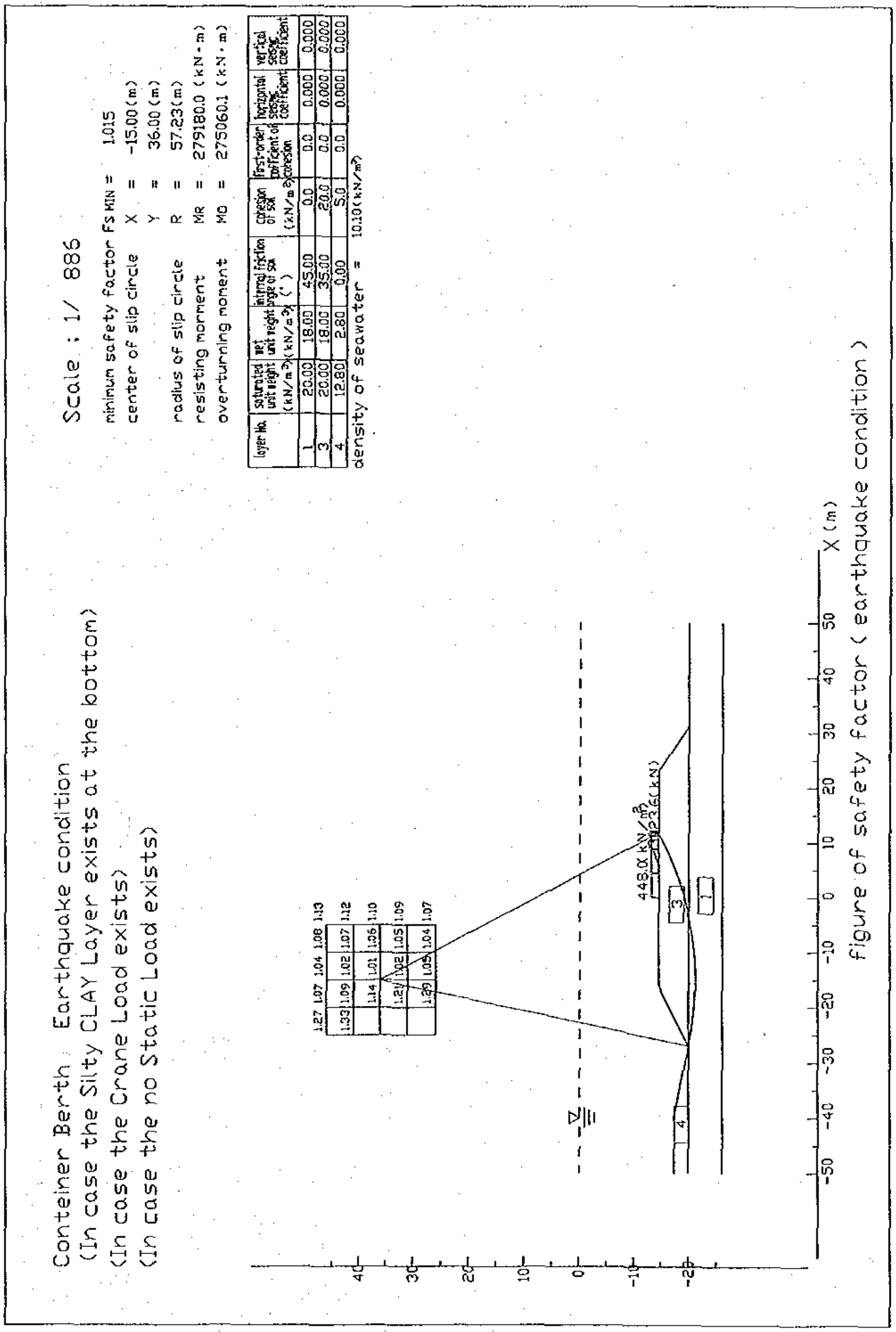
- In case the Silty CLAY Layer exists at the bottom

Earthquake condition



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(4) Examination by Circular Slip Analysis

Allowable safety factor of circular slip analysis is F = 1.30.

Examination result of circular slip analysis is shown in the following table.

Any case satisfies allowable value.

Examination Case	Safety Factor F
Without Silty CLAY Layer	1.59
With Silty CLAY Layer	1.59

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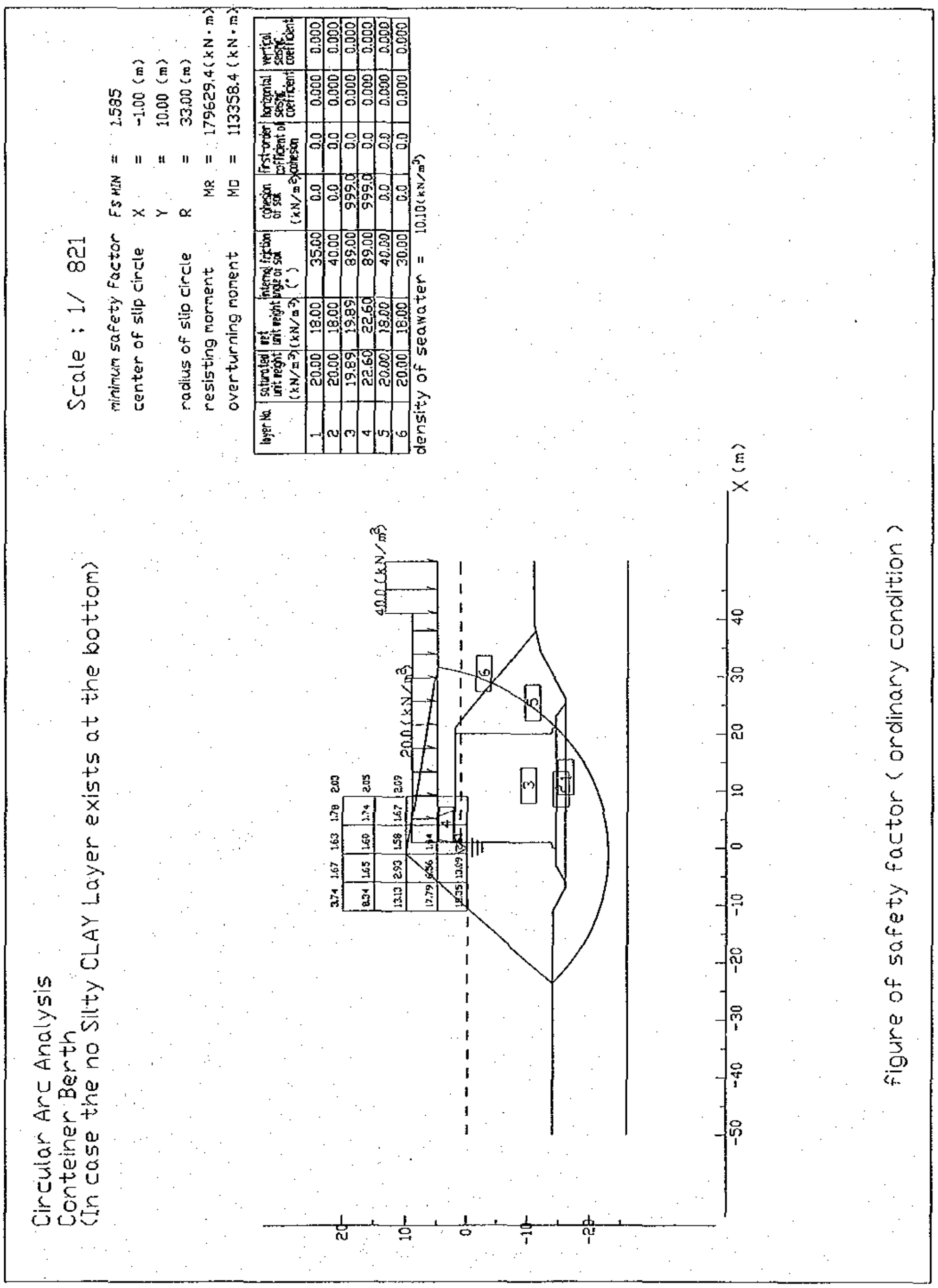
• In case the no Silty CLAY Layer exists at the bottom



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・In case the Silty CLAY Layer exists at the bottom

Circular Arc Analysis
Conteiner Berth
(In case the Silty CLAY Layer exists at the bottom)

Scale : 1/ 965

minimum safety factor $F_{S\,MIN}$ = 1.589
center of slip circle X = -7.00 (m)
Y = 14.00 (m)
radius of slip circle R = 40.00 (m)
resisting moment M_R = 267134.2 (kN・m)
overturning moment M_D = 168088.2 (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 cofficient of cohesion	horizontal seismic coefficient	vertical seismic coefficient
1	20.00	18.00	35.00	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	12.80	2.80	0.00	5.0	0.0	0.000	0.000
5	20.00	18.00	30.00	0.0	0.0	0.000	0.000
6	19.89	19.89	89.00	999.0	0.0	0.000	0.000
7	22.60	22.60	89.00	999.0	0.0	0.000	0.000

density of seawater = 10.10 (kN/m³)

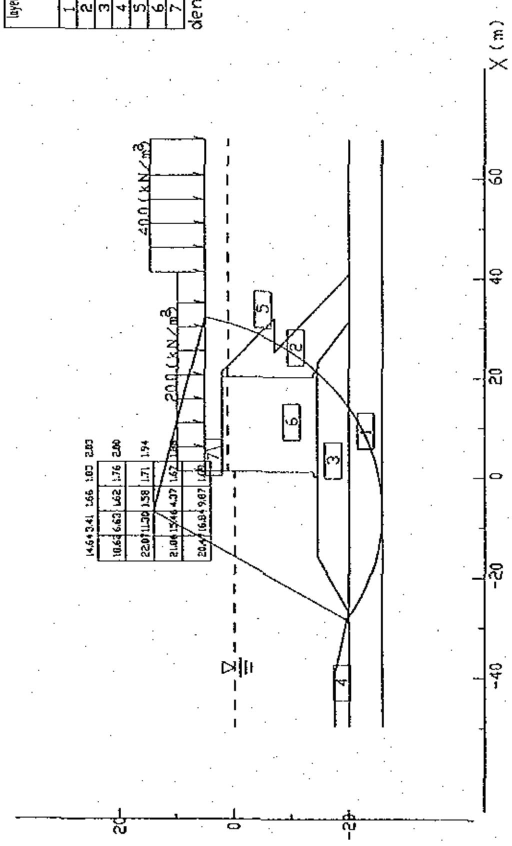

figure of safety factor (During earthquake)

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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: **Container and Multi-purpose Berth**

Calculation Objective:

Fender system

References, Calculation Notes and Comments

Refer to Drawings QW-01-040～QW-01-044

QW-01-063

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

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O	[signature]	26/07/02	1	JT	26 July 02	[signature]	26/07/02	
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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.	
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References/ Notes

5) Selection of Fenders

(1) Dimensions of Ships

Deadweight tonnage : 55,000DWT、Overall length : 294.0m、

Overall breadth : 32.2m、Full load draft : 13.1m

Length between perpendiculars : log(Lpp)=0.516+0.401 log(DWT)

=0.516+0.401 log(55,000)=2.417

Length between perpendiculars Lpp = 261.1m

Full load displacement : log(DT)=0.365+0.953 log(55,000) = 4.883

DT = 76,307 t

(2) Calculation of Ship's berthing energy

Approach velocity of the berthing ship at the movement of impact against the fender : v=0.10m/s

Softness factor : Cs=1.0

Shape factor of berth : Cc=1.0

Eccentricity factor : Ce=0.5 (1/4 point berthing)

Block coefficient : Cb=76,307/(261.1×32.2×13.1×1.03) = 0.673

Virtual mass factor : $Cm=1+(\pi/(2\times0.673))\times(13.1/32.2)=1.950$

Ship's berthing energy : $Ef=((76{,}307\times0.10^2)/2)\times0.5\times1.950\times1.0\times1.0$

=372.00 kN・m

(3) Selection of Fenders

The more economical one is selected among the following fender.

Hyper-ace V-1000H×2000L (CV2) Energy absorption 491 kN・m

Super M type SM-1000H×2000L(M3) Energy absorption 473 kN・m

Energy absorption of the fender used for examination is the value that multiplies above-mentioned value (written to catalog) by 0.9.

V-1000H×2000L (CV2) E = 491×0.9=441.9 kN・m ≧ 391.22kN・m O.K

SM-1000H×2000L(M3) E = 473×0.9=425.7 kN・m ≧ 391.22kN・m O.K

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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: **Container and Multi-purpose Berth**

Calculation Objective:

Reinforcement of Caisson

References, Calculation Notes and Comments

Refer to Drawings **QW-01-027~QW-01-037**

Calculation based on

TECHNICAL STANDERDS AND COMMENTARIES

FOR

PORT AND HARBOUR FACILITIES IN JAPAN

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FN : Calculation_Cover_Sheet

Project	Detailed Design on Port Reactivation Project in La Union	Calc. File No.	
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Subject	Quaywall	Page No. 1	Rev.

References/ Notes

6 . Detail Design of Container Berths

Bar arrangement calculation of caisson

Bar arrangement calculation of caisson calculates by the limit state design method.

1) Design External Forces :

The load factors and the combination of load in each state are shown in a lower table.

(1) Bottom slab

Conditions	The load factors of ultimate limit state	Influence coefficient on crack width of serviceability limit state
Under ordinary conditions	$0.9D + 1.1D_0 + 1.1F + 0.8W$	$1.0D + 1.0D_0 + 1.0F + 0.5W$
During an earthquake	$1.0D + 1.0R' + 1.0F + 1.0W'$	
While afloat	$0.9D_f + 1.1S_f$	$0.5D_f + 0.5S_f$

D ; Deadweight , D_0 ; Bottom slab plate reaction under permanent load

R' ; Bottom slab reaction during an earthquake , F ; Hydrostatic pressure

W ; Surcharge , W' ; Surcharge during an earthquake , D_f ; Deadweight while afloat

S_f ; Hydrostatic pressure while afloat

(2) Outer Wall

Conditions	Direction of load	The load factors of ultimate limit state	Influence coefficient on crack width of serviceability limit state
Under ordinary conditions	Load from inside	$1.1D + 1.1S$	$1.0D + 1.0S$
While afloat	Load from outside	$1.1S$	$0.5S_f$

D ; Internal earth pressure , S ; Internal water pressure

The allowable crack width is shown in a lower table.

The position of steel reinforcement	Crack Width W_{lim}(cm)	The minimum covering (cm)
The undersurface of the bottom slab The outside of an outer wall Footing	0.0035C	8.0
The upper surface of the bottom slab The inner side of an outer wall	0.0040C	6.0
Partition wall		10.0

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Subject	Quaywall	Page No. 2.	Rev.

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2) Examination of members to ultimate limit state

Examination of a member to ultimate limit state is performed by confirming that the value for a design of sectional capacity (M_{ud}) is beyond a value for a design of section force (M_d).

$$\frac{\gamma_i M_d}{M_{ud}} \leqq 1.0$$

γ_i ; The structure factor 1.0 for earthquake load, otherwise 1.1

(1) Calculation of the required amount of steel reinforcement.

The amount of steel reinforcement is computed by the following formula.

$$A_{sn} = \frac{A_n \left(d - \sqrt{d^2 - \dfrac{4\gamma_b \gamma_i M_d}{A_n}}\right)}{2 f_{yd}}$$

where

$A_n = 1.7\, b_w\, f'_{cd}$

f_{yd} ; Design tensile yield strength of steel reinforcement $f_{yd} = f_{yk} / \gamma_s$

f'_{cd} ; Design compressive yield strength of concrete $f'_{cd} = f'_{ck} / \gamma_c$

d ; Effective height

γ_b ; The member factor 1.0 for earthquake load, otherwise 1.15

γ_s ; The material factor of steel reinforcement 1.0

γ_c ; The material factor of concrete 1.3

(2) Calculation of bending capacity

The value for a design of bending capacity is computed by the following formula.

$$M_{ud} = A_s f_{yd} d \left\{1 - \frac{P_w M f_{yd}}{1.7 f'_{cd}}\right\} / \gamma_d$$

where

A_s ; The amount of tensile steel reinforcement (cm^2)

P_w ; $A_s / (b_w d)$

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References/ Notes

3) Examination of members to serviceability limit state

Examination of the member of serviceability limit state examines a crack width limit state.

Moreover,

calculation of crack width is performed by the following formula.

$$W = k_1 \{4C + 0.7 (C_\phi - \phi)\} [\sigma_{se} / E_s + \varepsilon_\phi]$$

where W ; flexural crack width (cm)

k_1 ; constant indicating the effect of the bonding properties of the steel material ,which may usually be taken as 1.0 in the case of deformed bars

C ; covering (cm)

C_ϕ ; distance between centers of steel materials (cm)

ϕ ; diameter of steel materials (cm)

σ_{se} ; increased stress on reinforcement (N/mm²)

E_s ; Young's modulus of reinforcement (200kN/mm²)

ε_ϕ ; constant introduced to represent the increase of crack width caused by creep and drying shrinkage of concrete (this can be 0.0 under seawater)

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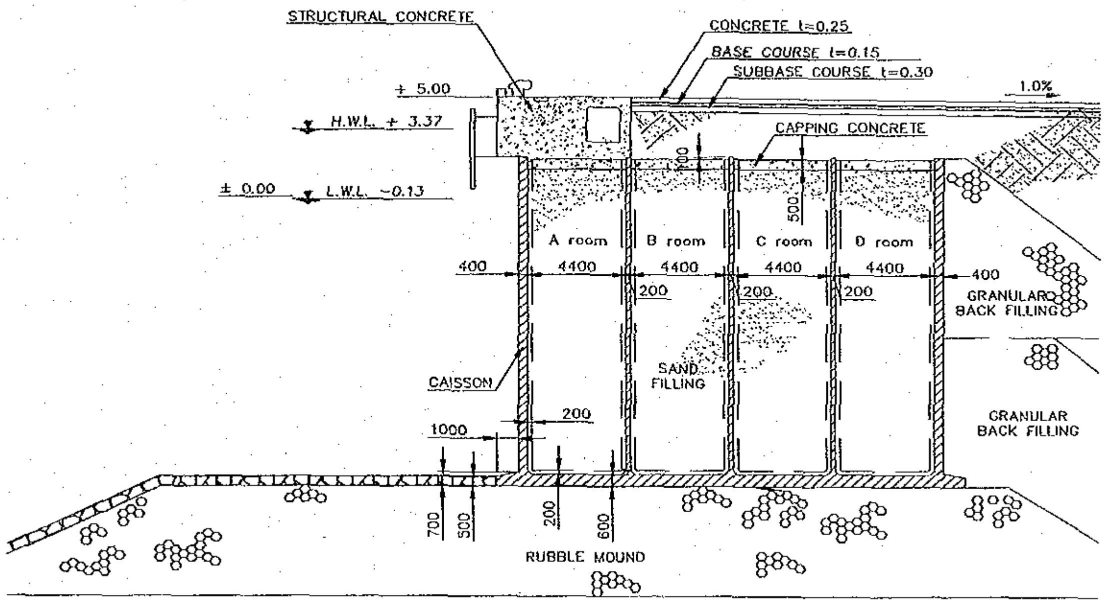
4) Surcharge

As shown in the following figure, since the side wall and the partition wall support structural concrete, the load does not act on filling materials at A room. Moreover, in order that direct surcharge may act on capping concrete about D room from B room, the load acts on filling materials.

Therefore, bar arrangement calculation of caisson is performed about two cases.



Case.1	When surcharge on caisson acts on filling materials.		
	Static load		18.0(kN/m³)×3(m)=54.0(kN/m²)
	Surcharge	Under ordinary conditions	20.0(kN/m²)
		During an earthquake	10.0(kN/m²)
Case.2	When surcharge on caisson doesn't act on filling materials.		
	Static load		0.0(kN/m²)
	Surcharge	Under ordinary conditions	0.0(kN/m²)
		During an earthquake	0.0(kN/m²)

This examination calculates bar arrangement in upper two cases, and accepts more safety case.

The bar arrangement calculation result list in each case is shown from the following page.

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