NIPPON KOEI CO.,LTD.

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:

Rainforcement of platform 2.

References, Calculation Notes and Comments

Refer to drawing **QW-02-012～QW-02-024**

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Rev	Prepared by	Prepared Date	No. of Pages	Checked by	Checked Date	Reviewed by	Reviewed Date	Superseded by Calc No.
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1) Examination Case

Combination of the load of the examination case of calculation of reinforcing bar arrangement, and each examination case

	Deadweight	Surcharge	Earthquake force	Wheel Load (Truck)
Ordinary	○	○	—	—
Earthquake	○	○	○	—
Wheel Load (Truck)	○	—	—	○

Moreover, calculation of reinforcing bar arrangement of each examination case is performed as follows.

	Ultimate limit	Serviceability limit	Fatigue limit
Ordinary	○	○	—
Earthquake	○	—	—
Wheel Load (truck)	○	○	○

2) Partial Safety Factors

The partial safety factor used for this examination is shown below.

(1) Load Factor

	Ulitimate limit	Serviceability limit	Fatigue limit
Deadweight	1.1	1.0	1.0
Surcharge	1.2 (1.0)	1.0	1.0
Wheel Load	1.2	1.0	1.0
Earthquake Force	1.0	—	—

※The inside of a parenthesis is a value in case of an earthquake.

(2) The other numbers of partial safety factor.

		Ulitimate limit	Serviceability limit	Fatigue limit
Material factor	Concrete	1.30	1.00	1.30
(γm)	Reinforcing Bar	1.00	1.00	1.05
Structure analysis factor(γa)		1.00	1.00	1.00
Member factor (γb)		1.15	1.00	1.00
Structure factor (γi)		Earthquake 1.00 Otherwise 1.20	1.00	1.00

※Member Factor

When calculating bending and axial strength : 1.15

When calculating upper limit of axial compressive strength : 1.30

When calculating shear capacity borne by concrete : 1.30

When calculating shear capacity borne by shear reinforcement : 1.15

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

3) Calculation Method of Cross-Sectional Force

(1) Beam

The cross-sectional force of a beam is computed using a 2-dimensional framework model (continuation beam). Action load is multiplied by the partial safety factor. The calculation result computed by the basic design is used for the pile head moment in case of an earthquake.

(2) Deck Slab

The deck slab of the platform central part surrounded by the beam should be designed as a slab fixed on four sides. The deck slab of a platform end should be designed as a slab fixed on three sides and free on one side.

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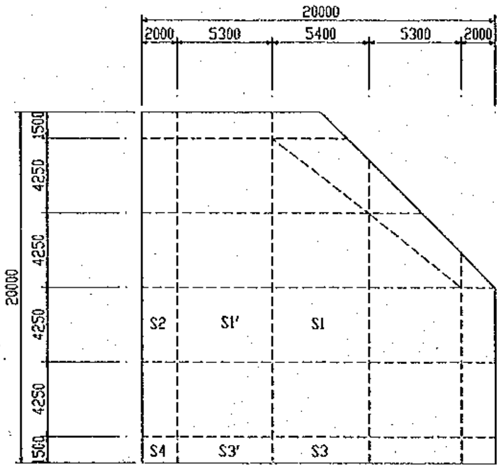
4) Calculation of Load

(1) Deck Slab

The examination cases of calculation of reinforcing bar arrangement of a deck slab are the following two cases.

・Ordinary Condition　　・Conditions on which Wheel Load(Truck) acts



Cross-sectional force is calculated only about "S1" and "S3". "S1'", "S2", "S3'", and "S4" omit calculation. "S1'" and "S2" are taken as the same reinforcing bar arrangement as "S1". And, "S3'" and "S4" are taken as the same reinforcing bar arrangement as "S3".

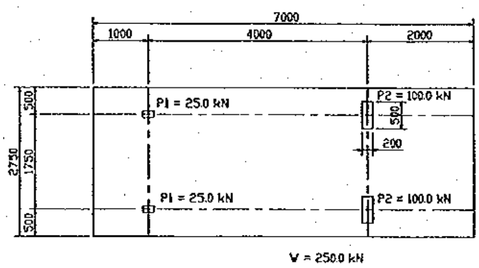
a) Deadweight　Thickness of deck slab　　$t = 0.25cm$

Equivalent uniform distribution　　$w = 0.25 \times 2.4.0 = 6.00\ kN/m^2$

b) Surcharge　　$w = 20.0\ kN/m^2$

c) Wheel Load (Truck)

Wheel load (Truck) is converted into equivalent uniform distribution and partial equivalent uniform distribution. Section force is computed about each distribution load, and the larger one is made into design section force.



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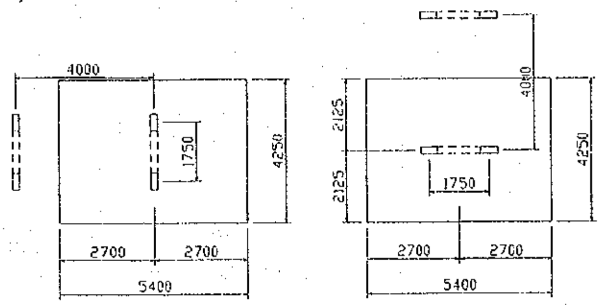
Wheel load (Truck) shall act only on "S1" of the member of deck slab. The action situation of wheel load (Truck) is shown below.



(i) Conversion to Equivalent Uniform Distribution Load

Wheel load is converted into equivalent uniform distribution load"w1" using the following formulas.

$$w1 = \frac{P}{C \times (0.50 \times L_1 + 0.25 \times L_2)}$$

where、P : Wheel Load (2×100 = 200 kN)

C : Width of Truck (= 2.75 m)

L_1 : Length of the longer side

L_2 : Length of the shorter side

・The truck run direction is the vertical direction to the face line.

$w1 = 200 / (2.75 \times (0.50 \times 5.40 + 0.25 \times 4.25)) = 19.33$ kN/m^2

・The truck run direction is the parallel direction to the face line.

$w1 = 200 / (2.75 \times (0.50 \times 4.25 + 0.25 \times 5.40)) = 20.93$ kN/m^2

Therefore, equivalent uniform distribution load used for examination is set to "w= 20.93kN/m^2 (The truck run direction is the parallel direction to the face line.)"

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(ii) Conversion to partial equivalent uniform distribution load

When converting wheel load into partial equivalent distribution load, cross-sectional force is computed using the graph for calculation of Pigeaud.

Wheel load acts as the following figures and computes conversion distribution width as follows.

Tire width of the longer one 2.25 m

Tire width of the shorter one 0.20 m

・Calculation of conversion distribution width

$u' = u + 2 \times (s + (t/2)) = 2.25 + 2 \times (0.1 + (0.25/2)) = 2.70$ m

$v' = v + 2 \times (s + (t/2)) = 0.20 + 2 \times (0.1 + (0.25/2)) = 0.65$ m

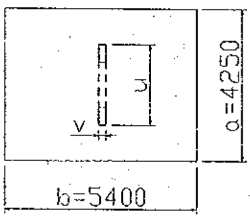
where u'、v' : conversion distribution width

s : thickness of pavement (= 0.10 m)

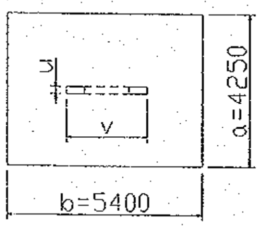
t : thickness of deck slab (=0.25 m)

Resultant Force of Wheel Load $P = 2 \times 100 = 200$ kN

When a truck runs in the vertical direction to the face line



When a truck runs in the parallel direction to the face line



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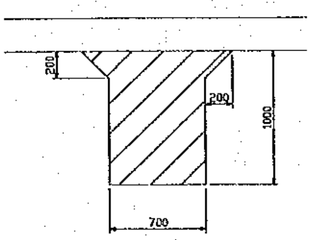
(2) Beam

Calculation of reinforcing bar arrangement of a beam carries out for all examination cases.

a) Deadweight of Beam

The section of a beam is shown below. (Hatching part)



Cross-sectional area of beam

$A = 0.7 \times 1.0 + 0.2^2 / 2 \times 2 = 0.74\ m^2$

Deadweight of beam

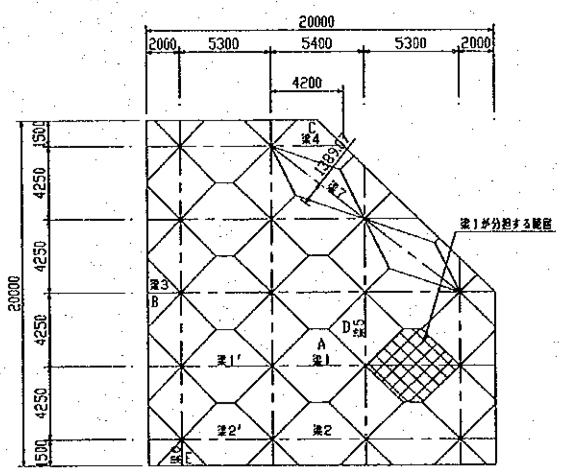
$w = 0.74 \times 24.0 = 17.76\ kN/m$

Land side end Cross-sectional area of beam $A = 4.25 \times 1.0 = 42.5\ m^2$

Deadweight $w = 4.25 \times 24 = 102.0\ kN/m$

b) Deadweight of Deck Slab

The deadweight of deck slab, which the individual beam shares, is shown in the following figures. Cross-sectional force is computed only about "Beam1", "Beam3", "Beam4", "Beam5", "Beam6", and "Beam7." Examination is omitted about "Beam2", "Beam1'" and "Beam2'" ,and it is made the same reinforced bar arrangement as "Beam1".



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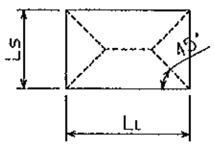
The deck slab weight, which the individual beam shares, is converted into equivalent uniform distribution load by the following formulas.



Converted equivalent uniform distribution load of short span

$W = w \times Ls / 3$ (kN/m)

Converted equivalent uniform distribution load of long span

$W = (w \times Ls / 2) \times (1 - (1/3) \times (Ls^2 / L_L^2))$ (kN/m)

where w : Deadweight of deck slab (kN/m²)

Ls : Length of short span (m)、 L_L : Length of long span (m)

The deadweight of deck slab member"A～E" in the figure of a front page is converted into equivalent uniform distribution load.

Load which acts on a long span beam (A、C)

	Length of long span L_L (m)	Length of short span Ls (m)	Deadweight (kN/m²)	Equivalent uniform distribution load (deck slab) (kN/m)
A	5.40	4.25	6.00	10.12
C	4.20	3.00	6.00	7.47

Load which acts on a short span beam (B、D、E)

	Length of long span L_L (m)	Length of short span Ls (m)	Equivalent uniform distribution load (deck slab) (kN/m)
B	4.00	6.00	8.00
D	4.25	6.00	8.50
E	3.00	6.00	6.00

Moreover, equivalent uniform distribution load, such as acting on a "beam 7", is computed based on a calculation formula. The value, which multiplied the value, which divided the deck slab weight, which acts on a beam 7 by "Ls", by 4/3, is made into equivalent uniform distribution load.

Equivalent uniform distribution load which acts on "Beam 7"

$w = ((1.39 \times 6.87 / 2) / 6.87) \times 4/3 \times 6.0 = 5.56$ kN/m

Therefore, the deck slab weight, which acts on the beam to examine, becomes as follows.

Beam 1 w = 10.12 + 10.12 = 20.24 kN/m (A+A)

Beam 3 w = 8.00 + 8.00 = 16.00 kN/m (B+B)

Beam 4 w = 7.47 + 7.47 = 14.94 kN/m (C+C)

Beam 5 w = 8.50 + 8.50 = 17.00 kN/m (D+D)

Beam 6 w = 6.00 + 6.00 = 12.00 kN/m (E+E)

Beam 7 w = 5.56 + 5.56 = 11.12 kN/m

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c) Surcharge

The surcharge which acts on a beam is computed like the deadweight of deck slab.

Load which acts on a long span beam (A、C)

	Length of long span L_L (m)	Length of short span L_S (m)	Surcharge (Ordinary) (kN/m²)	Surcharge (Earthquake) (kN/m²)	Equivalent uniform distribution load (Ordinary) (kN/m)	Equivalent uniform distribution load (Earthquake) (kN/m)
A	5.40	4.25	20.00	10.00	33.72	16.86
C	4.20	3.00	20.00	10.00	24.90	12.45

Load which acts on a short span beam (B、D、E)

	Length of long span L_S (m)	Surcharge (Ordinary) (kN/m²)	Surcharge (Earthquake) (kN/m²)	Equivalent uniform distribution load (Ordinary) (kN/m)	Equivalent uniform distribution load (Earthquake) (kN/m)
B	4.00	20.00	10.00	26.67	13.33
D	4.25	20.00	10.00	28.33	14.17
E	3.00	20.00	10.00	20.00	10.00

About "beam 7", it computes like deadweight of deck slab.

Equivalent uniform distribution load which acts on "Beam 7"

(Ordinary) $w = ((1.39 \times 6.87 / 2) / 6.87) \times 4/3 \times 20.0 = 18.53$ kN/m

(Earthquake) $w = ((1.39 \times 6.87 / 2) / 6.87) \times 4/3 \times 10.0 = 9.27$ kN/m

Therefore, the surcharge, which acts on the beam to examine, becomes as follows.

Beam 1	(Ordinary)	w = 33.72 + 33.72 = 67.44 kN/m	(A+A)
Beam 1	(Earthquake)	w = 16.86 + 16.86 = 33.72 kN/m	(A+A)
Beam 3	(Ordinary)	w = 26.67 + 26.67 = 53.34 kN/m	(B+B)
Beam 3	(Earthquake)	w = 13.33 + 13.33 = 26.67 kN/m	(B+B)
Beam 4	(Ordinary)	w = 24.90 + 24.90 = 49.80 kN/m	(C+C)
Beam 4	(Earthquake)	w = 12.45 + 12.45 = 24.90 kN/m	(C+C)
Beam 5	(Ordinary)	w = 28.33 + 28.33 = 56.67 kN/m	(D+D)
Beam 5	(Earthquake)	w = 14.17 + 14.17 = 28.34 kN/m	(D+D)
Beam 6	(Ordinary)	w = 20.00 + 20.00 = 40.00 kN/m	(E+E)
Beam 6	(Earthquake)	w = 10.00 + 10.00 = 20.00 kN/m	(E+E)
Beam 7	(Ordinary)	w = 18.53 + 18.53 = 37.06 kN/m	
Beam 7	(Earthquake)	w = 9.27 + 9.27 = 18.54 kN/m	

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d) Wheel Load (Truck)

The maximum reaction force of acting on a beam is computed out of various run situations. Wheel load (Truck) acts on "beam1", "beam4", "beam5", and "beam7". As for "Beam3", wheel load (truck) shall not act.

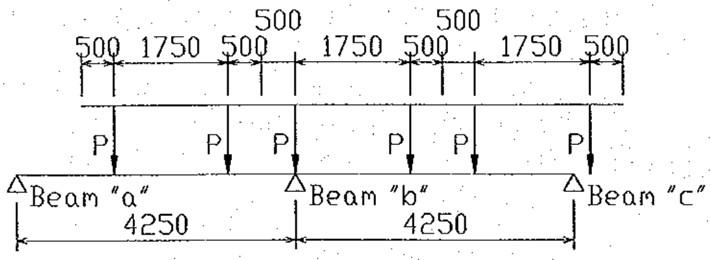
(i) Beam of Vertical Direction to the Face Line (Beam 1)

①The case a truck runs in the vertical direction to the face line

・Calculation of the maximum reaction force which acts on beam of vertical direction to the face line

Arrangement of the truck which maximum reaction force generates on the beam of vertical direction to the face line is shown in the following figures.

(Rear wheel P = 100 kN、Front Wheel P = 25 kN)



The Beam on which maximum reaction force acts is Beam "b".

Maximum reaction force

$$R = (1.50\times100/4.25) + (3.25\times100/4.25) + (2.50\times100/4.25)$$
$$+(1.50\times100/4.25) + 100 = 305.88\ kN$$ (Front wheel 76.47 kN)

Moreover, the maximum reaction force which acts on cantilever (beam 4) is the case where wheel load is acting only between beam "b"and "c" in the above figure.ま。

Maximum Reaction Force

$$R1 = (2.50\times100/4.25) + (1.50\times100/4.25) + 100 = 194.12\ kN$$

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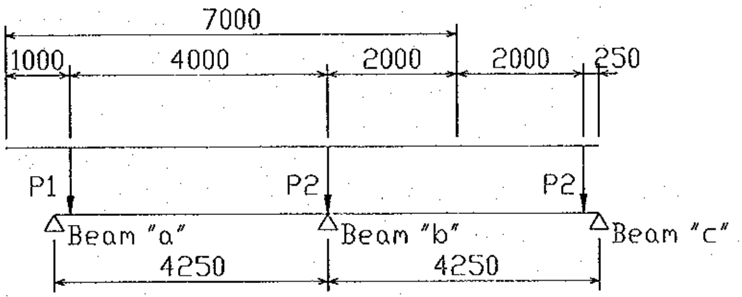
②The case a truck runs in the parallel direction to the face line

- Calculation of the maximum reaction force which acts on beam of vertical direction to the face line

Arrangement of the truck which maximum reaction force generates on the beam of vertical direction to the face line is shown in the following figures.

(P1 = 25 kN、P2 = 100 kN)



The Beam on which maximum reaction force acts is Beam "b".

Maximum Reaction Force

$R = (0.25 \times 100 / 4.25) + (0.25 \times 100 / 4.25) + 100 = 111.76$ kN

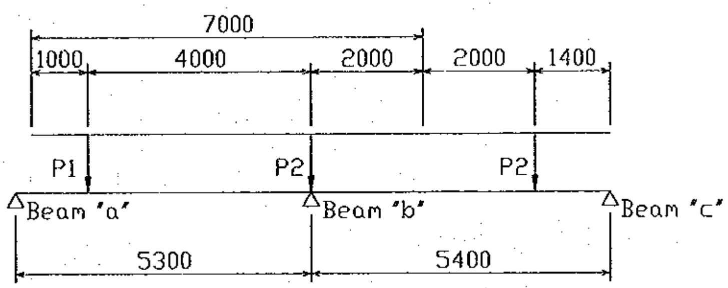
(ⅱ) Beam of Parallel Direction to the Face Line (Beam5)

①The case a truck runs in the vertical direction to the face line

- Calculation of the maximum reaction force which acts on beam of parallel direction to the face line

Arrangement of the truck which maximum reaction force generates on the beam of parallel direction to the face line is shown in the following figures.

(P1 = 25 kN、P2 = 100 kN)



The Beam on which maximum reaction force acts is Beam "b".

Maximum Reaction Force

$R = (1.30 \times 25 / 5.30) + (1.40 \times 100 / 5.40) + 100 = 132.06$ kN

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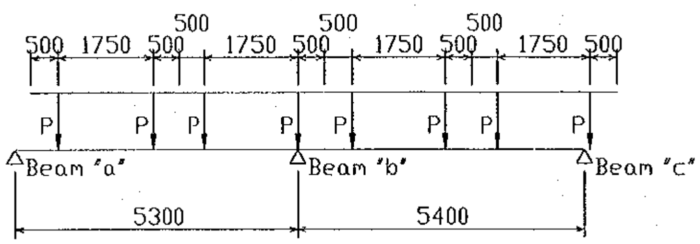
②The case a truck runs in the parallel direction to the face line

・Calculation of the maximum reaction force which acts on beam of parallel direction to the face line

Arrangement of the truck which maximum reaction force generates on the beam of parallel direction to the face line is shown in the following figures.

(P1 = 25 kN、P2 = 100 kN)



The Beam on which maximum reaction force acts is Beam "b".

Maximum Reaction Force

$R = (0.80\times100/5.30) + (2.55\times100/5.30) + (3.55\times100/5.30)$

$(4.40\times100/5.40) + (2.65\times100/5.40) + (1.65\times100/5.40) + 100$

$= 391.30$ kN (97.82 kN)

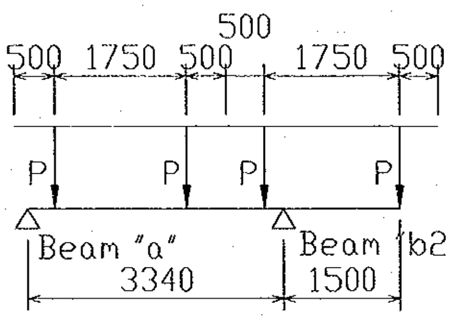
(iii) Beam of the Direction of Slant (Beam 7)

①The direction which a truck runs is a direction parallel to a beam.

Arrangement of the truck which maximum reaction force generates on the beam of parallel direction to the face line is shown in the following figures.

As for the range of 1.0m from the end of a deck slab, wheel load shall not act.

(Distance from beam to the end of deck slab about 2.50 m)



(Rear wheel P=100 kN、Front wheel P = 25.0 kN)

The Beam on which maximum reaction force acts is Beam "b".

Maximum Reaction Force

$R = ((3.34+1.5)\times100/3.34) + (0.34\times100/3.34) + (2.09\times100/3.34)$

$+ (3.09\times100/3.34) = 310.18$ kN (Front wheel R = 77.55 kN)

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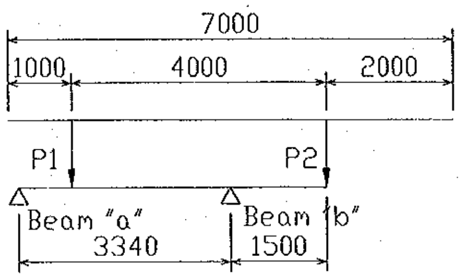
②The direction which a truck runs is a direction vertical to a beam.

Arrangement of the truck which maximum reaction force generates on the beam of parallel direction to the face line is shown in the following figures.

(P1 = 25 kN、P2 = 100 kN)



The Beam on which maximum reaction force acts is Beam "b".

Maximum reaction Force

$R = ((3.34 + 1.5) \times 100 / 3.34) + (0.84 \times 25 / 3.34) = 151.20$ kN

(iii) Weight of a small beam (The beam of the front of a platform)

$P = 1.0 \times 0.5 \times 4.25 \times 24.0 = 51.00$ kN

e) Earthquake Force

The pile head moment computed by the basic design is used.

(3) Fender attachment part (apron)

a) Deadweight

Parallel direction to face line $W = 4.25m \times 0.5m \times 4.0m \times 24\ kN/m^3 = 204.0$ kN

Vertical direction to face line $W = 5.40m \times 0.5m \times 4.0m \times 24\ kN/m^3 = 259.2$ kN

b) Reaction Force of the Fender

Fender uses two V-150H x1000L. An attachment interval is set to 4.0m.

Reaction Force of the Fender (catalog value) 110 kN

Design Reaction Force of the Fender $R = 110 \times 1.1 = 121.0$ kN → 125.0 kN

Reaction force of the fender computes Member force as what concentrates and acts on one place.

Reaction Force of the Fender $R = 125.0\ kN \times 2 = 250.0$ kN

References/ Notes

5) Calculation of the Section Force

(1) Deck Slab

The Design of a deck slab calculates "S1" and "S3" as follows.

S1 : a slab fixed on four side

S3 : a slab fixed on three sides and free on one side

Wheel load (Truck) is converted into equivalent uniform distribution and partial equivalent uniform distribution. Section force is computed about each distribution load, and the larger one is made into design section force. The deck slab of a variant part refers to S1, and performs reinforcing bar arrangement.

a) Calculation of the Section Force by Equivalent Uniform Distribution Load

Cross-sectional force in case the equivalent uniform distribution load acts on a deck slab is computed using the following formulas.

$Mx = X \times w \times L^2$: the bending moment of X-direction of an axis

$My = Y \times w \times L^2$: the bending moment of Y-direction of an axis

$S = Q \times w \times L$: the shearing force

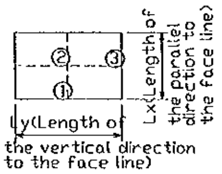
where X、Y : the moment factors of each direction of an axis

w : equivalent uniform distribution load, such as acting on a deck slab

L : length of the short span of a deck slab

Q : the shearing force factors

Cross-sectional forces by the load (deadweight, surcharge, and wheel load (track)), which act on the deck slab, are calculated. A calculation position and a calculation result are shown below.



Deadweight : w = 6.00 kN/m²

Surcharge : w = 20.00 kN/m²

Wheel Load (Truck) : w = 20.93 kN/m²

○The bending moment by equivalent uniform distribution load (kN・m/m)

deck slab	Lx (m)	Ly (m)	λ	position	Factor X	Factor Y	Deadweight Mx	Deadweight My	Surcharge Mx	Surcharge My	Wheel Load (Truck) Mx	Wheel Load (Truck) My
S1	4.25	5.40	0.75	1	-0.0701	-0.0117	-7.60	-1.27	-25.32	-4.23	-26.50	-4.42
	4.25	5.40	0.75	2	0.0318	0.0179	3.45	1.94	11.49	6.47	12.02	6.77
	4.25	5.40	0.75	3	-0.0094	-0.0565	-1.02	-6.12	-3.40	-20.41	-3.55	-21.36
S3	1.50	5.40	0.30	1	-0.3819	-0.0636	-5.16	-0.86	-17.19	-2.86		
	1.50	5.40	0.30	2	-0.0434	0.0204	-0.59	0.28	-1.95	0.92		
	1.50	5.40	0.30	3	-0.0249	-0.1495	-0.34	-2.02	-1.12	-6.73		

○The shearing force by equivalent uniform distribution load (kN/m)

deck slab	Lx (m)	Ly (m)	λ	position	Factor		Deadweight		Surcharge		Wheel load (Truck)	
					X	Y	Mx	My	Mx	My	Mx	My
S1	4.25	5.40	0.75	1	0.4590		11.70		39.02		40.83	
	4.25	5.40	0.75	3		0.5020		12.80		42.67		44.65
S3	1.50	5.30	3.20	1	1.0200		9.18		30.60			
	1.50	5.30	3.20	3		1.3400		12.06		40.20		

b) Calculation of the Section Force by Partial Equivalent Uniform Distribution load

The section force by partial equivalent uniform distribution load is calculated only to the wheel load (Truck). The section force is calculated using the graph for calculating of Pigeaud.

Length of short span (the vertical direction to the face line) a = 4.25 m
Length of long span (the parallel direction to the face line) b = 5.40 m
Width of wheel (the direction to short span) u' = 2.70 m
Width of wheel (the direction to long span) v' = 0.65 m

The case a truck runs in the vertical direction to the face line
u' / a = 0.635、 v' / b = 0.120

The case a truck runs in the parallel direction to the face line
u' / a = 0.153、 v' / b = 0.50 m

$\rho = 4.25 / 5.40 = 0.787 \rightarrow 0.70$

The bending moment of a deck slab is computed using the following formulas.

$Mx = 0.8 \times (M1 + \eta \times M2) \times P$

$My = 0.8 \times (M2 + \eta \times M1) \times P$

where Mx : the bending moment of the parallel direction to the face line
(By this examination, it is the direction of short span.)
My : the bending moment of the vertical direction to the face line
(By this examination, it is the direction of long span.)
M1、M2 : The distribution factor of a bending moment
η : poisson's ratio (=0.15 (reinforced concrete))

The shearing force is computed using the following formulas.

In the case of "u > v"

The shearing force of the direction of short span $Su = P / (2\times u + v)$

The shearing force of the direction of long span $Sv = P / (3\times u)$

In the case of "u < v"

The shearing force of the direction of short span $Su = P / (3\times v)$

The shearing force of the direction of long span $Sv = P / (2\times v + u)$

○Section Force(Wheel Load) by Partial Equivalent Uniform Distribution load

deck slab	Wheel load (kN)	M1 (kN・m/m)	M2 (kN・m/m)	Mx (kN・m/m)	My (kN・m/m)	Sx (kN/m)	Sy (kN/m)
S1 (the vertical direction to the face line)	200	0.115	0.111	21.064	20.52	33.06	24.69
S1 (the parallel direction to the face line)	200	0.158	0.069	26.936	14.832	24.69	33.06

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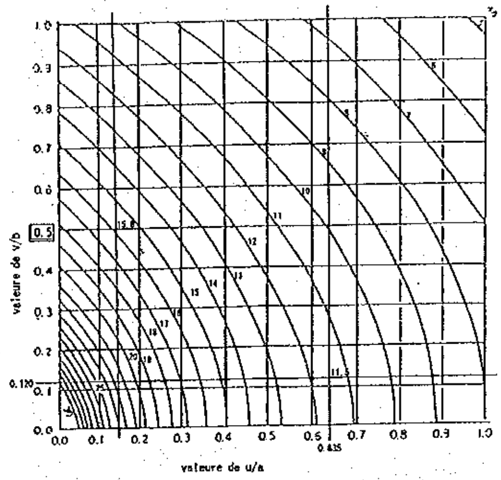
The bending moment distribution factor : M1

The value of 100M1 to ρ=0.7



The case a truck runs in the vertical direction to the face line

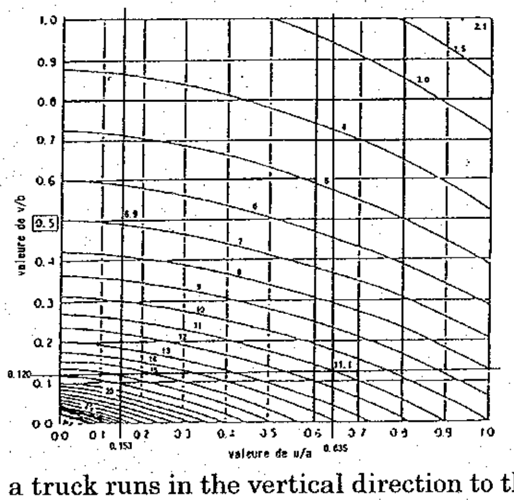
100×M1 = 11.5 Therefore M1 = 0.115

The case a truck runs in the parallel direction to the face line

100×M1 = 15.8 Therefore M1 = 0.158

The bending moment distribution factor : M2

The value of 100M2 to ρ=0.7



The case a truck runs in the vertical direction to the face line

100×M2 = 11.1 Therefore M1 = 0.111

The case a truck runs in the parallel direction to the face line

100×M2 = 6.90 Therefore M1 = 0.069

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

c) Generalization of Section Force

・Generalization of the section force of deck slab "S1"

	Bending moment(kN・m/m)				Shearing force (kN/m)	
	Parallel to the face line Mx		Vertical to the face line My		Parallel to the face line Sx	Vertical to the face line Sy
	Fulcrum	Center	Fulcrum	Center		
Deadweight (D)	-7.60	3.45	-6.12	1.94	11.70	12.80
Surcharge (S)	-25.32	11.49	-20.41	6.47	39.02	42.67
Wheel Load (Truck)						
Equivalent Uniform Distribution Load (M1)	-26.50	12.02	-21.36	6.77	40.83	44.65
Partial Equivalent Uniform Distribution Load (Vertical to the face line) (M2)	-21.06	21.06	-20.52	20.52	33.06	24.69
Partial Equivalent Uniform Distribution Load (Parallel to the face line) (M3)	-26.94	26.94	-14.83	14.83	24.69	33.06
Ultimate limit state						
Ordinary 1.1D+1.2S	-38.74	17.58	-31.22	9.90	59.69	65.28
Wheel Load (Truck) 1.1D+1.2M1	-40.16	18.22	-32.36	10.26	61.87	67.66
Wheel Load (Truck) 1.1D+1.2M2	-33.63	29.07	-31.36	26.76	52.54	43.71
Wheel Load (Truck) 1.1D+1.2M3	-40.69	36.12	-24.53	19.93	42.50	53.75
Serviceability limit state						
Permanent Load 1.0D	-7.60	3.45	-6.12	1.94	11.70	12.80
Variable Load 1.0S	-25.32	11.49	-20.41	6.47	39.02	42.67
1.0M1	-26.50	12.02	-21.36	6.77	40.83	44.65
1.0M2	-21.06	21.06	-20.52	20.52	33.06	24.69
1.0M3	-26.94	26.94	-14.83	14.83	24.69	33.06
Fatigue limit state						
Permanent Load 1.0D	-7.60	3.45	-6.12	1.94	11.70	12.80
Variable Load 1.0M1	-26.50	12.02	-21.36	6.77	40.83	44.65
1.0M2	-21.06	21.06	-20.52	20.52	33.06	24.69
1.0M3	-26.94	26.94	-14.83	14.83	24.69	33.06

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・Generalization of the section force of deck slab "S3"

	Bending Moment (kN・m/m)				Shearing force (kN/m)	
	Parallel to the face line Mx		Vertical to the face line My		Parallel to the face line Sx	Vertical to the face line Sy
	Fulcrum	Center	Fulcrum	Center		
Deadweight (D)	-5.16	—	-2.02	0.28	9.18	12.06
Surcharge (S)	-17.19	—	-6.73	0.92	30.60	40.20
Ultimate limit state						
Ordinary 1.1D+1.2S	-26.30	—	-10.30	1.41	46.82	61.51
Serviceability limit state						
Permanent Load 1.0D	-5.16	—	-2.02	0.28	9.18	12.06
Variable Load 1.0S	-17.19	—	-6.73	0.92	30.60	40.20

※Since the bending moment of the center part of the parallel direction to the face line shows a small value compared with a fulcrum part, it omits examination.

		Prepared by	Y. Ando	Checked by	R. NISHIMURA
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(2) Beam

The section force of a beam computes the vertical and parallel direction beam to the face line as a continuation beam.

When wheel load acts on cantilever (Beam4), big section force occurs near the pile by the side of land. Therefore, cantilever (Beam4) calculates separately with the continuation beam.

The member to examine is shown below.

The vertical direction beam to the face line : Beam 1 +Beam 3
(Ordinary、Wheel Load (Truck)、Earthquake)

The parallel direction beam to the face line : Beam 5 +Beam 6
(Ordinary、Wheel Load (Truck)、Earthquake)

Cantilever : Beam 4 (Wheel Load (Truck))

Beam of the Direction of Slant : Beam 7 (Wheel Load (Truck))

("Beam7" has the small influence of deadweight of deck slab and surcharge compared with other beams. Moreover, "Beam7" has large rigidity. Therefore, examination of ordinary condition and earthquake condition is excluded.)

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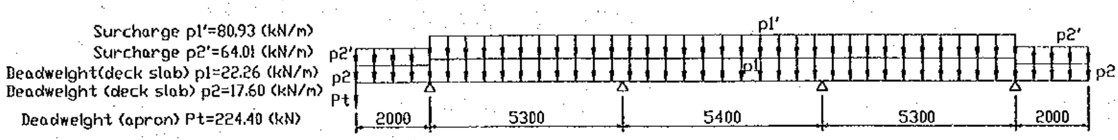
a) Ultimate Limit State

(i) Ordinary

Load which acts (Ordinary) 1.1D (Deadweight) + 1.2S (Surcharge)

①The vertical direction beam to the face line

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



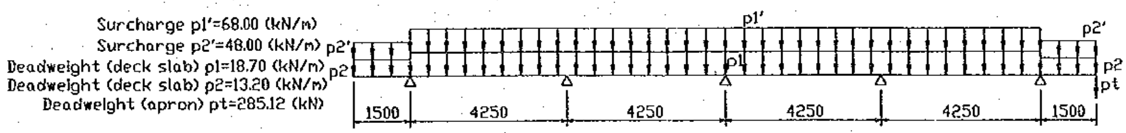
Maximum bending moment upper side Mmax = 651.09 kN・m

lower side Mmax = 199.34 kN・m

Maximum shearing force Smax = 426.69 kN

②The parallel direction beam to the face line

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 518.51 kN・m

lower side Mmax = 118.98 kN・m

Maximum shearing force Smax = 406.22 kN

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(ii) Wheel Load (Truck)

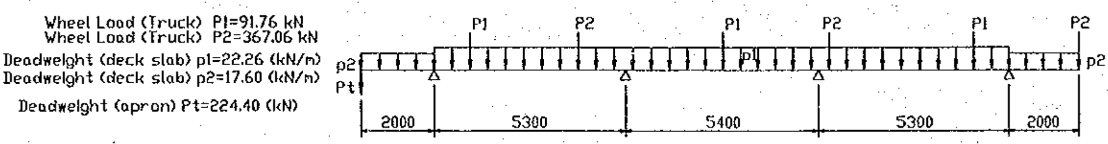
Load which acts (Wheel Load) 1.1D (Deadweight) + 1.2M (Wheel Load (Truck))

①The vertical direction beam to the face line

①− 1 The case a truck runs in the vertical direction to the face line

- Reinforcing bar of upper side (Bending Moment)

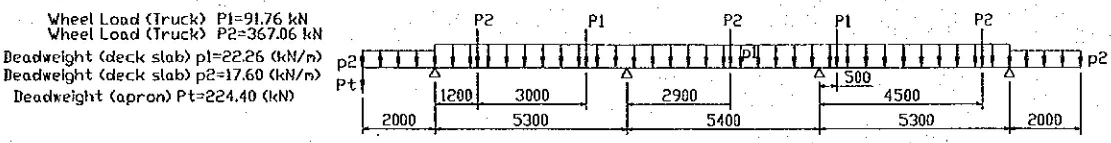
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 920.30 kN・m

- Reinforcing bar of lower side (Bending moment)

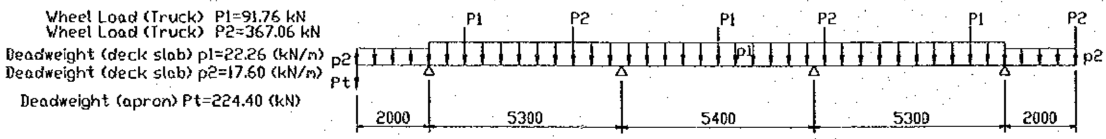
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 365.44 kN・m

- Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum shearing force Smax = 626.66 kN

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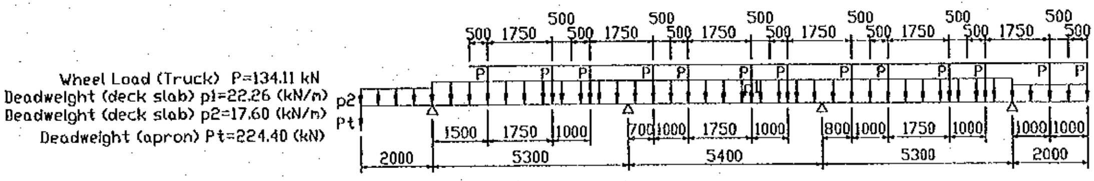
①− 2 The case a truck runs in the parallel direction to the face line

・Reinforcing bar of upper side (Bending Moment)

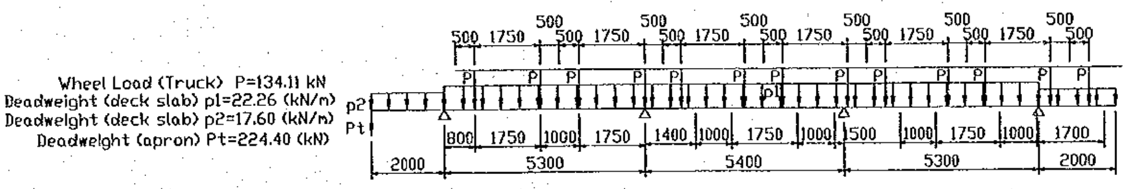
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 594.88 kN・m

・Reinforcing bar of lower side (Bending Moment)

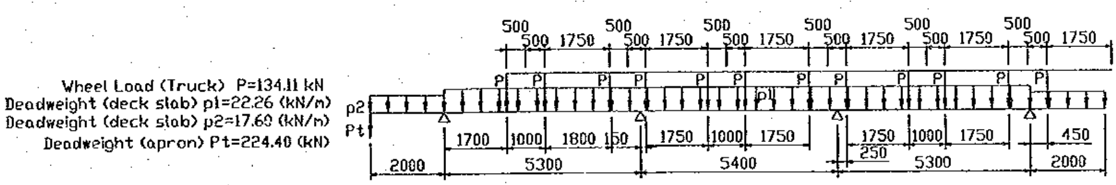
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 204.88 kN・m

・Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum shearing force Smax = 483.12 kN

②The parallel direction beam to the face line

②− 1 The case a truck runs in the vertical direction to the face line

・Reinforcing bar of upper side (Bending Moment)

However wheel load (truck) may act, bending moment by deadweight of fender attachment part (apron) will serve as the maximum bending moment.

Therefore, Maximum bending moment upper side Mmax = 464.51 kN・m

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

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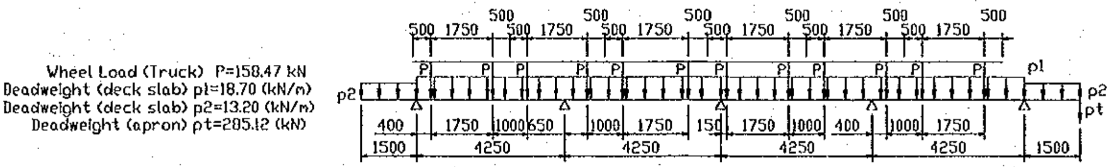
· Reinforcing bar of lower side (Bending Moment)

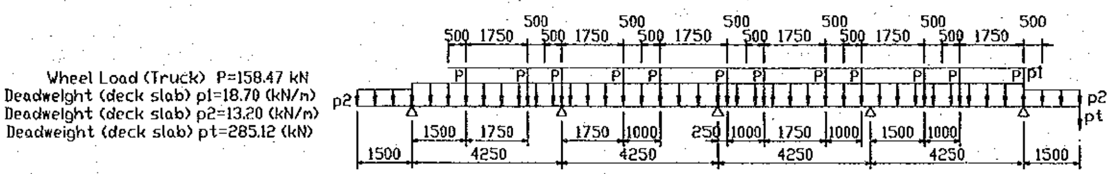
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 206.28 kN · m

· Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum shearing force Smax = 441.53 kN

②− 2 The case a truck runs in the parallel direction to the face line

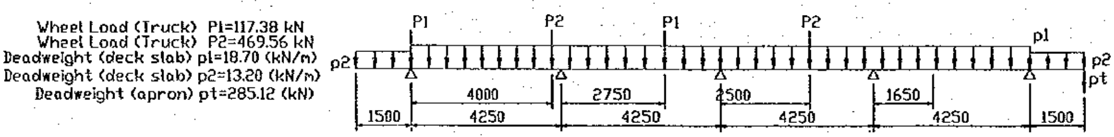
· Reinforcing bar of upper side (Bending Moment)

However wheel load (truck) may act, bending moment by deadweight of fender attachment part (apron) will serve as the maximum bending moment.

Maximum bending moment upper side Mmax = 464.51 kN · m

· Reinforcing bar of lower side (Bending Moment)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 392.02 kN · m

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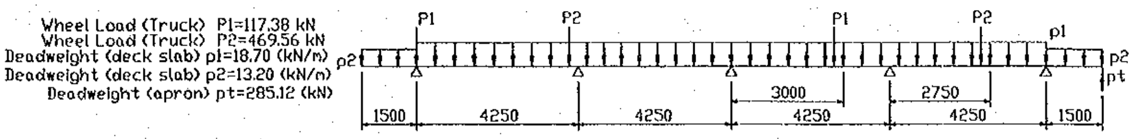
References/ Notes

・Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



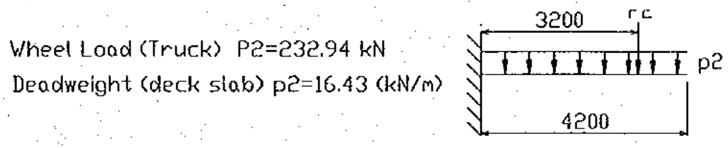
Maximum shearing force　　Smax = 542.03 kN

③Cantilever of a land side (Beam 4)

Section force of beam4 is computed. Bar arrangement of cantilever of other variant parts is set to the same bar arrangement as beam4.

A frame model is shown below. (Deadweight of a beam is taken into consideration.)

Deadweight of beam　$w = 0.74 \times 24 \times 1.1 = 19.54$ kN/m



All equivalent Uniform Distribution Load　$w = 19.54 + 16.43 = 35.97$ kN/m

Maximum bending moment

$M_{max} = (35.97 \times 4.2^2) / 2 + 232.94 \times 3.2 = 1{,}062.66$ kN・m

Maximum shearing force

$S_{max} = 35.97 \times 4.2 + 232.94 = 384.01$ kN

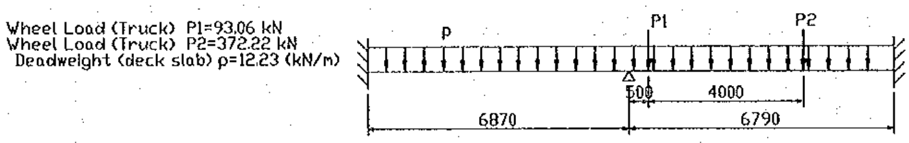
References/ Notes

④Beam of the Direction of Slant (Beam 7)

④− 1 The direction which a truck runs is a direction parallel to a beam.

・Reinforcing bar of upper side (Bending Moment)

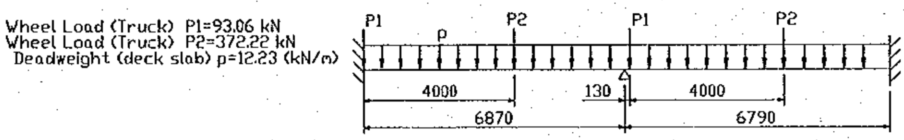
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 556.84 kN・m

・Reinforcing bar of lower side (Bending Moment)

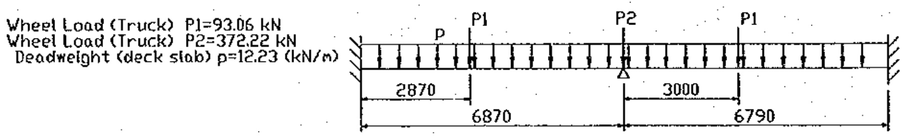
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 381.55 kN・m

・Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)

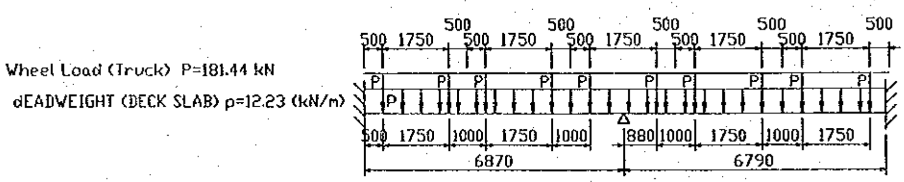


Maximum shearing force Smax = 532.56 kN

④− 2 The direction which a truck runs is a direction vertical to a beam.

・Reinforcing bar of upper side (Bending Moment)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 660.73 kN・m

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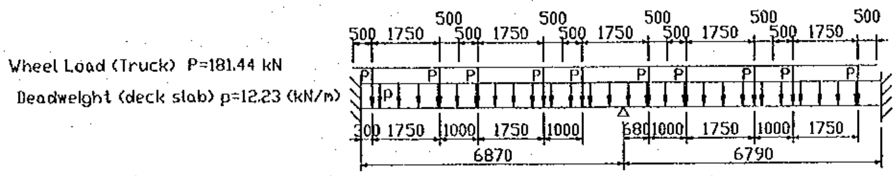
· Reinforcing bar of lower side (Bending Moment)

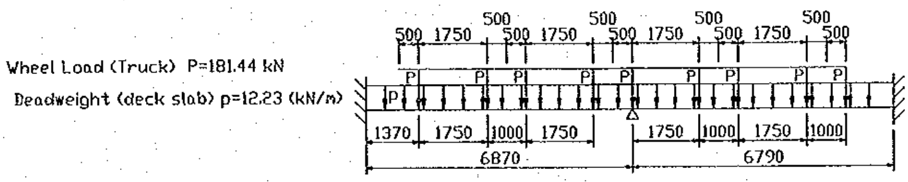
A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment lower side Mmax = 337.72 kN · m

· Shearing force

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum shearing force Smax = 674.57 kN

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

References/ Notes

(iii) Earthquake Condition

Load which acts (Earthquake)

1.1D (Deadweight) +1.0S (Surcharge) +1.0E (Earthquake Force)

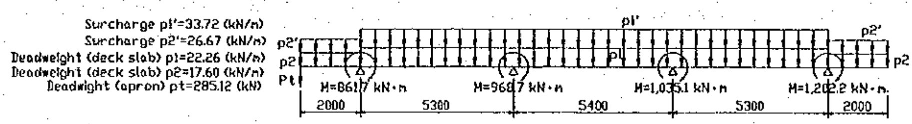
The pile head moment computed by the basic design is used.

①The vertical direction beam to the face line

A frame model is shown below. (Deadweight of a beam is taken into consideration.)

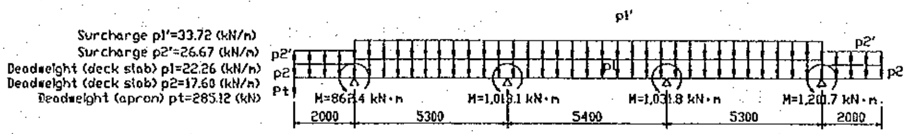
Earthquake

Sea→Land



Earthquake

Land→Sea



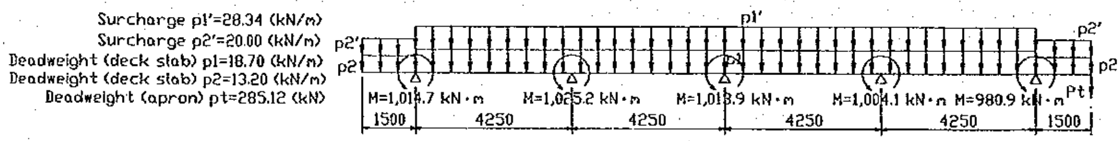
Maximum bending moment upper side Mmax = 1,515.14 kN・m

lower side Mmax = 888.78 kN・m

Maximum bending moment Smax = 591.19 kN

②The parallel direction beam to the face line

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 1,467.91 kN・m

lower side Mmax = 955.37 kN・m

Maximum shearing force Smax = 633.54 kN

(iv) Berting Condition (Fender attachment part (apron))

Thickness of fender attachment part (apron) is 500mm. Deadweight is taken into consideration as tensile force.

Load which acts(Berthing) 1.1D (Deadweight) +1.0S_B (Reaction force of the fender)

※Berthing condition is taken as extraordinary.

Fender shall be attached in the center between piles. Moreover, section force is computed about two cases, the case where reaction force of the fender acts on a lower end (+1.00), and the case, which acts on the central part (+3.00). Fender attachment part (apron) computed section force by having performed FEM analysis as "slab fixed on three sides and free on one side".

Maximum bending moment

(Horizontal reinforcing bar) Mmax = 188.70 kN・m/m (lower end)

(Vertical reinforcing bar) Mmax = 71.75 kN・m/m (center)

Maximum axial force

(Horizontal reinforcing bar) N = 0.0 kN/m

(Vertical reinforcing bar) N = 4.0×1.0×0.5×24 = 48.0 kN/m

References/ Notes

b) Serviceability Limit State

The Section force of a serviceability limit state is divided and computed when the case where permanent load (Deadweight) acts, and variable load (Surcharge, Wheel Load (Truck)) act. Design load is computed using the following formulas.

$$S_k = k_p \times S_p + k_r \times S_r$$

where

S_k : characteristic value of load for examination of the serviceability limit state

S_p : characteristic value of permanent load

S_r : characteristic value of variable load

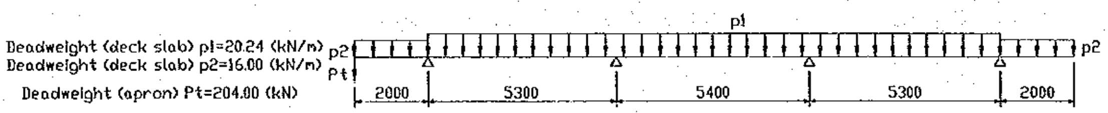
k_p,k_r : constans to represent the effects on crake widths and the corrosion of steel by the permanent load and variable load, respectively. It may be taken that k_p is 1.0 and k_r is 0.5.

(i) Ordinary

①The vertical direction beam to the face line

・Permanent Load (Deadweight)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



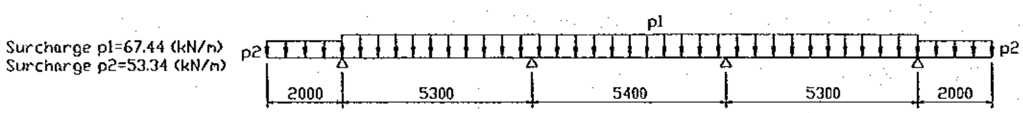
Maximum bending moment upper side Mmax = 475.52 kN・m

lower side Mmax = 102.67 kN・m

Maximum shearing force Smax = 271.52 kN

・Variable Load (Surcharge)

A frame model is shown below.



Maximum bending moment upper side Mmax = 171.62 kN・m

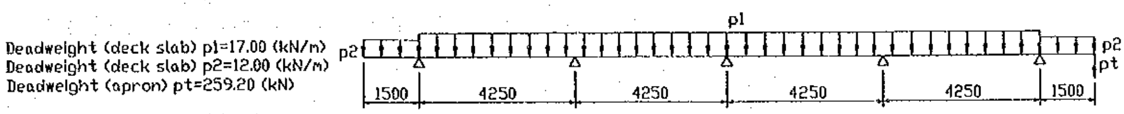
lower side Mmax = 98.76 kN・m

Maximum shearing force Smax = 190.97 kN

②The parallel direction beam to the face line

・Permanent Load (Deadweight)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



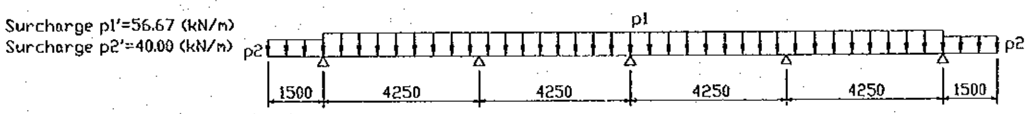
Maximum bending moment upper side Mmax = 475.52 kN・m

lower side Mmax = 36.36 kN・m

Maximum shearing force Smax = 370.87 kN

・Variable Load (Surcharge)

A frame model is shown below.



Maximum bending moment upper side Mmax = 106.68 kN・m

lower side Mmax = 58.35 kN・m

Maximum shearing force Smax = 190.97 kN

(ii) Wheel Load (Truck)

①The vertical direction beam to the face line

①－1 Permanent Load (Deadweight)

The same value as the value computed by ordinary condition is used for the section force of permanent load.

Maximum bending moment upper side Mmax = 475.52 kN・m

lower side Mmax = 102.67 kN・m

Maximum shearing force Smax = 271.52 kN

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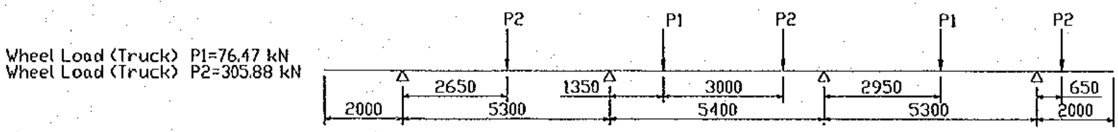
①− 2 Variable Load (Wheel Load (Truck))

・The case a truck runs in the vertical direction to the face line

(Reinforcing bar of upper side (Bending Moment))

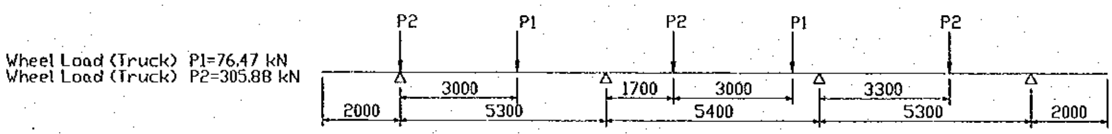
A frame model is shown below.



Maximum bending moment upper side Mmax = 245.89 kN・m

(Reinforcing bar of lower side (Bending Moment))

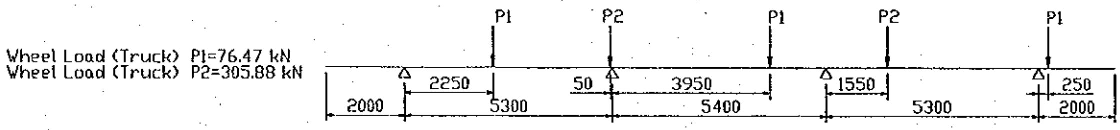
A frame model is shown below.



Maximum bending moment lower side Mmax = 304.08 kN・m

(Shearing force)

A frame model is shown below.

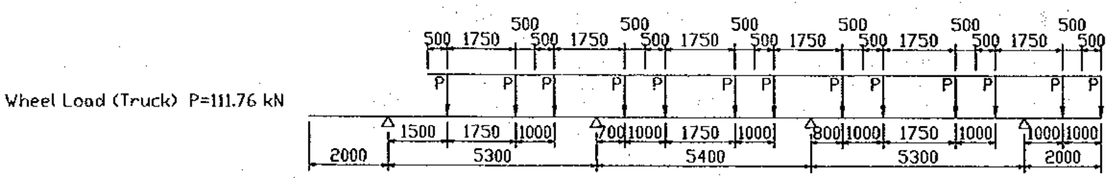


Maximum shearing force Smax = 305.88 kN

・The case a truck runs in the parallel direction to the face line

(Reinforcing bar of upper side (Bending Moment))

A frame model is shown below.



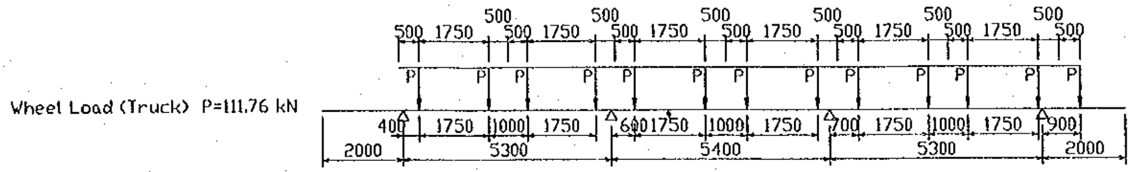
Maximum bending moment upper side Mmax = 335.28 kN・m

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

References/ Notes

(Reinforcing bar of lower side (Bending Moment))

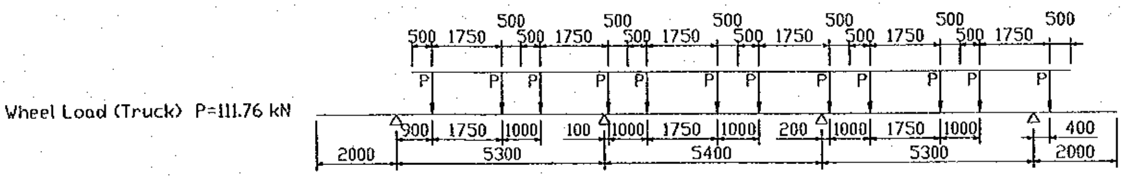
A frame model is shown below.



Maximum bending moment lower side Mmax = 190.75 kN · m

(Shearing force)

A frame model is shown below.



Maximum shearing force Smax = 293.65 kN

②The parallel direction beam to the face line

②－1 Permanent Load (Deadweight)

The same value as the value computed by ordinary condition is used for the section force of permanent load.

Maximum bending moment upper side Mmax = 475.52 kN · m

lower side Mmax = 36.36 kN · m

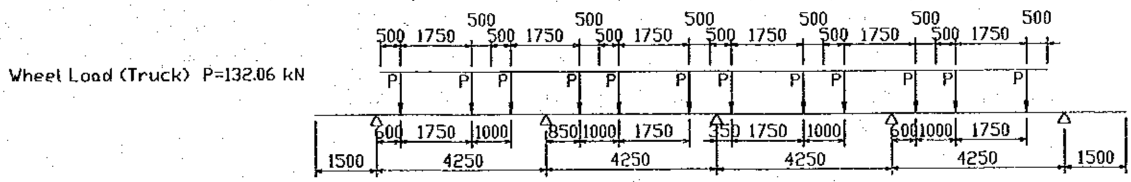
Maximum shearing force Smax = 370.87 kN

②－2 Variable Load (Wheel Load (Truck))

· The case a truck runs in the vertical direction to the face line

(Reinforcing bar of upper side (Bending Moment))

A frame model is shown below.



Maximum bending moment upper side Mmax = 200.66 kN · m

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		26 / 07 /2002		08 / 08 /2002

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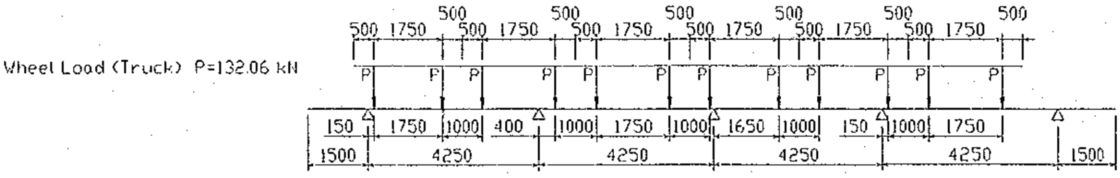
(Reinforcing bar of lower side (Bending Moment))

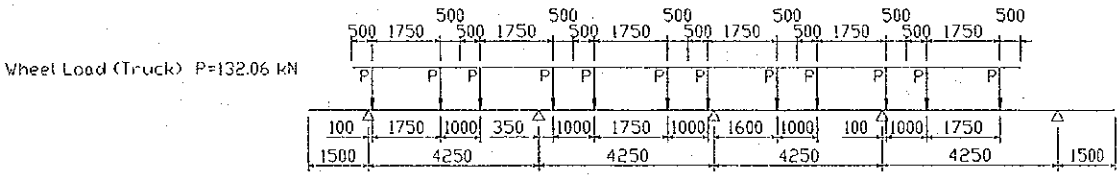
A frame model is shown below.



Maximum bending moment lower side Mmax = 144.98 kN・m

(Shearing force)

A frame model is shown below.

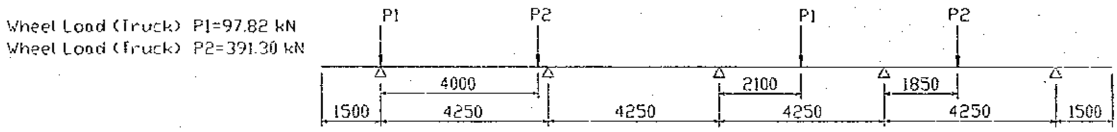


Maximum shearing force Smax = 308.73 kN

・The case a truck runs in the parallel direction to the face line

(Reinforcing bar of upper side (Bending Moment))

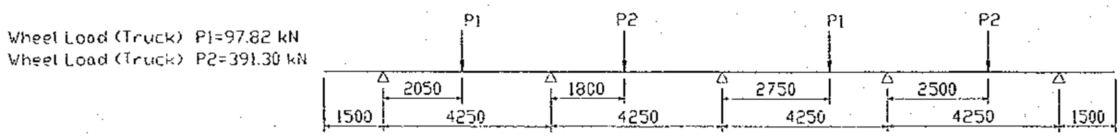
A frame model is shown below.



Maximum bending moment upper side Mmax = 204.94 kN・m

(Reinforcing bar of lower side (Bending Moment))

A frame model is shown below.



Maximum bending moment lower side Mmax = 338.05 kN・m

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

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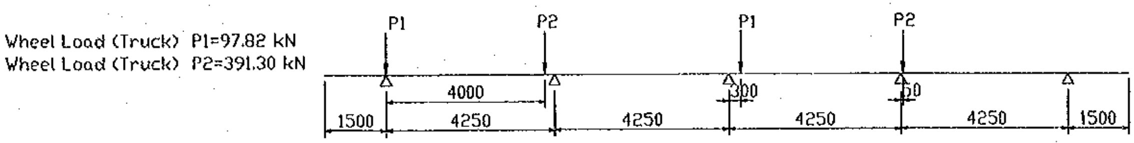
(Shearing force)

A frame model is shown below.



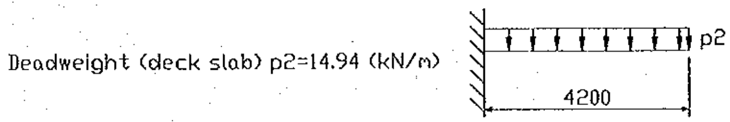
Maximum shearing force Smax = 390.83 kN

③Cantilever of a land side (Beam 4)

Section force of beam4 is computed. Bar arrangement of cantilever of other variant parts is set to the same bar arrangement as beam4.

・Permanent Load (Deadweight)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Deadweight of beam $w = 0.74 \times 24 = 17.76$ kN/m

All Equivalent uniform distribution load $w = 17.76 + 14.94 = 32.70$ kN/m

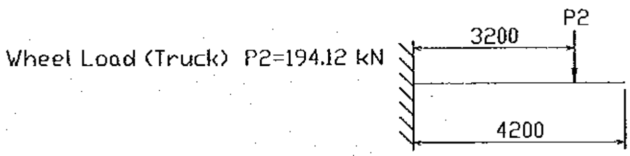
Maximum bending moment $M_{max} = (32.70 \times 4.20^2) / 2 = 288.41$ kN・m

Maximum shearing force $S_{max} = 32.70 \times 4.20 = 137.34$ kN

・Variable Load (Wheel Load (Truck))

Wheel Load (Truck) shall act on the part 1.0m away from the beam end.

A frame model is shown below.



Maximum bending moment $M_{max} = 194.12 \times 3.20 = 621.18$ kN・m

Maximum shearing force $S_{max} = 194.12$ kN

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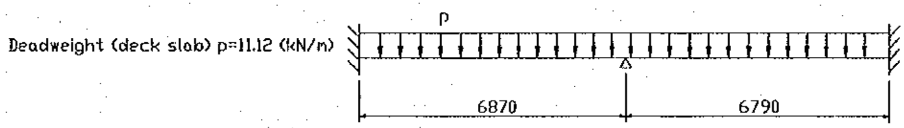
④Beam of the Direction of Slant (Beam 7)

④－1 Permanent Load (Deadweight)

A frame model is shown below. (Deadweight of a beam is taken into consideration.)



Maximum bending moment upper side Mmax = 114.24 kN・m

lower side Mmax = 57.12 kN・m

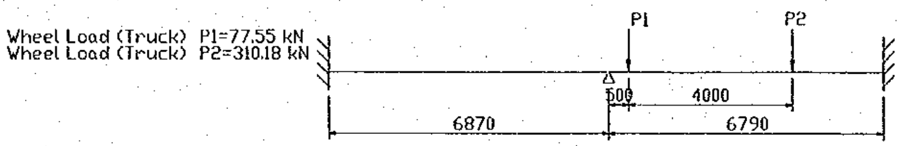
Maximum shearing force Smax = 99.49 kN

④－2 Variable Load (Wheel Load (Truck))

・The direction which a truck runs is a direction parallel to a beam.

(Reinforcing bar of upper side (Bending Moment))

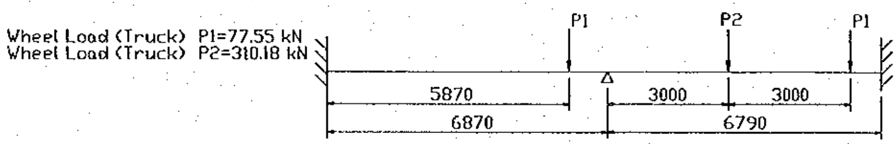
A frame model is shown below.



Maximum bending moment upper side Mmax = 362.92 kN・m

(Reinforcing bar of lower side (Bending Moment))

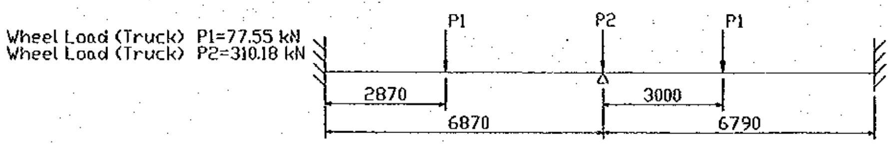
A frame model is shown below.



Maximum bending moment lower side Mmax = 299.15 kN・m

(Shearing force)

A frame model is shown below.



Maximum shearing force Smax = 353.65 kN

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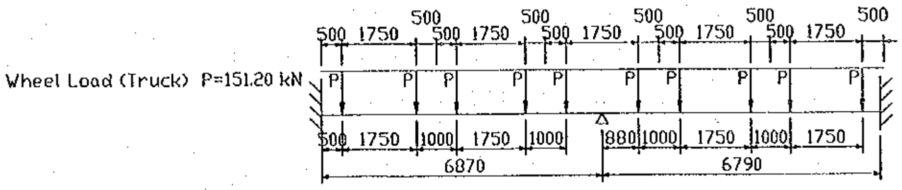
- The direction which a truck runs is a direction parallel to a beam.

(Reinforcing bar of upper side (Bending Moment))

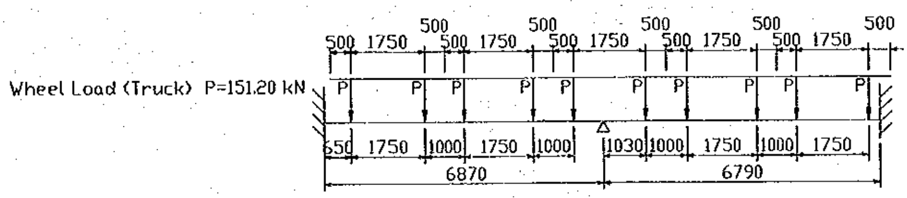
A frame model is shown below.



Maximum bending moment upper side Mmax = 447.68 kN・m

(Reinforcing bar of lower side (Bending Moment))

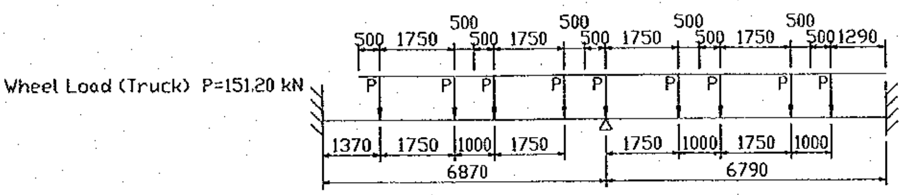
A frame model is shown below.



Maximum bending moment lower side Mmax = 238.27 kN・m

(Shearing force)

A frame model is shown below.



Maximum shearing force Smax = 471.47 kN

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(iii) Berting Condition (Fender attachment part (apron))

Section force uses the value computed in ultimate limit state.

Permanent Load (Maximum axial force)

(Horizontal reinforcing bar) N = 0.0 kN/m

(Vertical reinforcing bar) $N = 4.0 \times 1.0 \times 0.5 \times 24 = 48.0$ kN/m

Variable Load (Maximum bending moment)

(Horizontal reinforcing bar) Mmax = 188.70 kN・m/m (lower end)

(Vertical reinforcing bar) Mmax = 71.75 kN・m/m (center)

c) Fatigue Limit State

The examination case of a fatigue limit state is only Wheel Load (Truck).

The section force of using by examination of a fatigue limit state is the same as the section force of using by examination of a serviceability limit state.

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d) Generalization of the load in each limit state

(i) The vertical direction beam to the face line

・Bending Moment (kN・m)

	Ultimate limit		Serviceability limit			
	upper side	lower side	Permanent load		Variable load	
			upper	lower	upper	lower
Ordinary	651.09	199.34	475.52	102.67	171.62	98.76
Wheel Load (Truck)	920.30	365.44	475.52	102.67	335.28	304.08
Earthquake	1,515.14	888.78	—	—	—	—

・Shearing Force (kN)

	Ultimate limit	Serviceability limit	
		Permanent load	Variable load
Ordinary	426.69	271.52	190.97
Wheel Load (Truck)	626.66	271.52	305.88
Earthquake	591.19	—	—

※The examination case of a fatigue limit state is only Wheel Load (Truck).
The section force of using by examination of a fatigue limit state is the same as the section force of using by examination of a serviceability limit state.

※The section force of Wheel Load (Truck) extracted the larger one of the section force of each run direction of a truck.

(ii) The parallel direction beam to the face line

・Bending Moment (kN・m)

	Ultimate limit		Serviceability limit			
	upper side	lower side	Permanent load		Variable load	
			upper	lower	upper	lower
Ordinary	518.51	118.98	475.52	36.36	106.68	58.35
Wheel Load (Truck)	464.51	392.02	475.52	36.36	204.95	338.05
Earthquake	1,467.91	955.37	—	—	—	—

・Shearing Force (kN)

	Ultimate limit	Serviceability limit	
		Permanent load	Variable load
Ordinary	406.22	370.87	190.97
Wheel Load (Truck)	542.03	370.87	390.83
Earthquake	633.54	—	—

※The examination case of a fatigue limit state is only Wheel Load (Truck).
The section force of using by examination of a fatigue limit state is the same as the section force of using by examination of a serviceability limit state.
※The section force of Wheel Load (Truck) extracted the larger one of the section force of each run direction of a truck.

(iii) Cantilever of a land side (Beam 4)

・Bending Moment (kN・m)

	Ultimate limit		Serviceability limit			
	upper side	lower side	Permanent load		Variable load	
			upper	lower	upper	lower
Wheel Load (Truck)	1,062.66	–	288.41	–	621.18	–

・Shearing Force (kN)

	Ultimate limit	Serviceability limit	
		Permanent load	Variable load
Wheel Load (Truck)	384.01	137.34	194.12

※The examination case of a fatigue limit state is only Wheel Load (Truck).
The section force of using by examination of a fatigue limit state is the same as the section force of using by examination of a serviceability limit state.

(iv) Beam of the Direction of Slant (Beam 7)

・Bending Moment (kN・m)

	Ultimate limit		Ultimate limit			
	upper side	lower side	Permanent load		Variable load	
			upper	lower	upper	lower
Wheel Load (Truck)	660.73	381.55	114.24	57.12	447.68	299.15

・せん断力 (kN)

	Ultimate limit	Serviceability limit	
		Permanent load	Variable load
Wheel Load (Truck)	674.57	99.49	471.47

※The examination case of a fatigue limit state is only Wheel Load (Truck).
The section force of using by examination of a fatigue limit state is the same as the section force of using by examination of a serviceability limit state.
※The section force of Wheel Load (Truck) extracted the larger one of the section force of each run direction of a truck.

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(v) Berting Condition (Fender attachment part (apron))

	Ultimate limit		Serviceability limit	
			Permanent load	Variable load
	Bending moment	Axial force	Axial force	Bending moment
Berthing	188.70 71.85	0.0 48.0	0.0 48.0	188.70 71.85

※upper : Horizontal reinforcing bar

lower : Vertical reinforcing bar

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6) Calculation of Reinforcing Bar Arrangement

Calculation of reinforcing bar arrangement is performed by RC section calculation program. (FORUM8 Co., Ltd)

(1) Examination of Ultimate Limit State

a) Examination of Bending Strength

The area of reinforcing bar to be used calculates it as satisfying the following conditions.

$\gamma_i \cdot M_d / M_{ud} \leqq 1.0$

M_d ; calculated value of bending moment acting on pile in design

M_{ud} ; design bending moment capacity、It computes by the following formula.

$$M_{ud} = \frac{C'_c(d - y_c) + C'_s(d - d')}{\gamma_b} = \{A_s f_{yd} d - A'_s f'_{yd} d' - \frac{(A_s f_{yd} - A'_s f'_{yd})^2}{1.7 f_{cd} b}\} / \gamma_b$$

C'_c ; The compression resultant of concrete (N) $(=0.68 \cdot f'_{cd} \cdot b \cdot x)$

C'_s ; Compressive force of acting on a compression reinforcing bar (N) $(=A'_s \cdot f'_{yd})$

T ; tensile force of a tensile reinforcing bar (N) $(=A_s \cdot f_{yd})$

As ; area of reinforcing bar in tensile zone (mm^2)

A's ; area of reinforcing bar in compressive zone (mm^2)

d ; effective depth of a tensile reinforcing bar (mm)

d' ; effective depth of a compressive reinforcing bar (mm)

x ; distance of a compression end and a neutral axis (mm)

y_c ; $=0.4 \cdot x$ (mm)

f_{yd} ; design tensile yield strength of steel (N/mm^2)

$(= f_{yk}/\gamma_{ms}=345\ N/mm^2)$

f_{yk} ; tensile yield strength of steel $(=345\ N/mm^2)$

γ_{ms} ; material factor of steel (=1.0)

f'_{cd} ; design compressive strength of concrete (N/mm^2)

$(= f'_{ck}/\gamma_{mc}=18.5\ N/mm^2)$

f'_{ck} ; characteristic compressive strength of concrete

$(=24\ N/mm^2)$

γ_{mc} ; material factor of concrete (=1.3)

γ_b ; member factor of bending members

γ_i ; structure factor

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γ_i ; structure factor

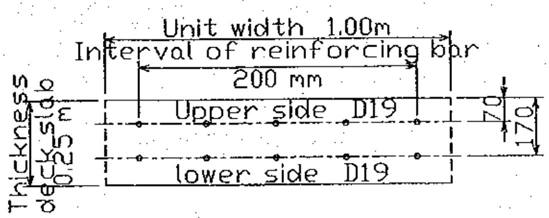
(i) Deck Slab

①Deck Slab "S1" : the parallel direction to the face line

・Examination of bending moment capacity of ultimate limit state

		unit	Ordinary		Wheel Load (distribution)		Wheel Load (Partial distribution) Vertical to the face line		Wheel Load (Partial distribution) Parallel to the face line	
			upper	lower	upper	lower	upper	lower	upper	lower
reinforcing bar (tension side)		mm	D19	D19	D19	D19	D19	D19	D19	D19
reinforcing bar (compression side)		mm	D19	D19	D19	D19	D19	D19	D19	D19
number (tension)			5	5	5	5	5	5	5	5
number (compression)			5	5	5	5	5	5	5	5
area of reinforcement (tension side)	A_s	cm^2	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33
area of reinforcement (compression side)	A'_s	cm^2	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33
width of member	b_w	mm	1,000	1,000	1,000			1,000	1,000	1,000
effective depth (tension)	d	mm	180	170	180	170	180	170	180	170
effective depth (compression)	d	mm	170	180	170	180	170	180	170	180
f_{yd}		N/mm^2	490	490	490	490	490	490	490	490
f'_{cd}		N/mm^2	24	24	24	24	24	24	24	24
M_{ud}		kN·m	80.08	72.11	80.08	72.11	80.08	72.11	80.08	72.11
M_d		kN·m	38.74	17.58	40.16	18.22	33.63	29.07	40.69	36.12
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.581	0.293	0.602	0.303	0.504	0.484	0.610	0.601
Judgment			O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K

・Dimension of an examination section



	Prepared by Y.Ando		Checked by R. NISHIMURA
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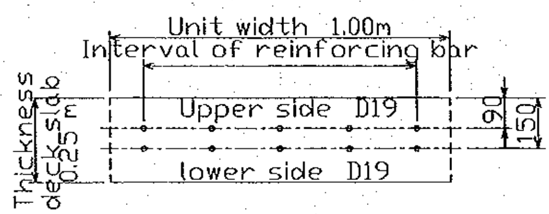
②Deck Slab "S1" : the vertical direction to the face line

・Examination of bending moment capacity of ultimate limit state

		unit	Ordinary		Wheel Load (distribution)		Wheel Load (Partial distribution) Vertical to the face line		Wheel Load (Partial distribution) Parallel to the face line	
			upper	lower	upper	lower	upper	lower	upper	lower
reinforcing bar (tension side)		mm	D19	D19	D19	D19	D19	D19	D19	D19
reinforcing bar (compression side)		mm	D19	D19	D19	D19	D19	D19	D19	D19
number (tension)			5	5	5	5	5	5	5	5
number (compression)			5	5	5	5	5	5	5	5
area of reinforcement (tension side)	A_s	cm^2	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33
area of reinforcement (compression side)	A'_s	cm^2	14.33	14.33	14.33	14.33	14.33	14.33	14.33	14.33
width of member	b_w	mm	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
effective depth (tension)	d	mm	160	150	160	150	160	150	160	150
effective depth (compression)	d	mm	150	160	150	160	150	160	150	160
f_{yd}		N/mm^2	490	490	490	490	490	490	490	490
f'_{cd}		N/mm^2	24	24	24	24	24	24	24	24
M_{ud}		kN·m	81.08	71.62	81.08	71.62	81.08	71.62	81.08	71.62
M_d		kN·m	31.22	9.90	32.36	10.26	31.36	26.76	24.53	19.93
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.462	0.166	0.479	0.172	0.464	0.448	0.363	0.334
Judgment			O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K

・Dimension of an examination section



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

References/ Notes

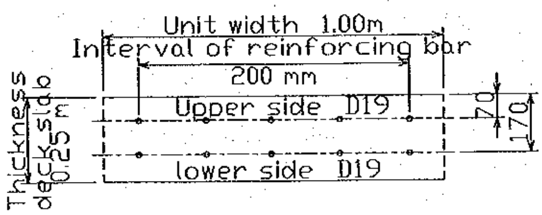
③Deck Slab "S3"

・Examination of bending moment capacity of ultimate limit state

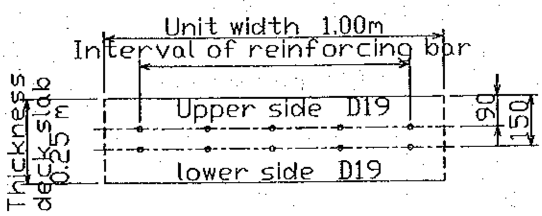
		unit	Ordinary Parallel		Ordinary Vertical	
			upper	lower	upper	lower
reinforcing bar (tension side)		mm	D19	D19	D19	D19
reinforcing bar (compression side)		mm	D19	D19	D19	D19
number (tension)			5	5	5	5
number (compression)			5	5	5	5
area of reinforcement (tension side)	A_s	cm^2	14.33	14.33	14.33	14.33
area of reinforcement (compression side)	A'_s	cm^2	14.33	14.33	14.33	14.33
width of member	b_w	mm	1,000	1,000	1,000	1,000
effective depth (tension)	d	mm	180	170	160	150
effective depth (compression)	d	mm	170	180	150	160
f_{yd}		N/mm^2	490	490	490	490
f'_{cd}		N/mm^2	24	24	24	24
M_{ud}		kN·m	80.08	72.11	81.08	71.62
M_d		kN·m	26.30	—	10.30	1.41
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.394	—	0.152	0.024
Judgment			O.K	—	O.K	O.K

・Dimension of an examination section

The parallel direction to the face line



The vertical direction to the face line



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

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References/ Notes

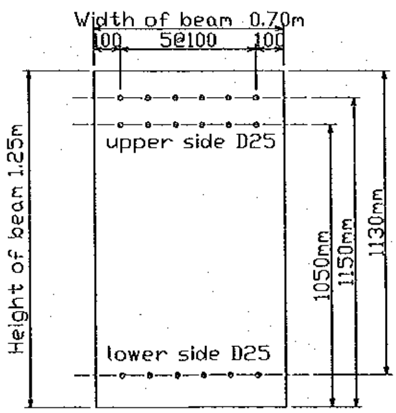
(ii) Beam

①The vertical direction beam to the face line

・Examination of bending moment capacity of ultimate limit state

		unit	Ordinary		Wheel Load (Truck)		Earthquake	
			upper	lower	upper	lower	upper	lower
reinforcing bar (tension side)			D25	D25	D25	D25	D25	D25
reinforcing bar (compression side)			D25	D25	D25	D25	D25	D25
number (tension)			12	6	12	6	12	6
number (compression)			6	12	6	12	6	12
area of reinforcement (tension side)	A_s	cm^2	60.80	30.40	60.80	30.40	60.80	30.40
area of reinforcement (compression side)	A'_s	cm^2	30.40	60.80	30.40	60.80	30.40	60.80
width of member	b_w	mm	700	700	700	700	700	700
effective depth (tension)	d	mm	1,100	1,130	1,100	1,130	1,100	1,130
effective depth (compression)	d	mm	1,130	1,100	1,130	1,100	1,130	1,100
f_{yd}		N/mm^2	490	490	490	490	490	490
f'_{cd}		N/mm^2	24	24	24	24	24	24
M_{ud}		kN·m	1,852.79	1,058.77	1,852.79	1,058.77	1,852.79	1,058.77
M_d		kN·m	651.09	199.34	920.30	365.44	1,515.14	888.78
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.422	0.226	0.596	0.414	0.818	0.839
Judgment			O.K	O.K	O.K	O.K	O.K	O.K

・Dimension of an examination section



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	26/ 07 /2002		08 / 08 /2002

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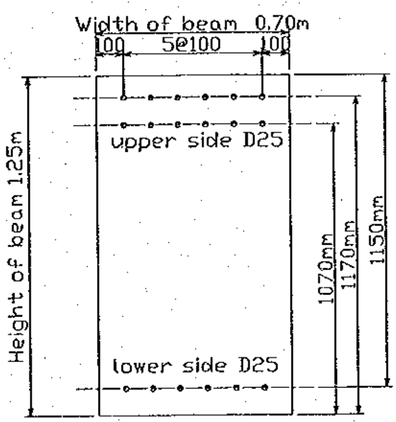
References/ Notes

②The parallel direction beam to the face line

・Examination of bending moment capacity of ultimate limit state

		unit	Ordinary		Wheel Load (Truck)		Earthquake	
			upper	lower	upper	upper	lower	upper
reinforcing bar (tension side)			D25	D25	D25	D25	D25	D25
reinforcing bar (compression side)			D25	D25	D25	D25	D25	D25
number (tension)			12	6	12	6	12	6
number (compression)			6	12	6	12	6	12
area of reinforcement (tension side)	A_s	cm²	60.80	30.40	60.80	30.40	60.80	30.40
area of reinforcement (compression side)	A'_s	cm²	30.40	60.80	30.40	60.80	30.40	60.80
width of member	b_w	mm	700	700	700	700	700	700
effective depth (tension)	d	mm	1,120	1,150	1,120	1,150	1,120	1,150
effective depth (compression)	d	mm	1,150	1,120	1,150	1,120	1,150	1,120
f_{yd}		N/mm²	490	490	490	490	490	490
f_{cd}		N/mm²	24	24	24	24	24	24
M_{ud}		kN·m	1,903.64	1,078.73	1,903.64	1,078.73	1,903.64	1,078.73
M_d		kN·m	518.51	118.98	464.51	392.02	1,467.91	955.37
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.327	0.132	0.293	0.436	0.771	0.886
Judgment			O.K	O.K	O.K	O.K	O.K	O.K

・Dimension of an examination section



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		26 / 07 /2002	08 / 08 /2002

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References/ Notes

③Other beams (Cantilever (Beam 4)、Beam of the Direction of Slant (Beam 7)、 Fender attachment part (apron))

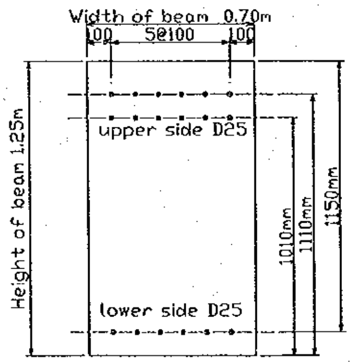
・Examination of bending moment capacity of ultimate limit state

		unit	Cantilever		Beam of the Direction of Slant		Fender attachment part	
			upper	lower	upper	lower	horizontal	vertical
reinforcing bar (tension side)			D25	D25	D25	D25	D19	D19
reinforcing bar (compression side)			D25	D25	D25	D25	—	—
number (tension)			12	6	12	6	10	5
number (compression)			6	12	6	12	—	—
area of reinforcement (tension side)	A_s	cm^2	60.80	30.40	60.80	30.40	28.65	14.32
area of reinforcement (compression side)	A'_s	cm^2	30.40	60.80	30.40	60.80	—	—
width of member	b_w	mm	700	700	700	700	1,000	1,000
effective depth (tension)	d	mm	1,100	1,130	1,060	1,150	420	400
effective depth (compression)	d	mm	1,130	1,100	1,150	1,060	—	—
f_{yd}		N/mm^2	490	490	490	490	490	490
f'_{cd}		N/mm^2	24	24	24	24	24	24
M_{ud}		kN・m	1,852.8	1,058.8	1,794.2	1,086.8	333.17	143.71
M_d		kN・m	1,062.7	—	660.73	381.55	188.70	71.85
Examination result ($\gamma_i \cdot M_d / M_{ud}$)			0.688	—	0.442	0.421	0.566	0.600
Judgment			O.K	—	O.K	O.K	O.K	O.K

・Dimension of an examination section

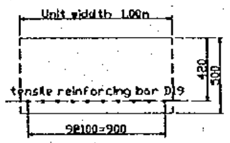
Dimension of section of cantilever is the same as the vertical direction beam to the face line.

Beam of the Direction of Slant

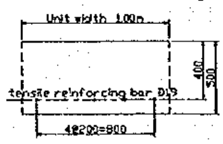


Fender attachment part

Horizontal reinforcing bar



Vertical reinforcing bar



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

References/ Notes

b) Examination of the Shearing Force

The steel reinforcement to be used calculates it as satisfying the following conditions.

$\gamma_i \cdot V_d / V_{yd} \leqq 1.0$

$V_{yd} = V_{cd} + V_{sd}$

V_{yd} ; design shear capacity

V_{cd} ; design shear capacity without shear reinforcement. It computes by the following formulas.

$$V_{cd} = \beta_d \cdot \beta_p \cdot \beta_n \cdot f_{vcd} \cdot b_w \cdot d / \gamma_b$$

f_{vcd} ; $0.2\times(f'_{cd})^{1/3}$

β_d ; coefficient to consider influence of effective depth on shear capacity

$\beta_d=(1000/d)^{1/4}$

β_p ; coefficient to consider influence of longitudinal reinforcement on shear capacity

$\beta_p=(100\cdot p_w)^{1/3}$

β_n ; coefficient to consider influence of axial force on shear capacity

$\beta_n=1+M_0/M_d$ ($N'_d \geqq 0$) when $\beta_n>2$, β_n is taken as 2.0

$\beta_n=1+2M_0/M_d$ ($N'_d < 0$) when $\beta_n<0$, β_n is taken as 0.0

N'_d ; design axial compressive force (N)

M_d ; design bending moment (N·mm)

M_0 ; decompression moment necessary to cancel the fiber stress due to axial force at the tension fiber corresponding to design moment M_d

b_w ; web width (mm)

d ; effective depth (mm)

p_w ; balanced ratio of reinforcement$=A_s/(b_w \cdot d)$

A_s ; area of reinforcing bar (mm^2)

f'_{cd} ; design compressive strength of concrete (=18.5N/mm^2)

γ_b ; member factor (=1.30)

V_{sd} ; design shear capacity carried by shear reinforcing steel

$$V_{sd} = \frac{A_w \cdot f_{wyd}}{S_s}(\sin\alpha_s + \cos\alpha_s)\cdot z/\gamma_b$$

A_w ; total amount of area of shear reinforcement over the interval S_s (mm^2)

f_{wyd} ; design yield strength of shear reinforcement (=345 N/mm^2)

α_s ; angle between shear reinforcement and member axis

S_s ; spacing of shear reinforcement (mm)

z ; distance from compression resultant to centroid of tension steel

Generally , d/1.15

γ_b ; member factor

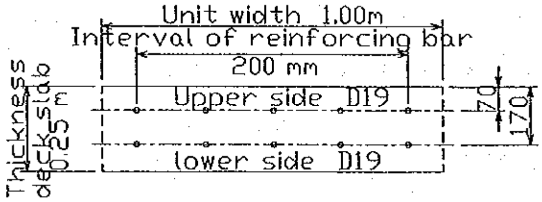
(i) Deck Slab

①Deck Slab "S1" : the parallel direction to the face line

・Examination of shearing force capacity of ultimate limit state

		unit	Ordinary	Wheel Load (Distribution)	Wheel Load (Partial distribution) Vertical to the face line	Wheel Load (Partial distribution) Parallel to the face line
reinforcing bar			D19	D19	D19	D19
number of reinforcing bar			5	5	5	5
area of reinforcing bar	A_s	cm^2	14.33	14.33	14.33	14.33
width of member	b_w	mm	1,000	1,000	1,000	1,000
effective depth	d	mm	170	170	170	170
axial compressive force	N'_d	kN	0	0	0	0
A_w		mm^2	2.534	2.534	2.534	2.534
α_s		°	90	90	90	90
s		mm	200	200	200	200
V_{cd}		kN	97.98	97.98	97.98	97.98
V_{sd}		kN	56.19	56.19	56.19	56.19
V_{yd}		kN	154.17	154.17	154.17	154.17
V_d		kN	59.69	61.87	52.54	42.50
Examination result ($\gamma_i \cdot V_d / V_{yd}$)			0.465	0.482	0.409	0.331
Judgment			O.K	O.K	O.K	O.K

・Dimension of an examination section



②Deck Slab "S1" : the vertical direction to the face line

・Examination of shearing force capacity of ultimate limit state

		unit	Ordinary	Wheel Load (Distribution)	Wheel Load (Partial distribution) Vertical to the face line	Wheel Load (Partial distribution) Parallel to the face line
reinforcing bar			D19	D19	D19	D19
number of reinforcing bar			5	5	5	5
area of reinforcing bar	A_s	cm^2	14.33	14.33	14.33	14.33
width of member	b_w	mm	1,000	1,000	1,000	1,000
effective depth	d	mm	150	150	150	150
axial compressive force	N'_d	kN	0	0	0	0
A_w		mm^2	2.534	2.534	2.534	2.534
α_s		°	90	90	90	90
s		mm	200	200	200	200
V_{cd}		kN	90.12	90.12	90.12	90.12
V_{sd}		kN	49.58	49.68	49.58	49.58
V_{yd}		kN	139.70	139.70	139.70	139.70
V_d		kN	65.28	67.66	43.71	53.75
Examination result ($\gamma_i \cdot V_d / V_{yd}$)			0.561	0.581	0.375	0.439
Judgment			O.K	O.K	O.K	O.K

・Dimension of an examination section