社会開発協力部報告書

No. 4

AFRICAN DEVELOPMENT BANK

GOVERNMENT OF MAURITIUS

BEAU BASSIN - PORT LOUIS LINK ROAD

CALCULATION NOTE

FOR

SUPERSTRUCTURES

OF

R.C. SLAB BRIDGES

SEPTEMBER 1980

Japan International Cooperation Agency

CONTENTS

1. Side Span R.C. Slab Bridge

CONTENTS

§ 1 DESIGN CONDITION

I. DESIGN CONDITION

TYPE — RC SOLID SLAB

BRIDGE LENGTH

GIRDER LENGTH

SPAN

WIDTH

LIVE LOAD — BS 153

HA LOADING

HB LOADING 37.5 UNITS

FOOTWAY LOADING 5 KN/M^2

VEHICLE COLLISION WITH GUARDRAIL

ACCORDING TO NAARSA

ULTIMATE LOAD FACTORS

HA LOADING	1.5 D + 2.5 L
	2 (D + L)
HB LOADING	1.5 D + 2.0 L

§ 2. MATERIAL STRENGTH AND PERMISSIBLE STRESS

1. CONCRETE

MAIN SLAB

SPECIFIED WORKS CUBE STRENGTH

AT 28 DAYS — $30\ N/mm^2$ ($306\ kg/cm^2$)

PERMISSIBLE COMPRESSIVE STRESS

BENDING COMPRESSION — $10\ N/mm^2$ ($101\ kg/cm^2$)

SHEAR — $0.87\ N/mm^2$ ($8.9\ kg/cm^2$)

2. REIN FORCEMENT

HOT ROLLED YIELD BARS

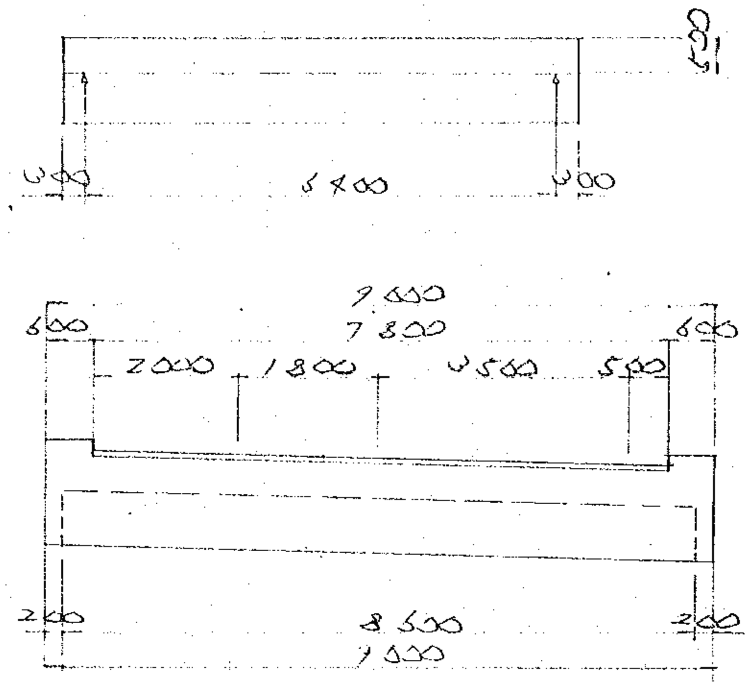
SPECIFIED CHARACTERISTIC STRENGTH

$f_{su} = 410\ N/m^2$ ($4180\ kg/cm^2$)

PERMISSIBLE TENSILE STRESS

$f_{sa} = 230\ N/mm^2$ ($2340\ kg/cm^2$)

§2 Moter way ℄-Ramp Bridge



Main slab.	w_{d0} =	9.00	× 1.20	× 2.41		=	26.028
〃	w_{d0} =	−8.60	× 0.70	× 2.41		=	−14.508
Kerb.	w_{d1} =	0.60	× 0.23	× 2.41	× 2	=	0.665
Pavement	w_{d2} =	7.80	× 0.08	× 2.305		=	1.438
Rail	w_{d3} =	0.112	× 2			=	0.224
					total	=	13.847 t/m

7.8 → 3 lane × 2.6 m

U.D.L = 31.5 kN/m

P_u = 1/3 × 31.5 = 10.5 kN/m² = 1.071 t/m²

P_l = = 40 kN/m = 4.080 t/m

$P_u' = 1.071 \times 2.6 \times 2 + 1/3 \times 1.071 \times 2.6 = 6.497$ t/m

$P_\ell' = 4.08 \times 2.6 \times 2 + 1/3 \times 4.08 \times 2.6 = 24.752$ t

$P_{HB} = 38.25$ t

1/3 HA $P_u' = 1/3 \times 1.071 \times 2.6 = 0.928$ t/m

$P_\ell' = 1/3 \times 4.08 \times 2.6 = 3.536$

· Reaction

Dead Load $R_d = 1/2 \times 13.847 \times 6.4 = 44.31$ t

HA $R_v = 1/2 \times 6.497 \times 6.4 = 20.79$

$R_\ell = \qquad = 24.75$

HB $R_{HB} = 38.25 \times (1.719) = 65.74$

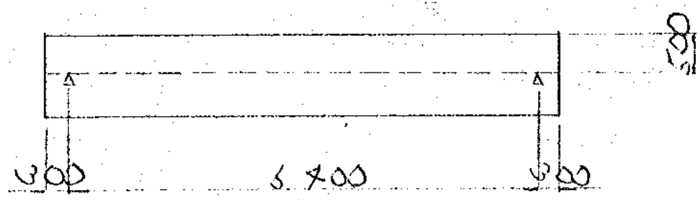
1/3 HA $R_v = 1/2 \times 0.928 \times 6.4 = 2.97$

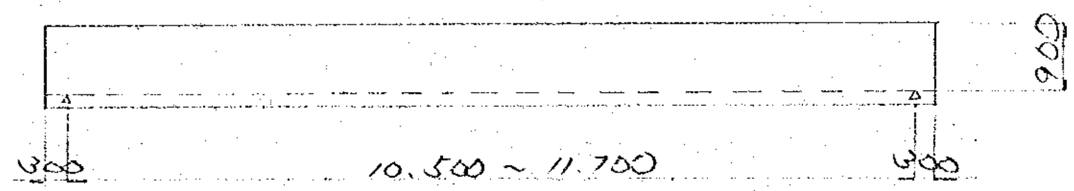
$R_\ell \qquad = 3.54$

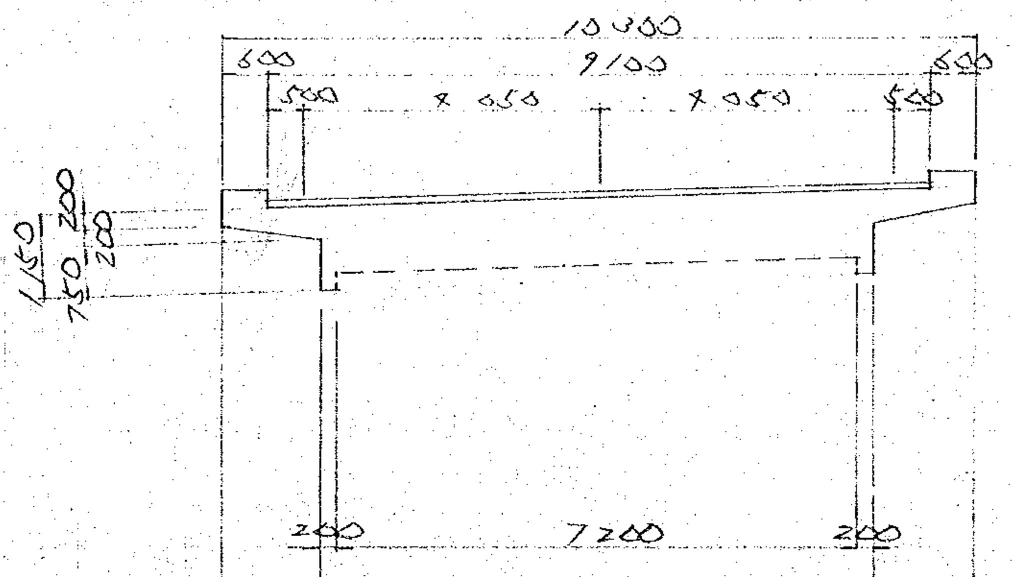
HA tatal = 89.85

HB tatal = 116.56

§3 Moterway B - Ramp Bridge







Calculation of Section

· Load

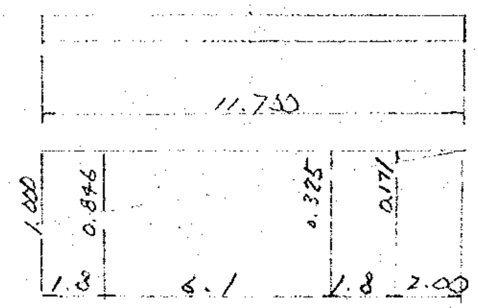
$W_{do} = 0.900 \times 2.41 = 2.169$

$W_{ds} = 0.080 \times 2.305 = 0.184$

$2.353\ t/m^2$

HB Load $11.953\ t/m$

· Span 11.7^m



Bending Moment.

$M = 1/8 \times 2.353 \times 11.7^2 + 11.953 \times (5.85 - 0.9)$

$= 99.43\ t \cdot m/m$

$S_o = 1/2 \times 2.353 \times 11.7 + 11.953 \times 2.242$

$= 41.76\ t \cdot m/m$

$M' = \frac{1}{1.25} M = 79.54\ t \cdot m$

$S' = \frac{1}{1.25} S = 33.41\ t$

$req\ As = \frac{7954000}{2300 \times 0.875 \times 84.15} = 46.97\ cm^2$

$As = \Phi 32 - 15^{cm}\ c \cdot to \cdot c = 8.04 \times 6.667 = 53.60\ cm^2$

$np = \frac{15 \times 53.60}{100 \times 83.8} = 0.096$ $c = 6.42$, $s = 11.80$

$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{7954000}{100 \times 83.8^2} \times 6.42 = 73\ kg/cm^2$

$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 11.327 \times 11.8 \times 15 = 2005$ "

$\tau = \frac{S}{b \cdot d'} = \frac{33410}{100 \times 90} = 3.7\ kg/cm^2$

Calculation of Load

Main slab	W_{d0}	7.6 × 1.15 × 2.41	21.063
"	W_{d0}	7.2 × 0.65 × 2.41	(− 11.279)
	W_{d0}	7.2 × 0.25 × 2.41	(− 4.338)
Cantilever slab	W_{d1}	½ × (0.2 + 0.4) × 1.35 × 2.41 × 2	1.952
Kerb	W_{d2}	0.60 × 0.23 × 2.41 × 2	0.665
Pavement	W_{d3}	9.1 × 0.08 × 2.305	1.678
Rail		0.112 × 2	0.224
Total			14.303
			21.244

$9.1^m \rightarrow 3$ lane × 3.033.

a) Span 6.4 m U.D.L = 31.5 kN/m

$P_K = 1/3.033 \times 31.5 = 10.385\ kN/m^2 = 1.059\ t/m^2$

$P_\ell = 120 \times 1/3.033 = 39.560\ kN/m = 4.035\ t/m$

$P_u' = 1.059 \times 3.033 \times 2 + 1/3 \times 1.059 \times 3.033 = 7.495\ t/m$

$P_\ell' = 4.035 \times 3.033 \times 2 + 1/3 \times 3.033 \times 4.035 = 28.56\ t$

$P_{HB} = 38.25\ t$

1/3 HA $P_u' = 1/3 \times 1.059 \times 3.033 = 1.071\ t/m$

$P_\ell = 1/3 \times 3.033 \times 4.135 = 4.080\ t.$

· Reaction

Dead Load	$R_d = 1/2 \times 14.303 \times 6.4$	=	45.77
HA	$R_U = 1/2 \times 7.495 \times 6.4$	=	23.98
HA	R_L	=	28.56
HB	$R_{HB} = 38.25 \times (1.719)$	=	65.74
1/3 HA	$R_U = 1/2 \times 1.071 \times 6.4$	=	3.43
〃	R_L	=	4.08

HA total 98.3

HB total 119.0

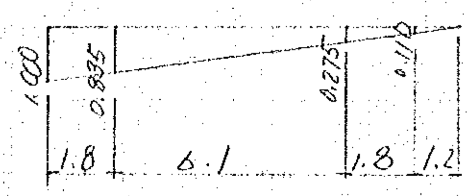
b) Span 10.9 m

· Reaction

Dead Load	$R_d = 1/2 \times 21.244 \times 10.9$	=	115.78
HA	$R_U = 1/2 \times 7.495 \times 10.9$	=	40.85
	R_L	=	28.56
HB	$R_{HB} = 38.25 \times (1.00 + 0.835 + 0.275 + 0.110)$	=	84.92
1/3 HA	$R_U = 1/2 \times 1.071 \times 10.9$	=	5.84
	R_L =	=	4.08

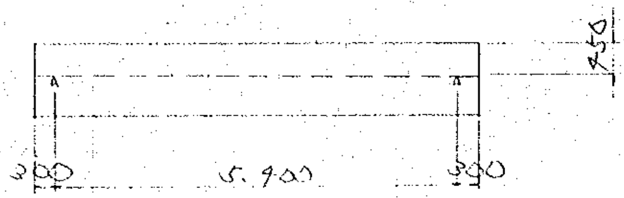
HA total 185.2 ton

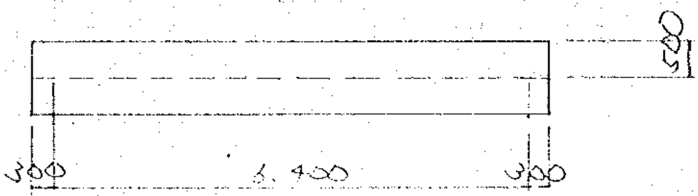
HB total 210.6 ton

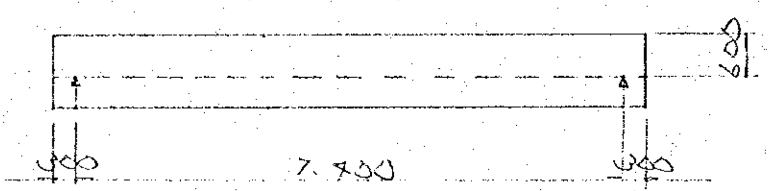


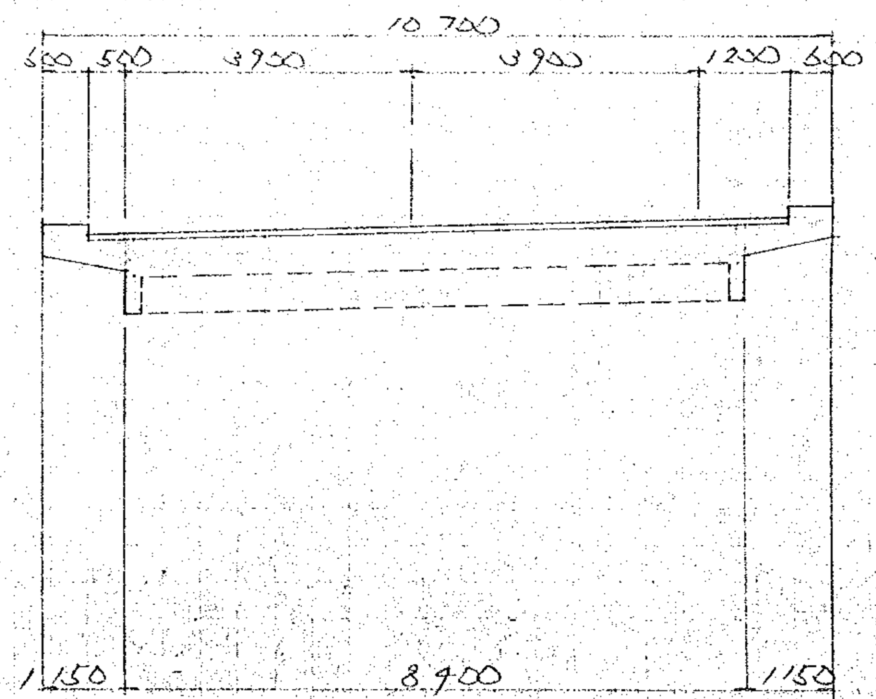
§.4 Pointe aux sables

1 Dimension









2 Calculation of Section

· Load (HB Loading)

$$W_{do} = 0.50 \times 2.41 = 1.205$$

$$W_{ds} = 0.08 \times 2.305 = 0.184$$

$$1.389 \ t/m^2$$

HB Load $4 \times 9.5625 / 3.2 = 11.953 \ t/m$

· Span 6.4^m

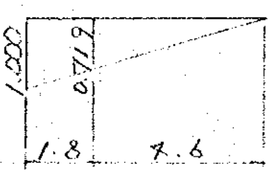
Bending Moment

$$M = 1/8 \times 1.389 \times 6.4^2 + 11.953 \times (3.2 - 0.9) = 34.60 \ t \cdot m/m$$

Shear Force

$$S_o = 1/2 \times 1.389 \times 6.4 + 11.953 \times (1.000 + 0.719) = 24.99 \ t/m$$

$$M' = \frac{1}{1.25} \times M = 27.68 \ t \cdot m$$



$$S' = \frac{1}{1.25} \times S = 19.99 \ t$$

$$req.\ As = \frac{2768000}{2300 \times 0.875 \times 44.15} = 31.15 \ cm^2$$

$$As = \Phi 25 - 15^{cm} \ c\ to\ c = 4.91 \times 6.667 = 32.73 \ cm^2$$

$$np = \frac{32.73 \times 15}{100 \times 44.15} = 0.111 \qquad c = 6.14, \ s = 10.4$$

$$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{2768000}{100 \times 44.15^2} \times 6.14 = 87 \ Kg/cm^2$$

$$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 14.201 \times 10.4 \times 15 = 2215 \ Kg/cm^2$$

$$\tau = \frac{S}{b \cdot d'} = \frac{19990}{100 \times 50} = 4.0 \ Kg/cm^2$$

· Load

$W_{do} = 0.60 \times 2.41 = 1.446$

$W_{ds} = 0.08 \times 2.305 = 0.184$

$W = 1.630 \; t/m^2$

HB Load $\qquad P_{HB} = 11.953 \; t/m$

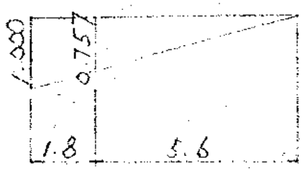
· Span 7.4^m

Bending Moment

$M = 1/8 \times 1.630 \times 7.4^2 + 11.953 \times (3.7 - 0.9) = 44.63 \; t{\cdot}m/m$

Shear Force

$S = 1/2 \times 1.630 \times 7.4 + 11.953 \times (1.000 + 0.757) = 27.03 \; t/m$



$M' = 44.63 \times 1/1.25 = 35.70 \; t{\cdot}m$

$S' = 27.03 \times 1/1.25 = 21.62 \; t$

$req\ A_s = \dfrac{3570000}{2300 \times 0.875 \times 54.15} = 32.76$

$A_s = \phi 25 - 12.5^{cm}$ c-to-c $= 4.91 \times 8 = 39.28$

$np = \dfrac{39.28 \times 15}{100 \times 54.15} = 0.109 \qquad c = 6.16 \quad s = 10.5$

$\sigma_c = \dfrac{M}{b \cdot d^2} \cdot c = \dfrac{3570000}{100 \times 54.15^2} \times 6.16 = 75 \; kg/cm^2$

$\sigma_s = \dfrac{M}{b \cdot d^2} \cdot s \cdot n = 12.175 \times 10.5 \times 15 = 1917$ 〃

$\tau = \dfrac{S}{b \cdot d'} = \dfrac{21620}{100 \times 60} = 3.6 \; kg/cm^2$

Calculation of Load.

1) Dead Load.

Main slab	Wdo	8.40 × 1.00 × 2.41	20.244
"		8.00 × 0.55 × 2.41	-10.604
"		8.00 × 0.50 × "	(- 9.640)
"		8.00 × 0.45 × "	(- 8.676)
Cantilever slab	Wd1	1/2 × (0.20 + 0.40) × 1.15 × 2.41 × 2	1.663
Kerb	Wd2	0.60 × 0.230 × 2.41 × 2	0.665
Pavement	Wd3	9.50 × 0.080 × 2.305	1.752
Rail	Wd4	0.112 t/m × 2	0.224
Total			13.944
			14.908
			15.872

9.5 m → 3 lane → 3.167 m

2) Live load

a) Span 5.4 m U.D.L = 41.1 KN/m

$P_u = 1/3.167 \times 41.1 = 12.979\ KN/m^2 = 1.324\ t/m^2$

$P_l = 120 / 3.167 = 37.895\ KN/m = 3.856\ t/m$

$P_u' = 1.324 \times 3.167 \times 2 + 1/3 \times 1.324 \times 3.167 = 9.783\ t/m$

$P_l' = 3.856 \times 3.167 \times 2 + 1/3 \times 3.856 \times 3.167 = 28.491\ t$

HB Load. $P_{HB} = 38.25\ t$

1/3·HA $P_u' = 1/3 \times 1.324 \times 3.167 = 1.398\ t/m$

$P_l' = 1/3 \times 3.856 \times 3.167 = 4.070\ t$

Reaction

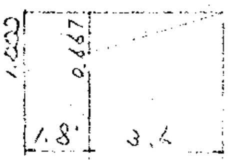
Dead Load $\quad R_d = \frac{1}{2} \times 13.944 \times 5.4 = 37.65^{t}$

HA Uniform $\quad R_U = \frac{1}{2} \times 9.783 \times 5.4 = 26.41$

Line $\quad R_\ell = \quad = 28.49$

HB Load $\quad R_{HB} = 38.25 \times 1.667 = 63.75$

$\frac{1}{3}$ · HA uni $\quad R_u = \frac{1}{2} \times 1.398 \times 5.4 = 3.77$



HA line $\quad R_\ell = 4.07$

HA total $\quad 92.55^{t}$

HB total $\quad 109.24^{t}$

b) Span 6.4^{m}

· HA Loading $\quad$ U.D.L $31.5\ ^{kN}/_{m}$

$P_u = \frac{1}{3.167} \times 31.5 = 9.947\ ^{kN}/_{m^2} = 1.015\ ^{t}/_{m^2}$

$P_\ell = 120 \times \frac{1}{3.167} = 37.895\ ^{kN}/_{m} = 3.865\ ^{t}/_{m}$

$P_u' = 1.015 \times 3.167 \times 2 + \frac{1}{3} \times 1.015 \times 3.167 = 7.500\ ^{t}/_{m}$

$P_\ell' = 3.865 \times 3.167 \times 2 + \frac{1}{3} \times 3.865 \times 3.167 = 28.56^{t}$

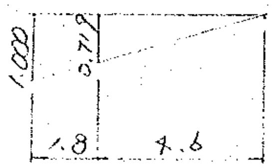
HB Load $\quad P_{HB} = 38.25^{t}$

$\frac{1}{3}$ HA $\quad P_u' = \frac{1}{3} \times 1.015 \times 3.167 = 1.071\ ^{t}/_{m}$

$P_\ell' = \quad = 4.080^{t}$

Reaction

Dead Load	$R_d = \frac{1}{2} \times 14.908 \times 6.4$	= 47.71
HA uni	$R_U = \frac{1}{2} \times 7.500 \times 6.4$	= 24.00
line	R_ℓ	= 28.56
HB load	$R_{HB} = 38.25 (1.000 + 0.719)$	= 65.74
1/3 HA	$R_U = \frac{1}{2} \times 1.071 \times 6.4$	= 3.43
	R_ℓ	= 7.08



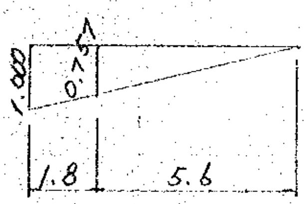
HA total = 100.27

HB total = 120.96

c). Span 7.4 m

Reaction

Dead Load	$R_d = \frac{1}{2} \times 15.872 \times 7.4$	= 58.73
HA Uni	$R_U = \frac{1}{2} \times 7.500 \times 7.4$	= 27.75
line	R_ℓ	= 28.56
HB load	$R_{HB} = 38.25 \times (1.000 + 0.757)$	= 67.20
1/3 HA	$R_U = \frac{1}{2} \times 1.071 \times 7.4$	= 3.96
	R_ℓ =	= 8.08

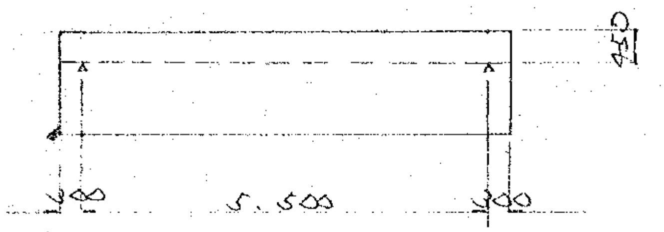


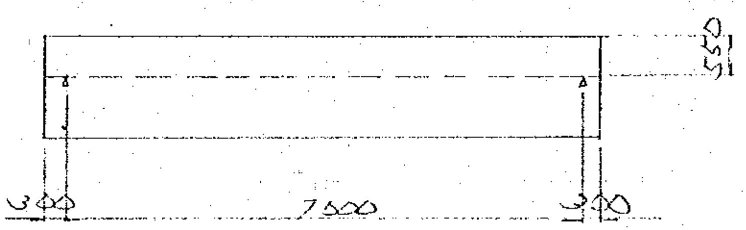
HA tatal = 115.04 t

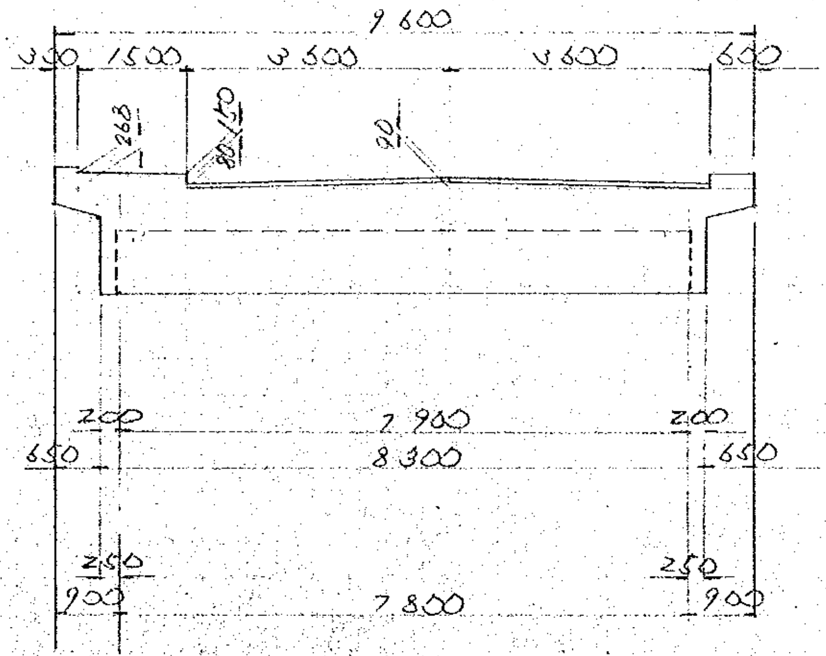
HB tatal = 133.97 t

§5 Pailles OVER BRIDGE

1 Dimension







2 Calculation of Section

· Load (H B Loading)

$$w_{do} = 0.550 \times 2.41 = 1.326$$

$$w_{ds} = (0.08 + 0.09) \times 2.305 = 0.392$$

$$1.718 \ t/m^2$$

HB Loading $4 \times 9.5625 / 3.2 = 11.953 \ t/m$

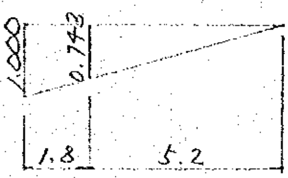
· Length 7.0^m

· Bending Moment

$$M = 1/8 \times 1.718 \times 7.0^2 + 11.953 \times (3.5 - 0.9) = 41.60 \ t \cdot m/m$$

· Shear Force

$$S_o = 1/2 \times 1.718 \times 7.0 + 11.953 \times (1.000 + 0.743) = 26.85 \ t/m$$



$$M' = \frac{1}{1.25} M = 33.28 \ t \cdot m/m$$

$$S' = \frac{1}{1.25} S = 21.48 \ t/m$$

$$req\ A_s = \frac{3328000}{2300 \times 0.875 \times 49.15} = 33.65 \ cm^2$$

$$A_s = \Phi 25 - 12.5^{cm} \ c\text{-}to\text{-}c = 4.91 \times 8 = 39.28 \ cm^2$$

$$np = \frac{15 \times 39.28}{100 \times 49.15} = 0.120 \qquad c = 5.97 \quad s = 9.56$$

$$\sigma_c = \frac{3328000}{100 \times 49.15^2} \times 5.97 = 82 \ kg/cm^2$$

$$\sigma_s = 13.776 \times 9.56 \times 15 = 1975$$

$$\tau = \frac{S}{b \cdot d'} = \frac{21480}{100 \times 55} = 3.9$$

3 Calculation of Load

1) Dead Load

			w
Main slab	Wdo	8.300 × 1.400 × 2.41	28.004
〃	Wdo	7.900 × 0.950 × 2.41	(-18.087)
	Wdo	7.900 × 0.850 × 2.41	(-16.183)
Cantilever slab	Wd1	½ × (0.200 + 0.400) × 0.650 × 2.41 × 2	0.940
Side walk	Wd2	½ × (0.180 + 0.218) × 1.50 × 1.80	0.537
〃	Wd2	0.050 × 1.50 × 2.41	0.181
kerb (1)	Wd4	0.368 × 0.300 × 2.41	0.266
〃 (2)	Wd4	0.230 × 0.600 × 2.41	0.333
Screeding Concrete	Wd5	½ × 7.2 × 0.090 × 2.305	0.747
Pavement	Wd6	7.2 × 0.080 × 2.305	1.328
Rail		0.112 t/m × 2	0.224
Span 5.5	total		14.473
Span 7.0	total		16.377

2). Live load

a) span 5.5 m

- HA Loading U.D.L = 41.1 KN/m

$Pu = 1/3.6 \times 41.1 = 11.417\ KN/m^2 = 1.164\ t/m^2$

$Pl = 120/3.6 = 33.33\ KN/m = 3.400\ t/m$

Notinal lane $2 \times 3.6 = 7.2^m$

$Pu' = 1.164 \times 3.6 \times 2 = 8.381\ t/m$

$Pl' = 3.400 \times 3.6 \times 2 = 24.48\ t$

- Crowd Load $Pc = 5\ KN/m^2 = 0.51\ t/m^2$

$Pc' = 0.51 \times 1.5 = 0.765\ t/m$

· HB Loading $P_{HB} = 38.25^{t}$

1/3 HA Loading $P_u' = 1/3 \times 1.164 \times 3.6 = 1.397^{t/m}$

$P_\ell' = 1/3 \times 3.400 \times 3.6 = 4.080^{t}$

Calculation of Reaction.

Dead Load $R_d = 1/2 \times 14.473 \times 5.5 = 39.80^{t}$

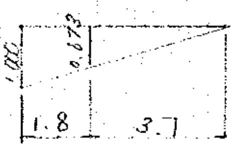
HA Uniform $R_u = 1/2 \times 8.381 \times 5.5 = 23.05^{t}$

" Line $R_\ell = 24.48$

Crowd $R_c = 1/2 \times 0.765 \times 5.5 = 2.10$

HB Load $R_{HB} = 38.25 \times 1.673 = 63.98^{t}$

1/3 HA $R_u = 1/2 \times 1.397 \times 5.5 = 3.84$



$R_\ell = \quad = 4.08$

HA total = 89.4^{t}

HB total = 113.8^{t}

b) Span 7.0^{m}

· HA Loading $UDL = 31.5\ ^{KN}/_{m}$

$P_u = 1/3.6 \times 31.5 = 8.75\ ^{KN}/_{m^2} = 0.893\ ^{t}/_{m^2}$

$P_\ell = 120\ /3.6 = 33.33\ ^{KN}/_{m} = 3.400\ ^{t}/_{m}$

Notional lane $2 \times 3.6 = 7.2^{m}$

$P_u' = 0.893 \times 7.2 = 6.430\ ^{t}/_{m}$

$P_\ell' = 3.400 \times 7.2 = 24.480^{t}$

· Crowd load $P_c = 0.51\ ^{t}/_{m^2}$

$P_c' = 0.51 \times 1.50 = 0.765\ ^{t}/_{m}$

· HB Loading　　$P_{HB} = 38.25^t$

1/3 · HA　　$P_u' = 1/3 \times 0.893 \times 3.6 = 1.072\ ^{t/m}$

$P_l' = 1/3 \times 3.400 \times 3.6 = 4.080\ ^t$

Calculation of Reaction

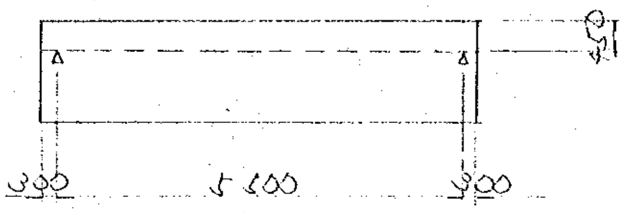
Dead Load	$R_d = 1/2 \times 16.377 \times 7.0$	= 57.32
HA Uniform	$R_u = 1/2 \times 6.430 \times 7.0$	= 22.51
HA Line	R_l	= 24.48
Crowd	$R_c = 1/2 \times 0.765 \times 7.0$	= 2.68
HB Load	$R_{HB} = 38.25 \times 1.743$	= 66.66
1/3 HA	$R_u = 1/2 \times 1.072 \times 7.0$	= 3.75
	$R_l =$	= 4.08

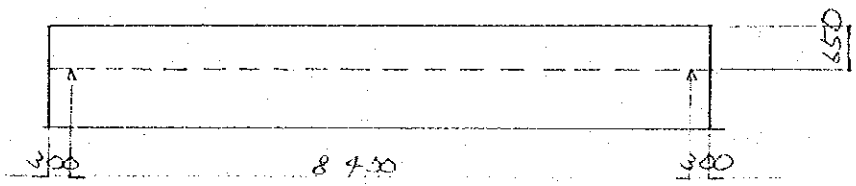
HA tatal = 107.0^t

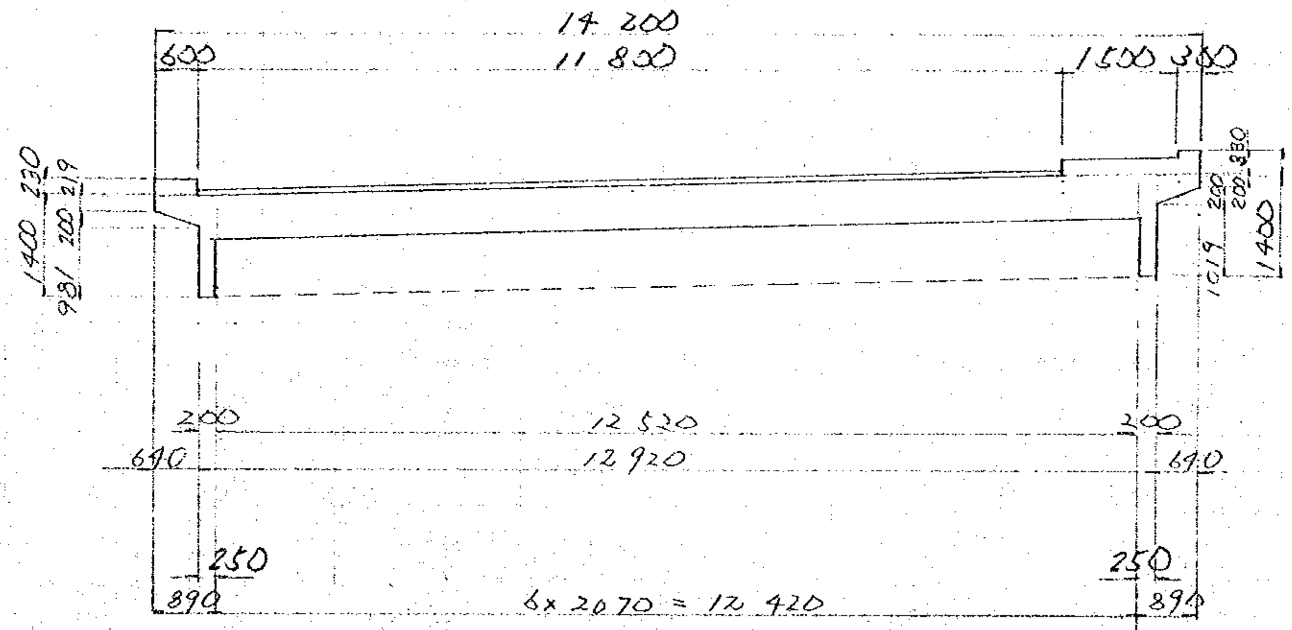
HB tatal = 134.5^t

§6 A 1 Road OVER BRIDGE

1. Dimension







2 Calculation of Load

1). Dead Load

Main slab	Wdo	12.92 × 1.40	× 2.41	43.59
"	Wd1	12.52 × 1.00	× 2.41	-30.17
"	Wd1'	12.52 × 0.75	× 2.41	(-22.63)
Cantilever slab	Wd2	½ × (0.219 + 0.319) × 0.64	× 2.41	0.41
	"	½ × (0.2 + 0.3) × 0.64	× 2.41	0.39
Side walk	Wd3	0.18 × 1.50	× 1.80	0.49
"	"	0.05 × 1.50	× 2.41	0.18
kerb (1)	Wd4	0.23 × 0.60	× 2.41	0.33
" (2)	"	0.33 × 0.30	× 2.41	0.24
Pavement	Wd5	0.08 × 11.8	× 2.305	2.18
Rail	Wd6	0.112 × 2		0.22
tatal				17.86 (25.40)

2) Live Load

A). Span 5.5 m

· HA Loading) W.D.L = 41.1 kN/m

$p_u = 1/3 \times 41.1 = 13.7\ \text{kN/m}^2 = 1.397\ \text{t/m}^2$

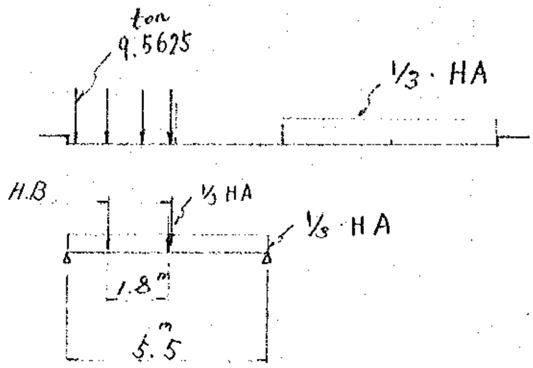
$P_l = 40\ \text{kN/m} = 4.080\ \text{t/m}$

Notional lane $4 \times 2.95 = 11.8\ \text{m}$

$P_u' = 1.397 \times 2.95 \times 2 + 1/3 \times 1.397 \times 2.95 \times 2 = 10.99\ \text{t/m}$

$P_l' = 4.08 \times 2.95 \times 2 + 1/3 \times 4.08 \times 2.95 \times 2 = 32.10\ \text{t}$

· H·B Loading) $37.5^{unit} = 38.25^{t}$



$P_{HB} = 9.5625 \times 4 = 38.25^{t}$

$P_l' = 1/3 \times 4.08 \times 2.95 \times 2 = 8.02^{t}$

$P_u' = 1/3 \times 1.397 \times 2.95 \times 2 = 2.747^{t/m}$

B) Span 8.4^{m}

· HA Loading) $U.D.L = 31.5^{kN/m}$

$P_u = 1/3 \times 31.5 = 10.5^{kN/m^2} = 1.071^{t/m^2}$

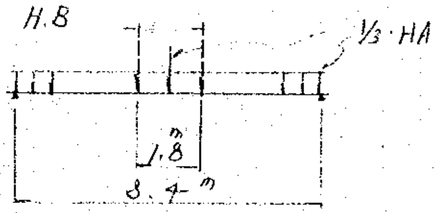
$P_l = 40^{kN/m} = 4.080^{t/m}$

Notional lane $4 \times 2.95 = 11.8^{m}$

$P_u' = 1.071 \times 2.95 \times 2 + 1/3 \times 1.071 \times 2.95 \times 2 = 8.43^{t/m}$

$P_l' = 4.08 \times 2.95 \times 2 + 1/3 \times 4.08 \times 2.95 \times 2 = 32.10^{t}$

· H B Loading



$P_{HB} = 9.5625 \times 4 = 38.25^{t}$

$P_u' = 1/3 \times 1.071 \times 2.95 \times 2 = 2.106^{t/m}$

$P_l = 1/3 \times 4.08 \times 2.95 \times 2 = 8.02^{t}$

· Crowd Load

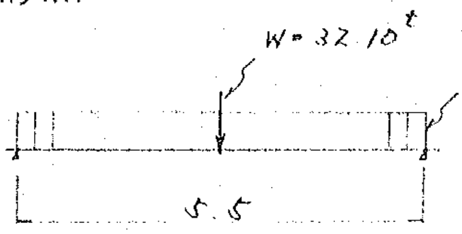
$P_c = 5^{kN/m^2} = 0.51^{t/m^2}$

$P_c' = 0.51 \times 1.5 = 0.765^{t/m}$

3. Calculation of Sectional Force

a) Span 5.5^m

A) HA



$w = w_d + P_u' + P_c'$
$= 17.86 + 10.99 + 0.765 = 29.62^{t/m}$

· Bending Moment

$M_{center} = \frac{1}{8} \cdot w\ell^2 + \frac{1}{4} W\ell = \frac{1}{8} \times 29.62 \times 5.5^2 + \frac{1}{4} \times 32.10 \times 5.5$

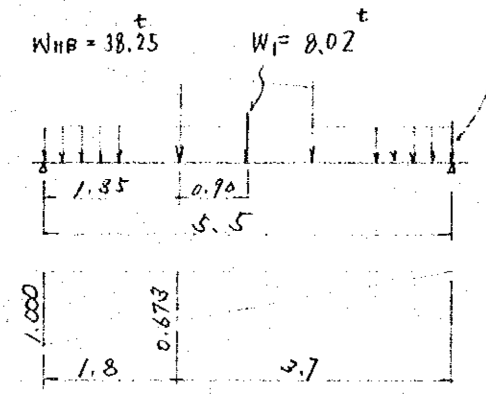
$= 156.14^{t \cdot m} / 12.92 = 12.08^{t \cdot m/m}$

· Shear Force

$S_o = \frac{1}{2} \cdot w\ell + W = \frac{1}{2} \times 29.62 \times 5.5 + 32.10$

$= 113.56^{t} / 12.92 = 8.79^{t/m}$

B) H.B



$w = w_d + P_u' + P_c'$
$= 17.86 + 2.747 + 0.765 = 21.37^{t/m}$

· Bending Moment

$M_{center} = \frac{1}{8} \cdot w\ell^2 + \frac{1}{4} W\ell + W_{HB}(\frac{1}{2}\ell - 0.90)$

$= \frac{1}{8} \times \overset{80.805}{21.37 \times 5.5^2} + \frac{1}{4} \times \overset{11.028}{8.02 \times 5.5} + 38.25(2.75 - 0.90)$

$= 162.60^{t \cdot m} / 12.92 = 12.58^{t \cdot m/m}$

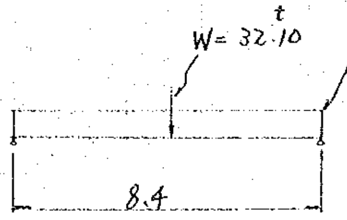
· Shear Force $S_o = \frac{1}{2} \cdot w\ell + W + W_{HB}(1.00 + 0.673)$

$= \frac{1}{2} \times 21.37 \times 5.5 + 8.02 + 38.25 \times 1.673 = 130.78^{t} / 12.92 = 10.12^{t/m}$

b) Span 8.4^m

A) HA Loading

$w = w_d + P_u' + P_s' = 25.40 + 8.43 + 0.77 = 34.60^{t/m}$



· Bending Moment

$M_{center} = \frac{1}{8} \cdot w \cdot l^2 + \frac{1}{4} W l$

$= \frac{1}{8} \times 34.6 \times 8.4^2 + \frac{1}{4} \times 32.1 \times 8.4$

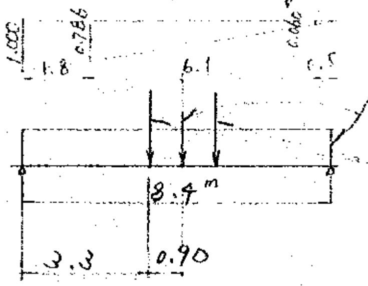
$= 372.59^{tm} \quad / 12.92 = 28.84^{t \cdot m/m}$

· Shear Force

$S_o = \frac{1}{2} \cdot w l + W = \frac{1}{2} \times 34.6 \times 8.4 + 32.1$

$= 177.42^t \quad / 12.92 = 13.73^{t/m}$

B) H.B Loading



$w = w_d + P_u' + P_s' = 25.40 + 2.106 + 0.763 = 28.27^{t/m}$

$W = 8.02^t$

$W_{HB} = 38.25^t$

· Bending Moment

$M_{center} = \frac{1}{8} \cdot w l^2 + \frac{1}{4} W l + W_{HB} (\frac{1}{2} l - 0.9)$

$= \frac{1}{8} \times 28.27 \times 8.4^2 + \frac{1}{4} \times 8.02 \times 8.4 + 38.25 (4.2 - 0.9)$

16.842

$= 392.41^{tm} \quad / 12.92 = 30.37^{t \cdot m/m}$

$S_o = \frac{1}{2} \cdot w \cdot l + W + W_{HB} (1.00 + 0.786 + 0.060)$

$= \frac{1}{2} \times 28.27 \times 8.4 + 8.02 + 38.25 \times 1.846$

$= 197.36^t \quad / 12.92 = 15.28^{t/m}$

Referance

a). Span 5.5 m

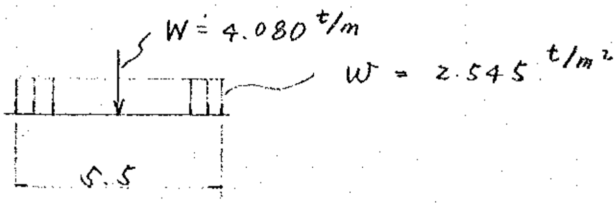
A) HA Loading

$W_{ds} = 0.080 \times 2.305 = 0.184$

$W_{do} = 0.400 \times 2.410 = 0.964$

live load $= 1.397$

$2.545 \ t/m^2$



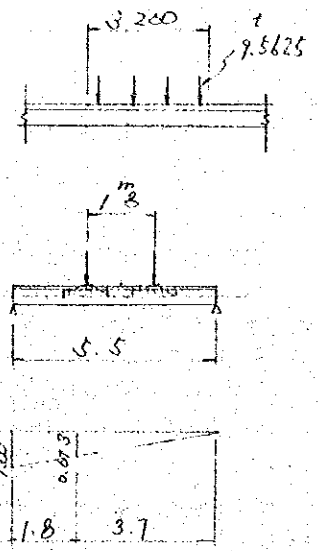
· Bending Moment $M = 1/8 \times 2.545 \times 5.5^2 + 1/4 \times 4.080 \times 5.5 = 15.23 \ tm/m$

· Shear Force $S_o = 1/2 \times 2.545 \times 5.5 + 4.080 = 11.08 \ t/m$

B) HB Loading

$W_d = 0.184 + 0.964 = 1.148 \ t/m^2$

HB Loading $4 \times 9.5625 / 3.2 = 11.953 \ t/m$



· Bending Moment

$M = \frac{1}{8} \times 1.148 \times 5.5^2 + 11.953 \times (2.75 - 0.9)$

$= 26.45 \ tm/m$

· shear Force

$S = \frac{1}{2} \times 1.148 \times 5.5 + 11.953 \ (1.00 + 0.673)$

$= 23.15 \ t/m$

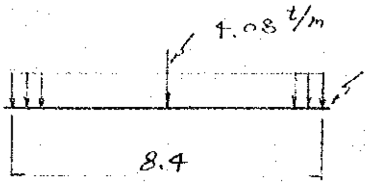
b) Span 8.4 ^{m}

A) HA Loading

$W_{d5} = 0.080 \times 2.305 = 0.184$

$W_{d0} = 0.650 \times 2.41 = 1.567$

$1.751 \; t/m^2$



· Bending Moment $M = 1/8 \times 2.822 \times 8.4^2 + 1/4 \times 4.08 \times 8.4 = 33.46 \; t\cdot m/m$

· Shear Force $S_0 = 1/2 \times 2.822 \times 8.4 + 4.08 = 15.93 \; t/m$

B) HB Loading

$W_d = 1.751 \; t/m^2$

HB Loading $4 \times 9.5625 / 3.2 = 11.953 \; t/m$

· Bending Moment

$M = 1/8 \times 1.751 \times 8.4^2 + 11.953 (4.2 - 0.9)$

$= 54.89 \; tm/m$

$S_0 = 1/2 \times 1.751 \times 8.4 + 11.953 (1.00 + 0.786 + 0.060)$

$= 29.42 \; t/m$

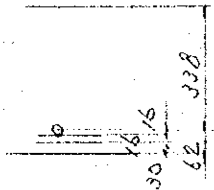
List of Sectional Force.

		M	S	M	S
Span 5.5	HA	12.08	8.79	15.23	11.08
	HB	12.58	10.12	(21.16) 26.45	(18.52) 23.15
Span 8.4	HA	28.84	13.73	33.46	15.93
	HB	30.37	15.28	(43.91) 54.89	(23.54) 29.42

4 Calculation of Section

a). Span 5.5^{m}

$$M = 21.16^{t\cdot m} \qquad S = 18.52^{t}$$



$$req\ As = \frac{2116000}{2300 \times 0.875 \times 33.8} = 31.11^{cm^2}$$

$$As = \Phi 25 - 15^{cm}\ c.to.c$$

$$= 4.91 \times 6.667 = 32.73^{cm^2}$$

$$d = 400 - (30 + 16 + 12.5) = 341.5^{mm} = 34.15^{cm}$$

$$np = \frac{15 \times 32.73}{100 \times 34.15} = 0.144 \qquad c = 5.62,\ s = 8.06$$

$$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{2116000}{100 \times 34.15^2} \times 5.62 = 102^{kg/cm^2}$$ → out

$$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 18.144 \times 8.06 \times 15 = 2194^{kg/cm^2}$$ 圧縮鉄筋

$$\tau = \frac{S}{bd'} = \frac{18520}{100 \times 40} = 4.6^{kg/cm^2}$$

b) Span 8.4^{m} $\qquad M = 43.91^{t\cdot m} \qquad S = 23.54^{t}$

$$req\ As = \frac{4391000}{2300 \times 0.875 \times 58.8} = 37.10^{cm^2}$$

$$As = \Phi 25 - 12.5^{cm}\ c.to.c$$

$$= 4.91 \times 8 = 39.28^{cm^2}$$

$$np = \frac{39.28 \times 15}{100 \times 59.15} = 0.100 \qquad c = 6.34,\ s = 11.4$$

$$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{4391000}{100 \times 59.15^2} \times 6.34 = 80^{kg/cm^2}$$

$$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 12.55 \times 11.4 \times 15 = 2146$$

$$\tau = \frac{S}{b \cdot d'} = \frac{23540}{100 \times 65} = 3.6$$

$As_1 = 32.73$ $\quad As' = 1/2\ As \cdot \Phi 25 - 30^{cm}$ c to c

$np = 0.144$ $\quad s = 8.1$, $c = 5.25$

$\sigma_c = 18.144 \times 5.25 = 95\ kg/cm^2$

depth → 0.900 → 0.950

$w = 0.080 \times 2.305 + 0.95 \times 2.41 = 1.268$

$M = 1/8 \times 1.268 \times 5.5^2 + 11.953\ (2.75 - 0.9)$

$= 26.91^{t \cdot m}$

$S = 1/2 \times 1.268 \times 5.5 + 11.953\ (1.00 + 0.673)$

$= 23.48^{t}$

25% increase overstress

$26.91 / 1.25 = 21.53^{t \cdot m}$

$23.48 / 1.25 = 18.78^{t}$

$req\ As = \dfrac{2153000}{2300 \times 0.875 \times 39.15} = 27.33$

$As = \Phi 25 - 15^{cm}$ c-to-c $= 32.73$

$np = \dfrac{15 \times 32.73}{100 \times 39.15} = 0.125$ $\quad c = 5.91$, $s = 9.30$

$\sigma_c = \dfrac{M}{b \cdot d^2} \cdot c = \dfrac{2153000}{100 \times 39.15^2} \times 5.91 = 83$

$\sigma_s = \dfrac{M}{b \cdot d^2} \cdot s \cdot n = 14.047 \times 9.30 \times 15 = 1960$

Calculation of Reaction.

$$w_d = 17.86 + 12.52 \times 0.05 \times 2.41 = 19.37\ ^{t/m}$$

Dead	R_d =	½ × 19.37 × 5.5	=	53.3 ton
HA Uniform	R_u =	½ × 10.99 × 5.5	=	30.2
HA Line	R_ℓ		=	32.1
Crowd	R_c =	½ × 0.765 × 5.5	=	2.1
HB	R_{HB} =	38.25 × (1.00 + 0.673)	=	64.0
⅓ HA uni	R_u =	½ × 2.747 × 5.5	=	7.6
⅓ HA lin	R_ℓ		=	8.0 t

HA total = 117.7 ton

HB total = 135.0 ton

b) Span 8.4 m

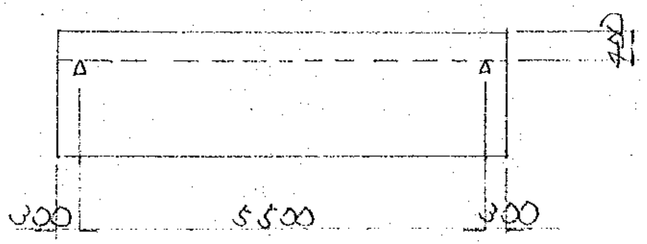
Dead	R_d =	½ × 25.40 × 8.4	=	106.7
HA uni	R_u =	½ × 8.43 × 8.4	=	35.4
HA Line	R_ℓ		=	32.1
Crowd	R_c =	½ × 0.77 × 8.4	=	3.2
HB	R_{HB} =	38.25 × 1.846	=	70.6
⅓ HA uni	R_u =	½ × 2.106 × 8.4	=	8.8
⅓ HA lin	R_ℓ		=	8.0

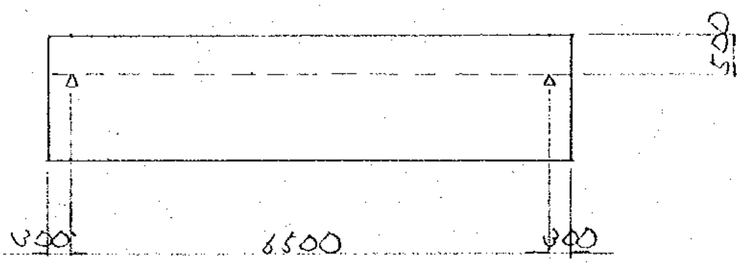
HA tatal = 177.4

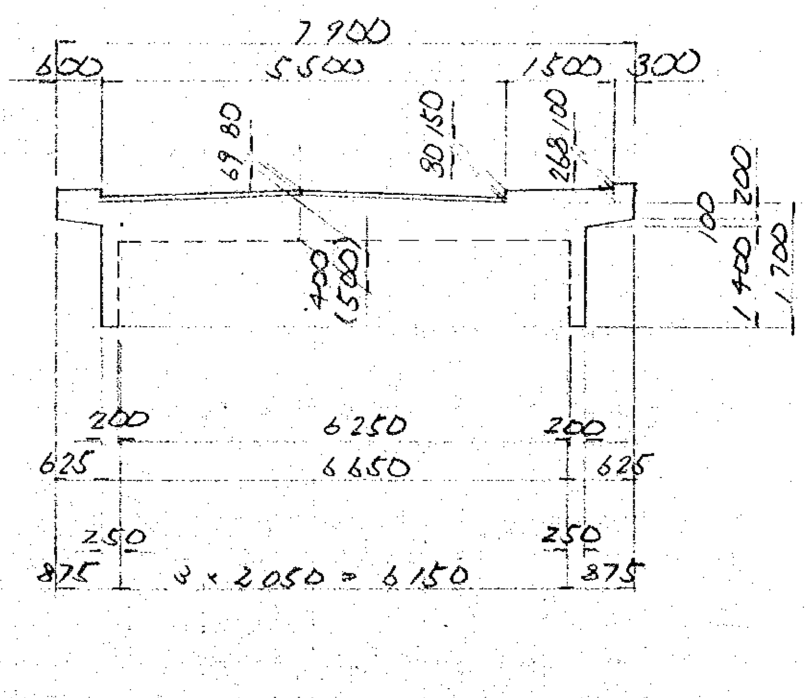
HB tatal = 197.3

§7 Coromandel O.V.

1. Dimension







2 Calculation of Load

1) Dead Load

Main slab	6.650 × 1.700 × 2.41	Wd_0	27.245
〃	6.250 × 1.300 × 2.41	Wd_1	−19.581
〃	(6.250 × 1.200) × 2.41	Wd_1'	(−18.075)
Contilever slab	1/2 × (0.2 + 0.3) × 0.625 × 2.41 × 2	Wd_2	0.753
side wolk	1/2 × (0.18 + 0.218) × 1.500 × 1.8	Wd_3	0.537
〃	0.05 × 1.500 × 2.41	Wd_4	0.181
Kerb (1)	0.230 × 0.60 × 2.41	Wd_5	0.333
〃 (2)	0.368 × 0.30 × 2.41	Wd_6	0.266
concreter	1/2 × 0.069 × 5.5 × 2.305	Wd_7	0.437
Pavement	5.5 × 0.08 × 2.305	Wd_8	1.014
Rail	0.112 t/m × 2	Wd_9	0.224
total			11.409 12.915

2). Live Load

U.D.L = 41.1 KN/m for span 5.5

31.5 KN/m 〃 〃 6.5

a). Span 5.5

$P_u = 1/3 \times 41.1 = 13.7\ KN/m^2 = 1.397\ t/m^2$

$P_l = 40\ KN/m = 4.080\ t/m$

$P_u' = 1.397 \times 5.5 = 7.686\ t/m$

$P_l' = 4.080 \times 5.5 = 22.44\ t$

crowd Load

$P_w = 5\ KN/m^2 = 0.51\ t/m^2$

$P_w' = 0.51 \times 1.5 = 0.765\ t/m$

b) Span 6.5

$P_u = 1/3 \times 31.5 = 10.5\ kN/m^2 = 1.071\ t/m^2$

$P_l = 40\ kN/m = 4.080\ t/m$

$P_u' = 1.071 \times 5.5 = 5.891\ t/m$

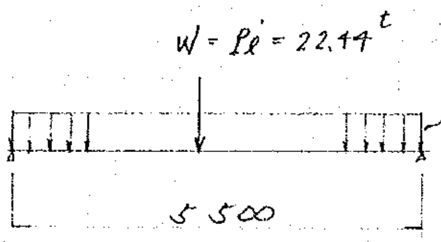
$P_l' = 4.080 \times 5.5 = 22.44\ t$

Crowd Load

$P_w' = \quad = 0.765\ t/m$

3) Calculation of Sectional Force

a) Span 5.5^m



$w = W_d + P_u' + P_w'$

$= 11.409 + 7.686 + 0.765$

$= 19.860\ t/m$

· Bending Moment

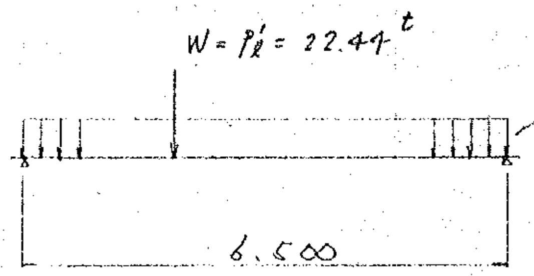
$M_{center} = \frac{1}{8} w l^2 + \frac{1}{4} W l$

$= 1/8 \times 19.860 \times 5.5^2 + 1/4 \times 22.44 \times 5.5 = 105.95\ tm$

· Shear Force

$S_0 = 1/2 \times wl + W = 1/2 \times 19.860 \times 5.5 + 22.44 = 77.06\ t$

b) Span 6.5 m



$w = w_d + P_u' + P_w'$

$= 12.915 + 5.891 + 0.765$

$= 19.571$ t

· Bending Moment.

$M_{center} = \frac{1}{8} \times 19.571 \times 6.5^2 + \frac{1}{4} \times 22.44 \times 6.5 = 139.82$ t·m

· Shear Force

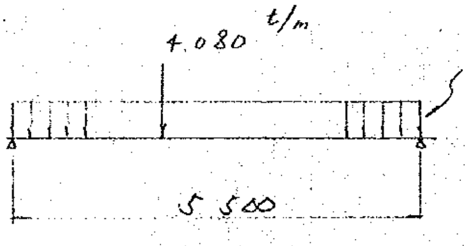
$S_0 = \frac{1}{2} \times 19.571 \times 6.5 + 22.44 = 86.05$ t

※ Referance.

slab width 1.0 m

Span 5.5 m

Dead Load	$W_{d0} = 0.400 \times 2.41$	=	0.964	t/m²
concrete	$W_{d7} = 0.069 \times 2.305$	=	0.159	
Pavement	$W_{d8} = 0.080 \times 2.305$	=	0.184	
		W_d =	1.307	t/m²



$w = W_d + P_u$

$= 1.307 + 1.397 = 2.704$ t/m²

· Bending Moment $M = \frac{1}{8} \times 2.704 \times 5.5^2 + \frac{1}{4} \times 4.080 \times 5.5 = 15.83$ t·m/m

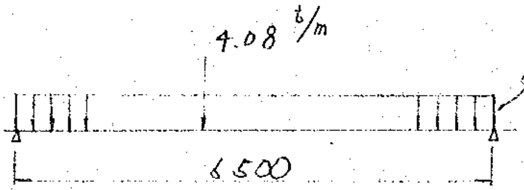
· Shear Force $S = \frac{1}{2} \times 2.704 \times 5.5 + 4.080 = 11.52$ t/m

Span 6.5 Dead Load main slab $Wd_0 = 0.500 \times 2.41 = 1.205$

Screeding concrete $Wd_1 =$ $= 0.159$

Pavement $Wd_8 =$ $= 0.184$

$Wd = 1.548$ t/m²



$w = Wd + P_u$

$= 1.548 + 1.071 = 2.619$ t/m²

· Bending Moment $M = 1/8 \times 2.619 \times 6.5^2 + 1/4 \times 4.08 \times 6.5 = 20.46$ tm/m

· Shear Force $S = 1/2 \times 2.619 \times 6.5 + 4.08 = 12.59$ t/m

Comparison Table

	M	M/6.65	S	S/6.65	M	S
Span 5.5	105.95	15.93	77.06	11.59	15.83	11.52
Span 6.5	139.82	21.03	86.05	12.94	20.46	12.59

3 Calculation of Section.

a) Span 5.5 ^{m}

$M = 15.93^{tm}$ ~ Req. As = $\frac{1593000}{2300 \times 0.875 \times 34.15}$

$S = 11.59^{t}$ = 23.18^{cm^2}

Used As $\Phi 25 - 15.0^{cm}$ c-to-c

$= 4.91 \times 6.667 = 32.73^{cm^2}$

$np = 15 \times \frac{32.73}{100 \times 34.15} = 0.144$ $c = 5.62$, $s = 8.06$

$\sigma_c = M/bd^2 \cdot c = \frac{1593000}{100 \times 34.15^2} \times 5.62 = 76.8$ kg/cm²

$\sigma_s = M/bd^2 \cdot s \cdot n = 13.659 \times 8.06 \times 15 = 1651$ "

$\tau = \frac{S}{b \cdot d} = \frac{11590}{100 \times 40} = 2.9$ kg/cm²

b) Span 6.5 ^{m}

$M = 21.03^{tm}$ ~ Req. As = $\frac{2103000}{2300 \times 0.875 \times 44.15}$

$S = 12.94^{t}$ = 23.67^{cm^2}

Used As = $\Phi 25 - 15.0^{cm}$ c-to-c

$= 4.91 \times 6.667 = 32.73^{cm^2}$

$np = 15 \times \frac{32.73}{100 \times 44.15} = 0.111$ $c = 6.14$, $s = 10.4$

$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{2103000}{100 \times 44.15^2} \times 6.14 = 66.3$ kg/cm²

$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 10.794 \times 10.4 \times 15 = 1684$ "

$\tau = \frac{S}{b \cdot d'} = \frac{12940}{100 \times 50} = 2.6$ kg/cm²

Calculation of Reaction

1) Span 5.5 m

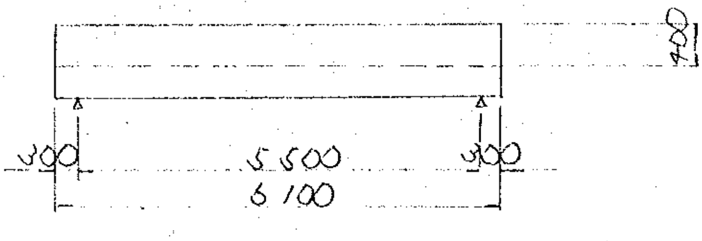
Dead Load	Rd = 1/2 × 11.409 × 5.5	=	31.4
HA Uniformed load	Rlu = 1/2 × 7.686 × 5.5	=	21.1
HA Line load	Rll =	=	22.4
Crowd load	Rc = 1/2 × 0.765 × 5.5	=	2.1
			77.0 t

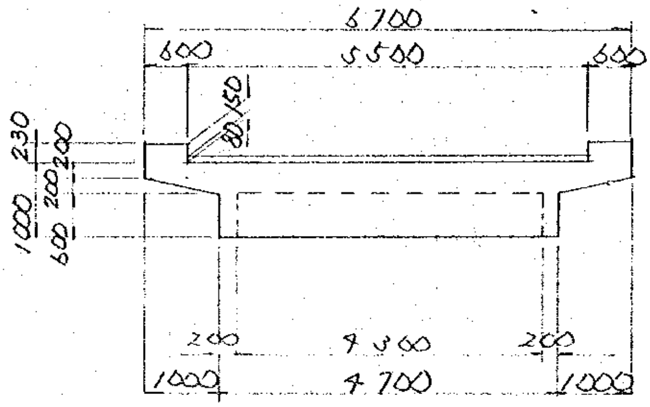
2) Span 6.5 m

Dead load	Rd = 1/2 × 12.915 × 6.5	=	42.0
HA Uniformed load	Rlu = 1/2 × 5.891 × 6.5	=	19.1
HA Line load	Rll	=	22.4
Crowd load	Rc = 1/2 × 0.763 × 6.5	=	2.5
			86.0 t

§8 No 22 O.V. Bridge

1. Dimension





Calculation of slab

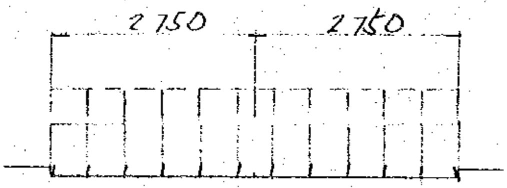
1. Calculation of Load

1) Dead Load

			w (t/m)
Main slab w_1	-4.300 × 0.600 4.700 × 1.00	× 2.41 × 2.41	-6.218 11.327
cantilever slab w_2	½ × (0.200 + 0.400) × 1.00	× 2.41 × 2	1.446
w_3	0.60 × 0.23	× 2.41 × 2	0.665
Pavement w_4	5.5 × 0.080	× 2.30	1.012
			3.232

gurad Fence $0.112\ t/m \times 2 = 0.224\ t/m$

2) Live load



$w_p = \frac{41.1}{3}\ kN/m = 13.7\ kN/m^2$

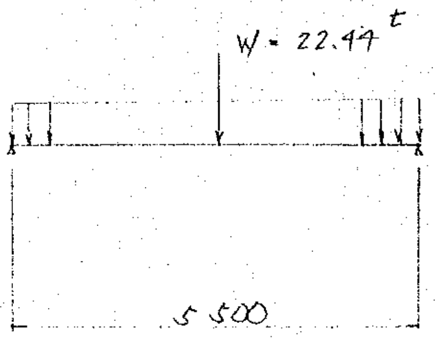
$= 1.397\ t/m^2$

$w_p' = 1.397 \times 5.5 = 7.69\ t/m$

$W_p = 40\ kN = 4.08\ t/m$

$W_p' = 4.08 \times 5.5 = 22.44\ t.$

2) Calculation of Sectional Forces



$w = 8.232 + 0.224 + 7.684 = 16.140 \ t/m$

- Bending Moment

$M_{center} = \frac{1}{8} \times w \cdot l^2 + \frac{1}{4} W l$

$= 1/8 \times 16.140 \times 5.5^2 + 1/4 \times 22.44 \times 5.5 = 91.884 \ t \cdot m$

- Shear Force

$S_o = 1/2 \times w \cdot l + W = \times$

$= 1/2 \times 16.140 \times 5.5 + 22.44 = 66.825 \ t$

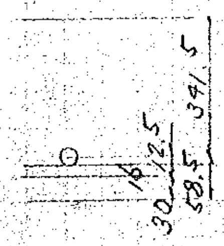
Sectional Forces For Unit Width

$M_{center} = 91.884 / 4.7 = 19.55 \ t \cdot m$

$S_o = 66.825 / 4.7 = 14.22 \ t$

Reinforcing Bar Required

$As = \frac{M}{\sigma_{sa} \, j \, d} = \frac{19.55 \times 10^5}{2300 \times 0.875 \times 34.15} = 28.45 \ cm^2$



$As = D25 \times 15^{cm}$ ctoc

$= 4.91 \times 6.667 = 32.73\ cm^2$

$np = 15 \times \frac{32.73}{100 \times 34.15} = 0.144$

$c = 5.62 \qquad s = 8.06$

$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{19.55 \times 10^5}{100 \times 34.15^2} \times 5.62 = 16.76 \times 5.62 = 94.2\ kg/cm^2$

$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 16.76 \times 8.06 \times 15 = 2027\ kg/cm^2$

$\tau = \frac{S}{b \cdot d} = \frac{14220}{100 \times 40} = 3.6\ kg/cm^2 < \tau_a\ 5.0\ kg/cm^2$

Minimum Required Reinforcement 0.18 % $b \times d$

Minimum Required Distribution Reinforcement

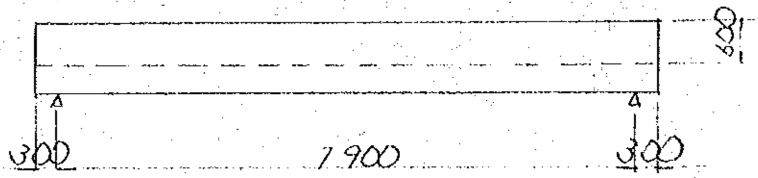
0.12 % ↑↑E

Calculation of Reaction

Refer to Shear force.

Dead Load	R_d	$= \frac{1}{2} \times (8.232 + 0.224) \times 5.5$	$= 23.3^t$
Uniform Live	R_{d1}	$= \frac{1}{2} \times 7.684 \times 5.5$	$= 21.1$
Line Live	R_{d2}	$=$	$= 22.4$
			66.8^t

span 7.9^m



Dead Load $\quad Wd = 10.305 + 0.224 = 10.529 \; t/m$

Live Load $\quad U.D.L = 31.5 \; kN/m$

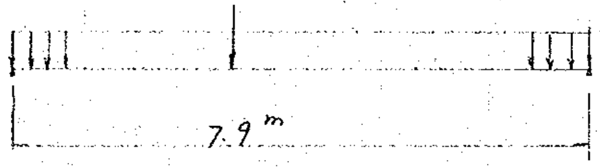
$wp = 1/3 \times 31.5 = 10.5 \; kN/m^2 = 1.071 \; t/m^2$

$wp' = 1.071 \times 5.5 = 5.89 \; t/m$

$Wp = 40 \; kN = 4.08 \; t/m$

$Wp' = 4.08 \times 5.5 = 22.44 \; t$

Calculation of Sectional Force



$w = 10.529 + 5.890$
$= 16.419 \; t/m$

Bending Moment

$M_{center} = 1/8 \cdot w \cdot l^2 + 1/4 \, Wl$

$= 1/8 \times 16.419 \times 7.9^2 + 1/4 \times 22.44 \times 7.9 = 172.33 \; tm$

$S_o = 1/2 \times w \cdot l + W$

$= 1/2 \times 16.419 \times 7.9 + 22.44 = 87.30 \; t$

Section Force for 4.7 m Width

$M_{center} = 1/4.7 \times 172.33 = 36.67\ ^{t\cdot m}$

$S_0 = 1/4.7 \times 87.30 = 18.57\ ^{t}$

$Req.\ A_s = \frac{M}{\sigma_{sa}\ j \cdot d} = \frac{3667000}{2300 \times 0.875 \times 54.15} = 33.65$

$A_s = \Phi 25 - 12.5^{cm}$ c.to.c

$= 39.28\ cm^2$

$np = \frac{39.28 \times 15}{100 \times 54.15} = 0.109$

$c = 6.18 \qquad s' = 10.6$

$\sigma_c = \frac{M}{b \cdot d^2} \cdot c = \frac{3667000}{100 \times 54.15^2} \times 6.18 = 77$

$\sigma_s = \frac{M}{b \cdot d^2} \cdot s \cdot n = 12.506 \times 10.6 \times 15 = 1988$

$\tau = \frac{S}{b \cdot d'} = \frac{18570}{100 \times 60} = 3.1$

Calculation of Reaction

Dead Load	$1/2 \times (10.305 + 0.224) \times 7.9$	=	41.6
Uniform Live	$1/2 \times 5.89 \times 7.9$	=	23.3
Line Live		=	22.4
			87.3 t.

2. R.C. Voided Slab Bridge (STA. 22 OV. BR)

CONTENTS

§§1 DESIGN CONDITION

§1. DESIGN CONDITION

TYPE	2 SPANS CONTINUANCE RC VOIDED SLAB BRIDE
BRIDGE LENGTH	31 650
GIRDER LENGTH	31 600
SPAN	2 x 15 500
WIDTH	5 500
LIVE LOAD	BS 153
	HA LOADING
	HB LOADING 37.5 UNITS
	FOOTWAY LOADING 5 KN/M^2
	VEHICLE COLLISION WITH GUARDRAIL ACCORDING TO NAARSA

ULTIMATE LOAD FACTORS

HA LOADING	1.5 D + 2.5 L
	2 (D + L)
HB LOADING	1.5 D + 2.0 L

§ 2. MATERIAL STRENGTH AND PERMISSIBLE STRESS

1. CONCRETE

MAIN SLAB

SPECIFIED WORKS CUBE STRENGTH

AT 28 DAYS — 30 N/mm^2 (306 kg/cm^2)

PERMISSIBLE COMPRESSIVE STRESS

BENDING COMPRESSION — 10 N/mm^2 (101 kg/cm^2)

SHEAR — 0.87 N/mm^2 (8.9 kg/cm^2)

2. REIN FORCEMENT

HOT ROLLED YIELD BARS

SPECIFIED CHARACTERISTIC STRENGTH

f_{su} = 410 N/m^2 (4180 kg/cm^2)

PERMISSIBLE TENSILE STRESS

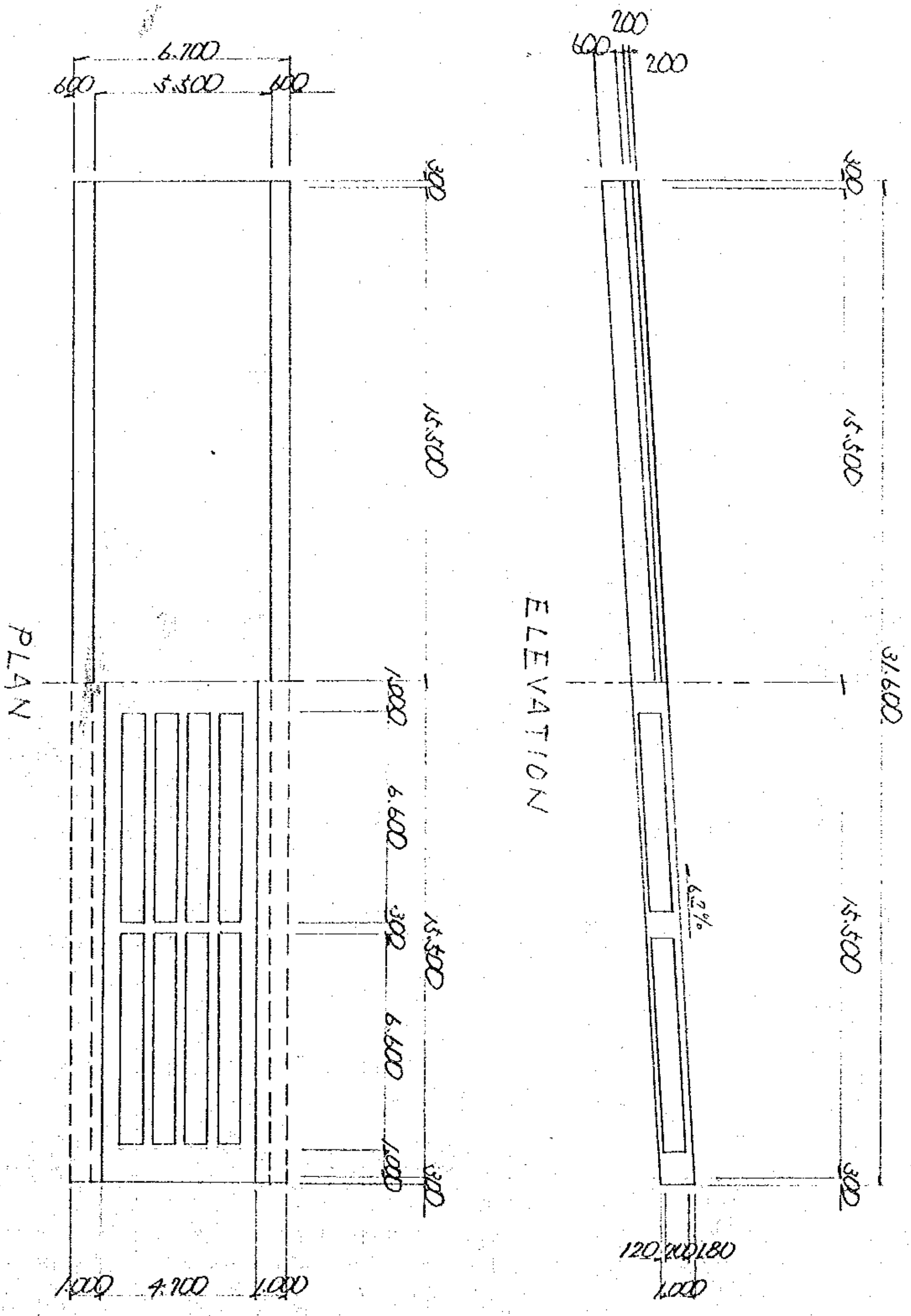
f_{sa} = 230 N/mm^2 (2340 kg/cm^2)

§§2 DESIGN OF MAIN SLAB

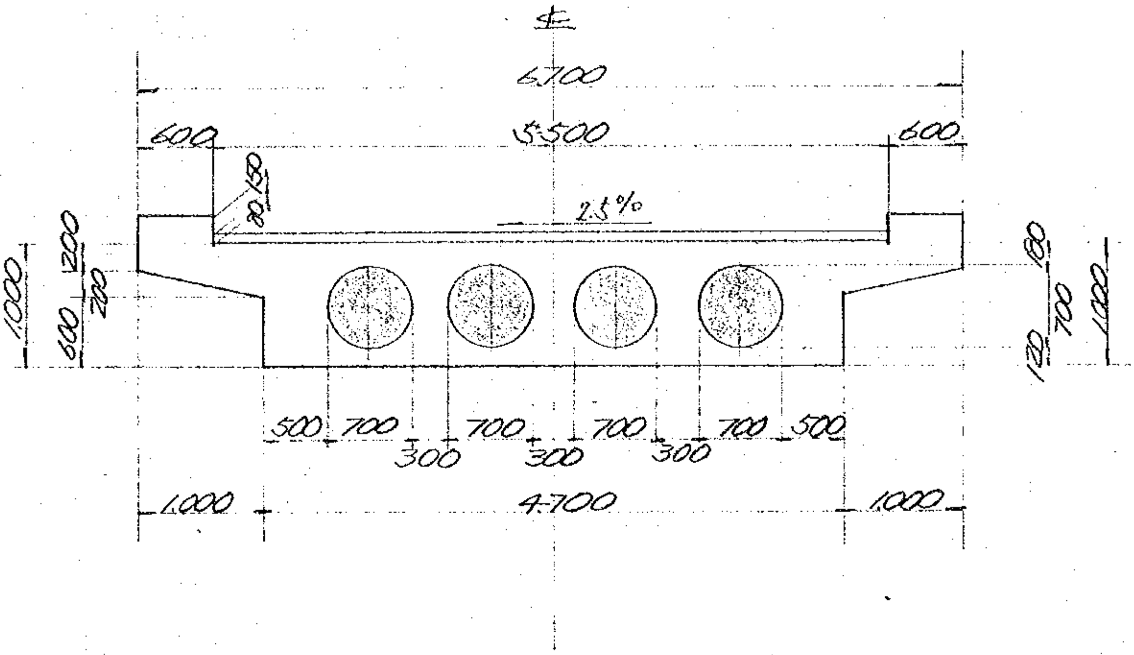
§1 PREPARATION

1. DIMENSIONS

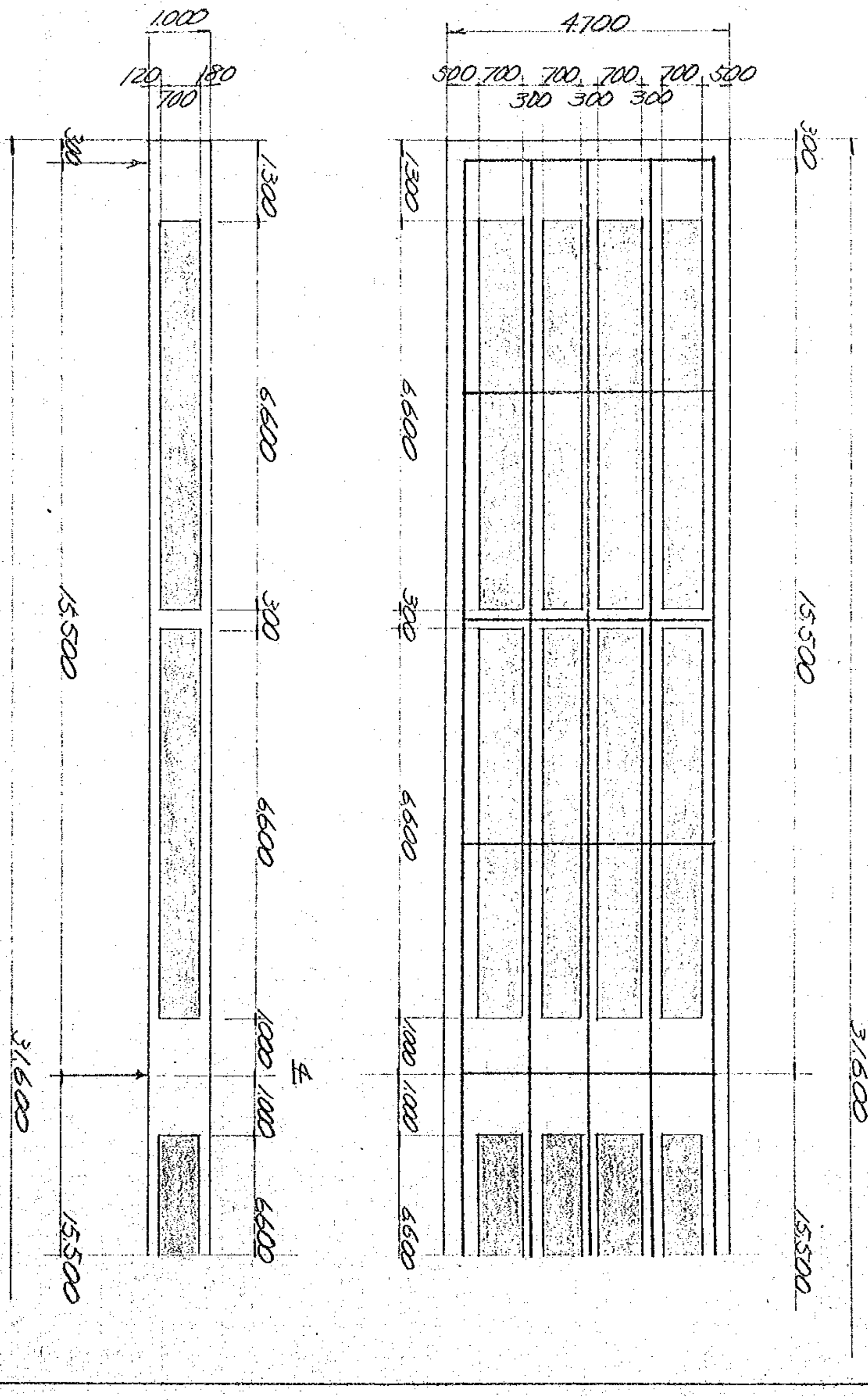
(1). ELEVATION



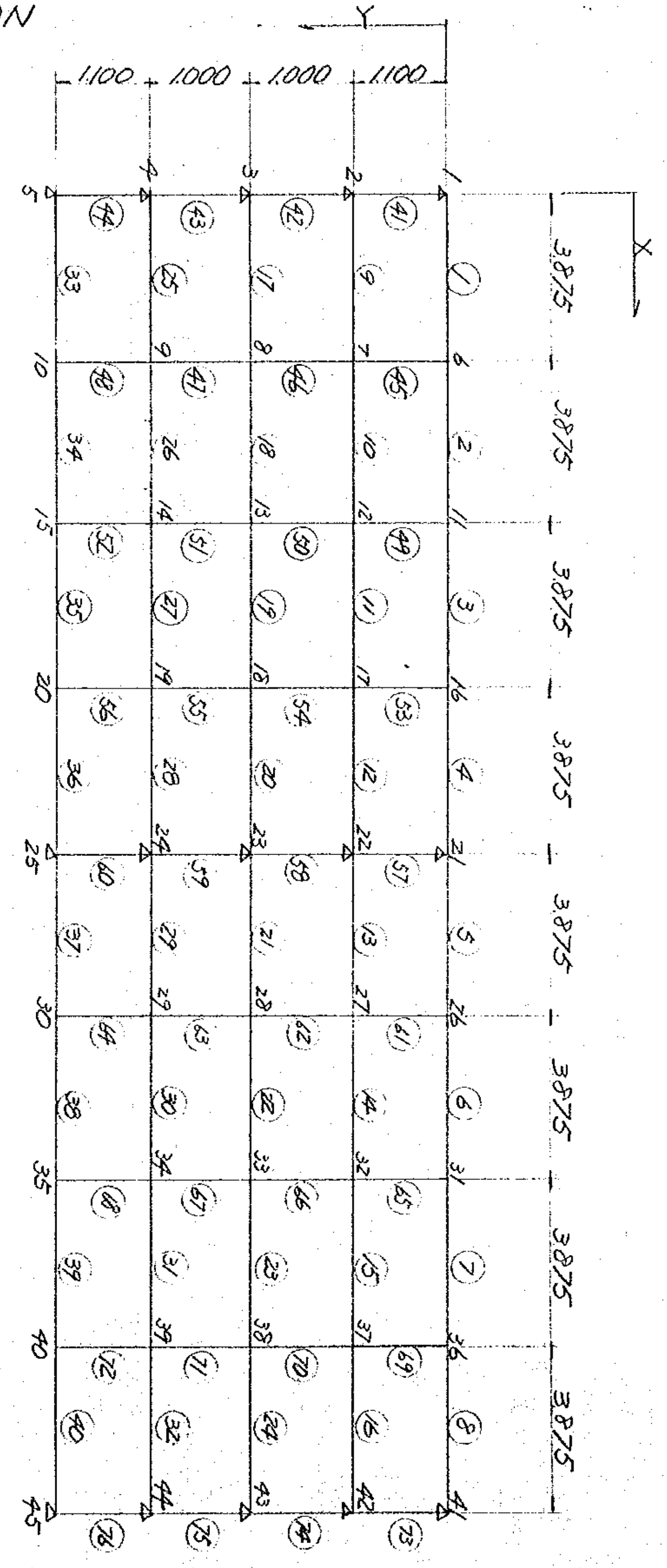
(2) SECTION.



(3) SLAB PLAN.


1,000
120
180
700
4,700
500 700 700 700 700 500
300 300 300
300
1,300
6,600
300
6,600
1,000
1,000
6,600
15,500
31,600
15,500

(4) SKELTON


Y
1,100
1,000
1,000
1,100
X
3,875
3,875
3,875
3,875
3,875
3,875
3,875
3,875

CO-ORDINATE

	X	Y		X	Y
1	0	0	24	15.500	3.100
2	0	1.100	25	15.500	4.200
3	0	2.100	26	19.375	0
4	0	3.100	27	19.375	1.100
5	0	4.200	28	19.375	2.100
6	3.875	0	29	19.375	3.100
7	3.875	1.100	30	19.375	4.200
8	3.875	2.100	31	23.250	0
9	3.875	3.100	32	23.250	1.100
10	3.875	4.200	33	23.250	2.100
11	7.750	0	34	23.250	3.100
12	7.750	1.100	35	23.250	4.200
13	7.750	2.100	36	27.125	0
14	7.750	3.100	37	27.125	1.100
15	7.750	4.200	38	27.125	2.100
16	11.625	0	39	27.125	3.100
17	11.625	1.100	40	27.125	4.200
18	11.625	2.100	41	31.000	0
19	11.625	3.100	42	31.000	1.100
20	11.625	4.200	43	31.000	2.100
21	15.500	0	44	31.000	3.100
22	15.500	1.100	45	31.000	4.200
23	15.500	2.100			

2. FIEXURAL AND TORTIONAL RIGIDITY.

MEMBER	I (m⁴)	J (m⁴)
①~⑧, ㉝~㊵	0.0671	0.1902
⑨~㉜	0.0725	0.1902
㊶~㊹, (73)~(76)	0.1610	0.1034
㊺~㊽, (53)~(56) (61)~(64), (69)~(72)	0.2048	0.0092
㊾~(52), (65)~(68)	0.2149	0.0138
(57)~(60)	0.2667	0.1869

CALCULATION OF I. AND J OF MAIN GIRDER

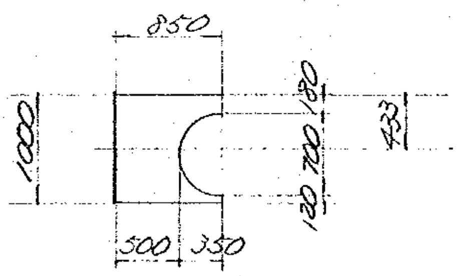
(1) CENTER OF GRAVITY IN TOTAL SECTION

	$b \times h = A$ m^2	y m	Ay m^2
①	$4.70 \times 1.00 = 4.700$	0.50	2.3500
②	$1.00 \times 0.20 = 0.200$	0.10	0.0200
③	$\frac{1.00 \times 0.20}{2} = 0.100$	0.267	0.0267
④	$1.00 \times 0.20 = 0.200$	0.10	0.0200
⑤	$\frac{1.00 \times 0.20}{2} = 0.100$	0.267	0.0267
⑥	$-0.35^2 \pi \times 4 = -1.539$	0.53	-0.8157
Σ	3.761		1.6277

$$y_G = \frac{1.6277}{3.761} = 0.433\ m$$

(2) CALCULATION OF I

EDGE GIRDER



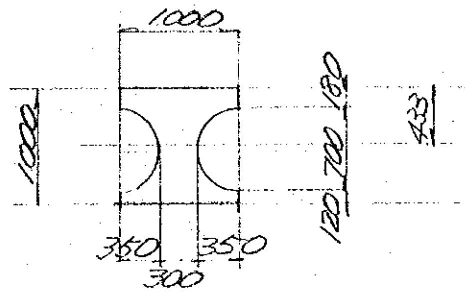
	$b \times h = A$ m^2	y m	Ay m^3	Ay^2 m^4	I_g m^4
①	$0.85 \times 1.00 = 0.850$	0.50	0.425	0.2125	0.0708
②	$-\frac{0.35^2 \times \pi}{2} = -0.192$	0.53	-0.102	-0.0539	-0.0059
Σ	0.658		0.323	0.1586	0.0649

$$y_G' = \frac{0.323}{0.658} = 0.491\ m \qquad \Delta y = 0.491 - 0.433 = 0.058\ m$$

$$I_G = 0.0649 + 0.1586 - 0.658 \times 0.491^2 = 0.0649\ m^4$$

$$I_0 = 0.0649 + 0.658 \times 0.058^2 = 0.0671\ m^4$$

INTERIOR GIRDER



	$b \times h = A$ m^2	y m	Ay m^3	Ay^2 m^4	I_G m^4
①	1.00 × 1.00 = 1.000	0.500	0.500	0.2500	0.0833
②	$-0.35^2 \times \pi$ = −0.385	0.530	−0.204	−0.1081	−0.0118
Σ	0.615		0.296	0.1419	0.0715

$y_G' = \frac{0.296}{0.615} = 0.481^{m}$ $\quad \Delta y = 0.481 - 0.433 = 0.048^{m}$

$I_G = 0.1419 + 0.0715 - 0.615 \times 0.481^2 = 0.0711^{m^4}$

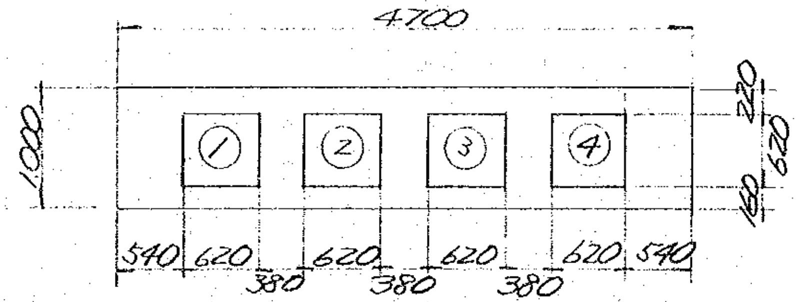
$I_0 = 0.0711 + 0.615 \times 0.048^2 = 0.0725^{m^4}$

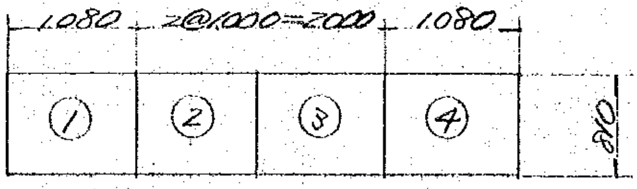
(3) TORSIONAL RIGIDITY J

AREA OF HOLLOW CIRCLE $A = 0.35^2 \pi = 0.385^{m^2}$

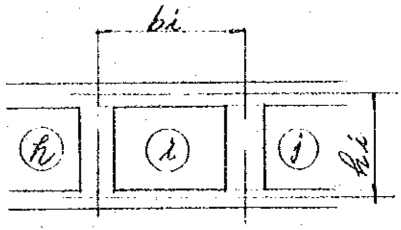
EQUIVALENT SQUARE $a = \sqrt{0.385} = 0.620^{m}$

$\Delta b = (0.700 - 0.620) \times 1/2 = 0.040^{m}$





$$GT = 2G\sum_{i=1}^{n} X_i F_i$$



	X_1	X_2	X_3	X_4	= A
①	a_{11}	a_{12}			$2F_1$
②	a_{21}	a_{22}	a_{23}		$2F_2$
③		a_{32}	a_{33}	a_{34}	$2F_3$
④			a_{43}	a_{44}	$2F_4$

WHERE

$$a_{ii} = \oint_i \frac{ds}{t}$$

$$a_{ij} = -\oint_{ij} \frac{ds}{t} = a_{ji} \quad (i \neq j)$$

$$a_{11} = \frac{0.810}{0.540} + \frac{0.810}{0.380} + \frac{1.080}{0.220} + \frac{1.080}{0.160}$$

$$= 1.500 + 2.132 + 4.909 + 6.750 \qquad = 15.291$$

$$a_{22} = a_{33} = \frac{0.810 \times 2}{0.38} + \frac{1.000}{0.220} + \frac{1.000}{0.160}$$

$$= 4.263 + 4.545 + 6.250 \qquad = 15.058$$

$$a_{12} = a_{21} = -\frac{0.810}{0.380} \qquad = -2.132$$

$$F_i = b_i h_i$$

$$F_1 = 1.08 \times 0.810 = 0.875 \qquad 2F_1 = 2 \times 0.875 = 1.750$$

$$F_2 = 1.00 \times 0.810 = 0.810 \qquad 2F_2 = 2 \times 0.810 = 1.620$$

	X_1	X_2	X_3	X_4	= A
①	15.291	−2.132			1.750
②	−2.132	15.058	−2.132		1.620
③		−2.132	15.058	−2.132	1.620
④			−2.132	15.291	1.750

$X_1 = X_4 = 0.1350$

$X_2 = X_3 = 0.1476$

$J = 2\sum_{i=1}^{n} X_i F_i = 2\{0.1350 \times 0.875 \times 2 + 0.1476 \times 0.810 \times 2\}$

$= 2 \times (0.2363 + 0.2391) = 0.9508$

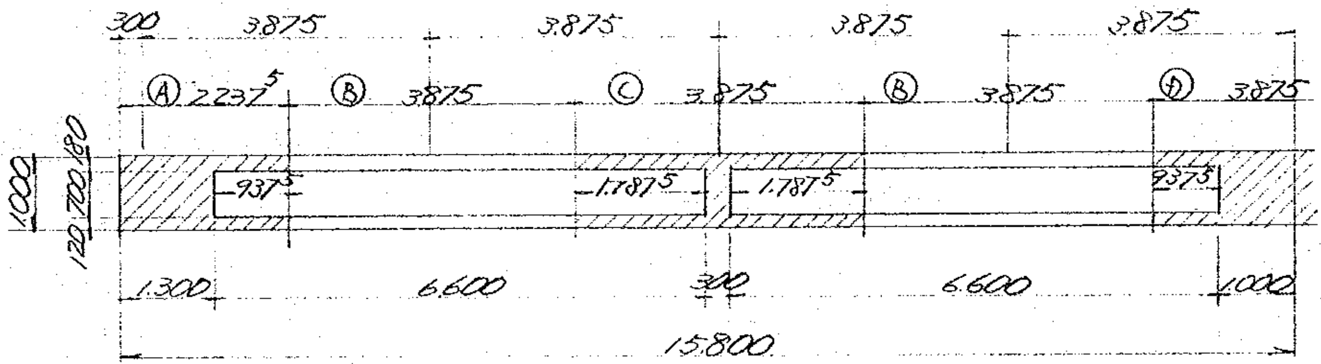
TORSIONAL RIGIDITY PER A MAIN GIRDER

$J = \frac{J}{n} = \frac{0.9508}{5} = 0.1902\ m^4$

3 CALCULATION OF I AND J OF TRANSVERSE BEAM

(1) CALCULATION OF I

i) CENTER OF GRAVITY IN TOTAL SECTION

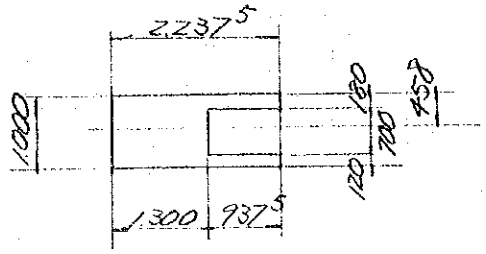


	$b \times h = A$ m^2	y m	Ay m^3
①	15.80 × 0.18 = 2.844	0.090	0.256
②	〃 × 0.12 = 1.896	0.940	1.782
③	2.60 × 0.70 = 1.820	0.530	0.965
Σ	6.560		3.003

$y_G = \frac{3.003}{6.560} = 0.458\ m$

ii) CALCULATION OF I

Ⓐ



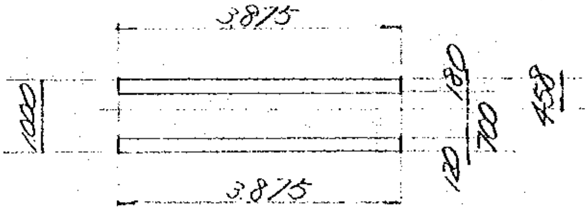
	$b \times h = A$ m^2	y m	Ay m^3	Ay^2 m^4	I_G m^4
①	$2.237^5 \times 1.00 = 2.238$	0.50	1.119	0.5595	0.1865
②	$-0.937^5 \times 0.70 = -0.656$	0.53	−0.348	−0.1843	−0.0268
Σ	1.582		0.771	0.3752	0.1597

$y_G = \frac{0.771}{1.582} = 0.487^{m}$ $\quad \Delta y = 0.487 - 0.458 = 0.029^{m}$

$I_G = 0.1597 + 0.3752 - 1.582 \times 0.487^2 \qquad = 0.1597^{m^4}$

$I_0 = 0.1597 + 1.582 \times 0.029^2 \qquad = 0.1610^{m^4}$

Ⓑ



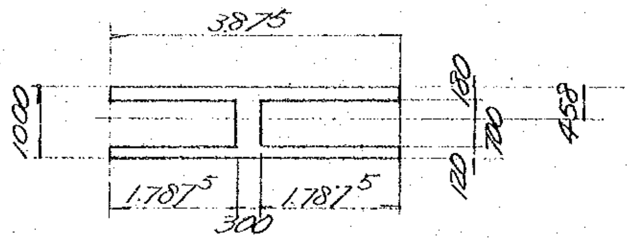
	$b \times h = A$ m^2	y m	Ay m^3	Ay^2 m^4	I_G m^4
①	$3.875 \times 1.00 = 3.875$	0.50	1.938	0.9688	0.3229
②	$-3.875 \times 0.70 = -2.713$	0.53	−1.438	−0.7621	−0.1108
Σ	1.162		0.500	0.2067	0.2121

$y_G = \frac{0.500}{1.162} = 0.430^{m}$ $\quad \Delta y = 0.458 - 0.430 = 0.028^{m}$

$I_G = 0.2121 + 0.2067 - 1.162 \times 0.430^2 \qquad = 0.2039^{m^4}$

$I_0 = 0.2039 + 1.162 \times 0.028^2 \qquad = 0.2048^{m^4}$

Ⓒ



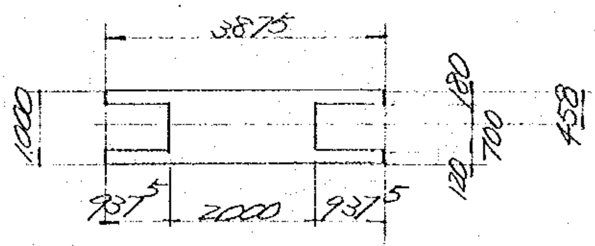
	b × h = A (m^2)	y (m)	Ay (m^3)	Ay^2 (m^4)	I_G (m^4)
①	3.875 × 1.00 = 3.875	0.50	1.938	0.9688	0.3229
②	−3.575 × 0.70 = −2.503	0.53	−1.327	−0.7031	−0.1022
Σ	1.372		0.611	0.2657	0.2207

$y_G = \frac{0.611}{1.372} = 0.445^{m}$ $\quad \Delta y = 0.458 - 0.445 = 0.013^{m}$

$I_G = 0.2207 + 0.2657 - 1.372 \times 0.445^2 \qquad = 0.2147^{m^4}$

$I_0 = 0.2147 + 1.372 \times 0.013^2 \qquad = 0.2149^{m^4}$

Ⓓ



	b × h = A (m^2)	y (m)	Ay (m^3)	Ay^2 (m^4)	I_G (m^4)
①	3.875 × 1.00 = 3.875	0.50	1.938	0.9688	0.3229
②	−1.875 × 0.70 = −1.313	0.53	−0.696	−0.3688	−0.0536
Σ	2.562		1.242	0.6000	0.2693

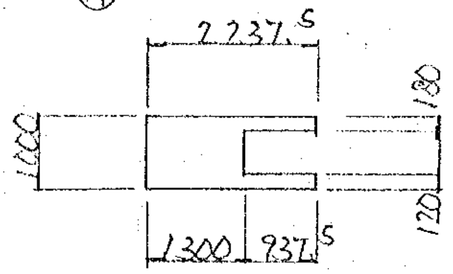
$y_G = \frac{1.242}{2.562} = 0.485^{m}$ $\quad \Delta y = 0.485 - 0.485 = 0^{m}$

$I_G = 0.2693 + 0.6000 - 2.562 \times 0.485^2 \qquad = 0.2667^{m^4}$

$I_0 = I_G \qquad = 0.2667^{m^4}$

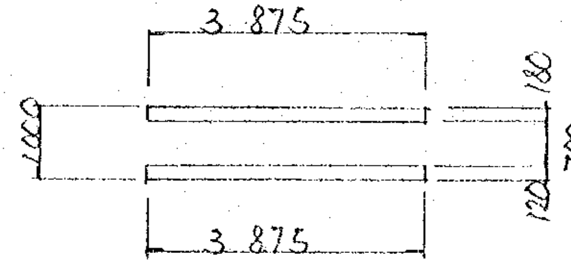
(2) CALCULATION OF TORSIONAL RIGIDITY

Ⓐ



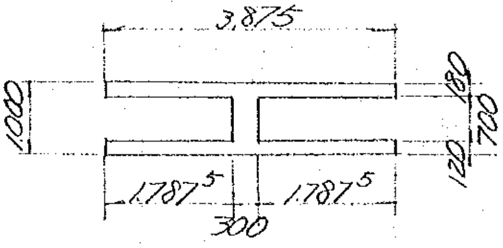
B (m)	t (m)	B/t	β	$\beta \cdot B \cdot t^3$ (m⁴)
2.237.5	0.18	12.431	0.312	0.0041
1.300	0.70	1.857	0.220	0.0981
2.237.5	0.12	18.646	0.312	0.0012
Σ				0.1034

Ⓑ



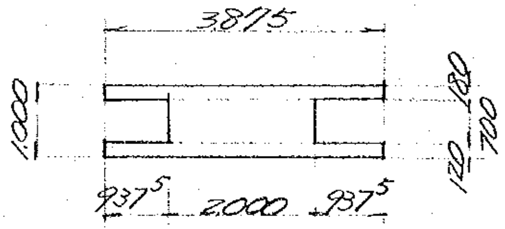
B (m)	t (m)	B/t	β	$\beta \cdot B \cdot t^3$ (m⁴)
3.875	0.18	21.528	0.312	0.0071
3.875	0.12	32.292	0.312	0.0021
				0.0092

Ⓒ



B m	t m	B/t	β	βBt³ m⁴
3875	0.18	21.528	0.312	0.0071
0.70	0.30	2.333	0.242	0.0046
3.875	0.12	32.292	0.312	0.0021
Σ				0.0138

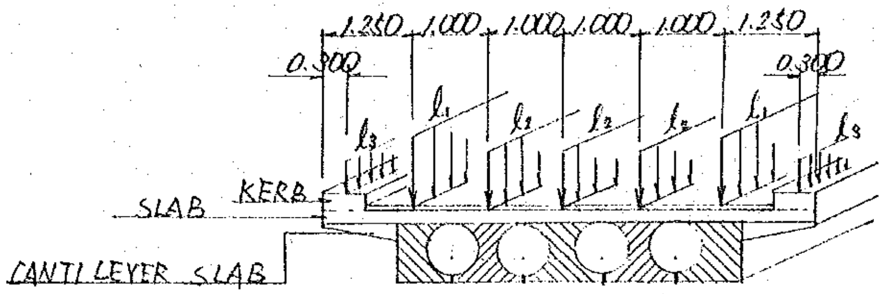
Ⓓ



B m	t m	B/t	β	βBt³ m⁴
3875	0.18	21.528	0.312	0.0071
2,000	0.70	2.857	0.259	0.1777
3.875	0.12	32.292	0.312	0.0021
Σ				0.1869

3. DEAD LOAD

1). LINE LOAD

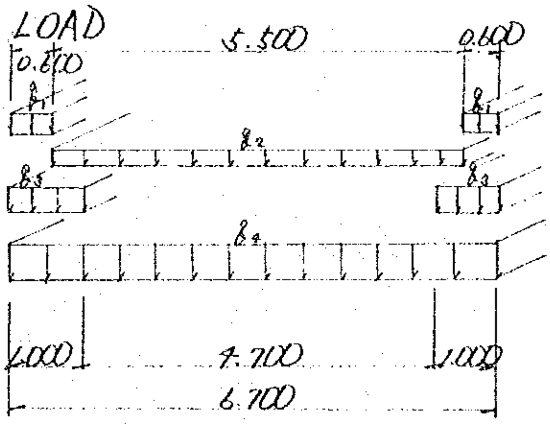


$l_1 = (0.658 - 0.180 \times 0.850) \times 23.6 = 11.908$ KN/m] MAIN BEAM

$l_2 = (0.615 - 0.180 \times 1.000) \times 23.6 = 10.270$ "] MAIN BEAM

$l_3 = 1.100$ KN/m HAND RAIL

2). UNIFORM LOAD



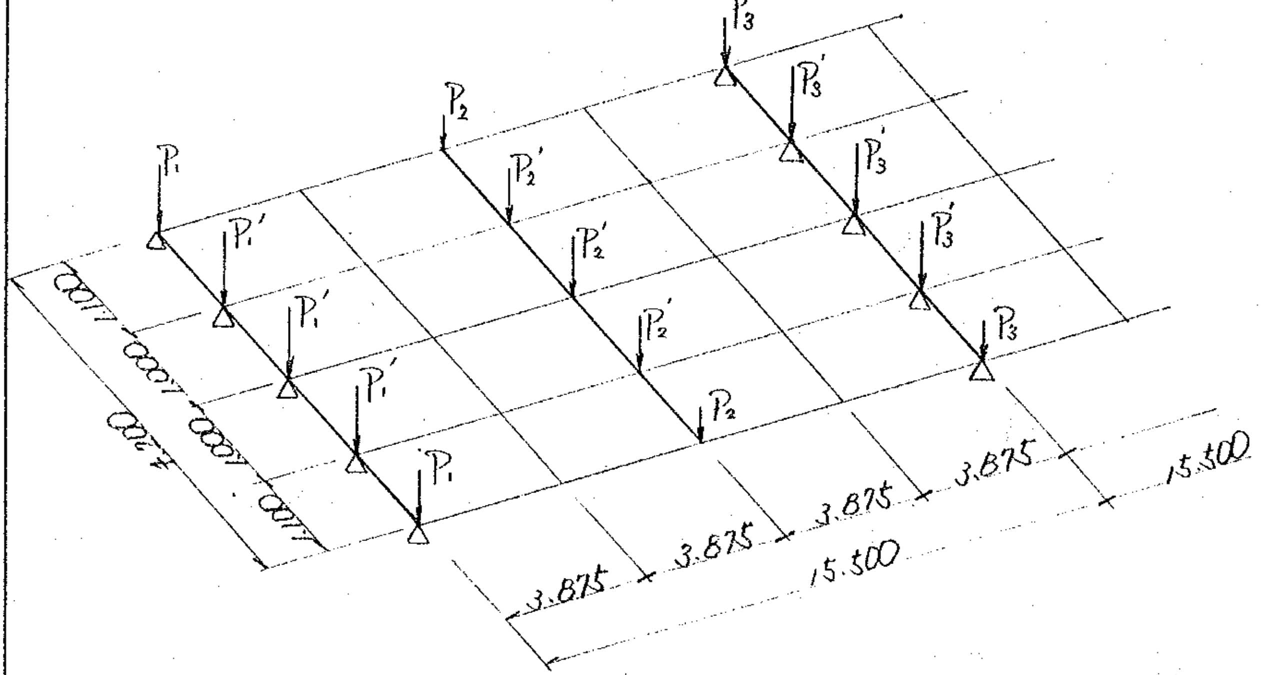
$g_1 = 0.230 \times 23.6 = 5.428$ KN/m² KERB.

$g_2 = 0.080 \times 22.6 = 1.808$ KN/m² PAVEMENT.

$g_3 = \frac{1}{2} \times (0.220 + 0.020) \times 23.6 = 2.832$ KN/m² CANTILEVER SLAB

$g_4 = 0.180 \times 23.6 = 4.248$ KN/m² SLAB.

3). CONCENTRATE LOAD
(CROSS BEAM)



$$P_1 = \pi \times 0.350^2 \times 1.300 \times 23.6 \times 1/2 = 5.909 \text{ KN}$$

$$P_1' = \pi \times 0.350 \times 1.300 \times 23.6 = 11.807 \text{ "}$$

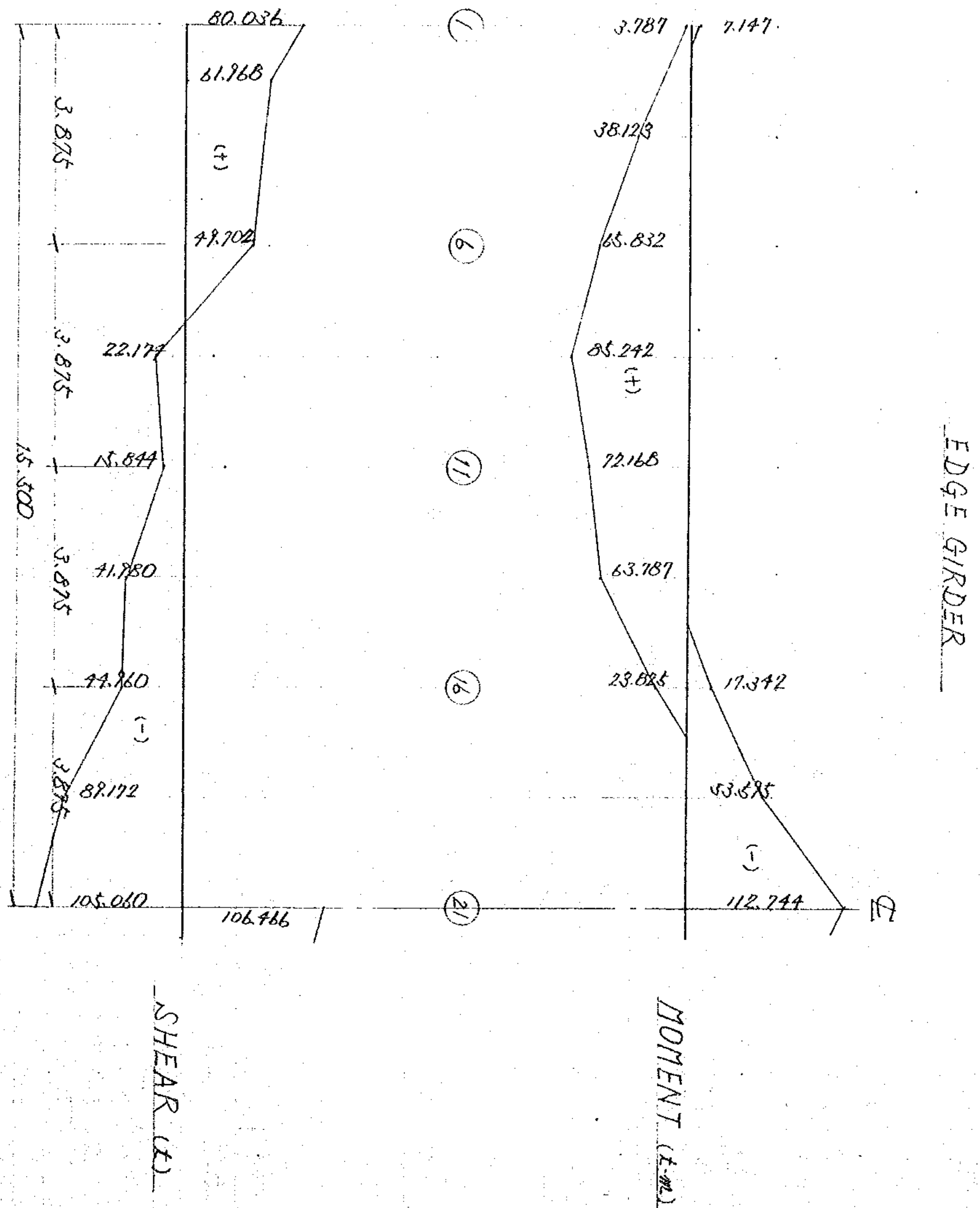
$$P_2 = \pi \times 0.350 \times 0.300 \times 23.6 \times 1/2 = 1.362 \text{ "}$$

$$P_2' = \pi \times 0.350 \times 0.300 \times 23.6 = 2.725 \text{ "}$$

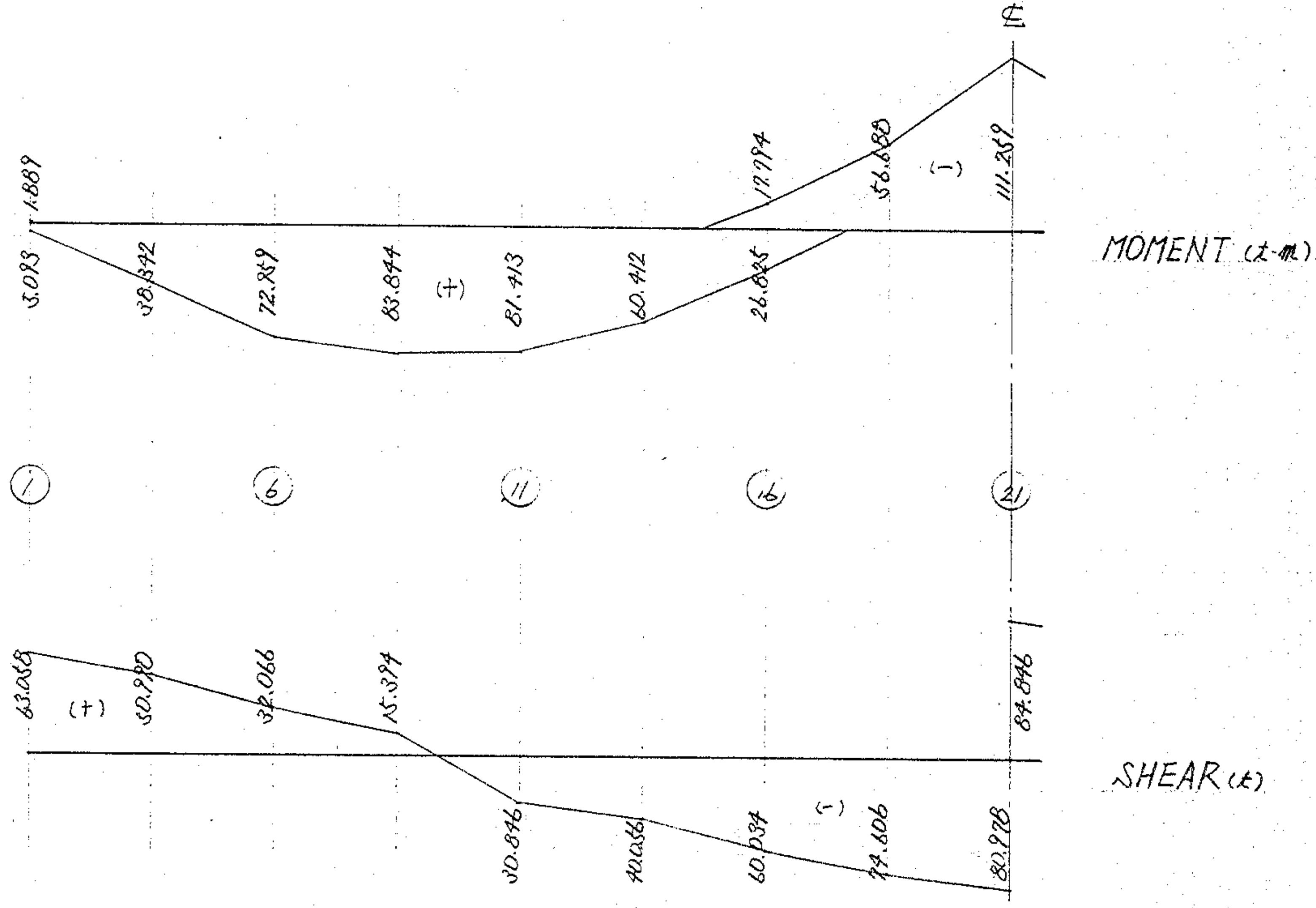
$$P_3 = \pi \times 0.350 \times 2.000 \times 23.6 \times 1/2 = 9.082 \text{ "}$$

$$P_3' = \pi \times 0.350 \times 2.000 \times 23.6 = 18.165 \text{ "}$$

§ 2 DRAWING OF SECTIONAL FORCE DIAGRAM

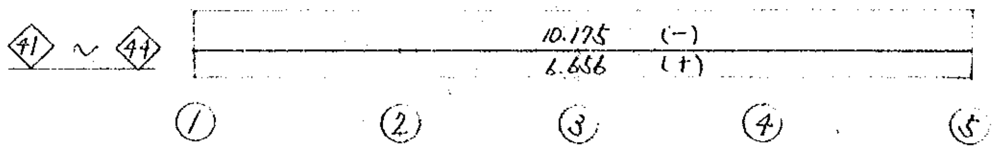


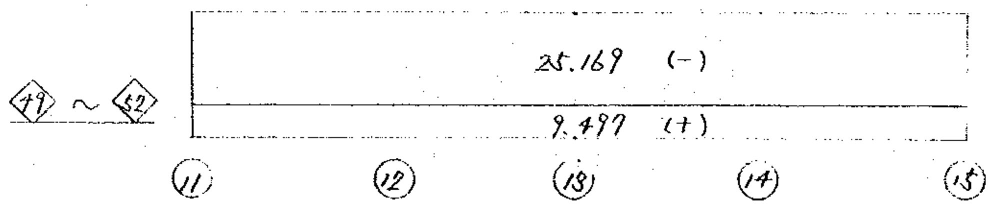
INTERIOR GIRDER

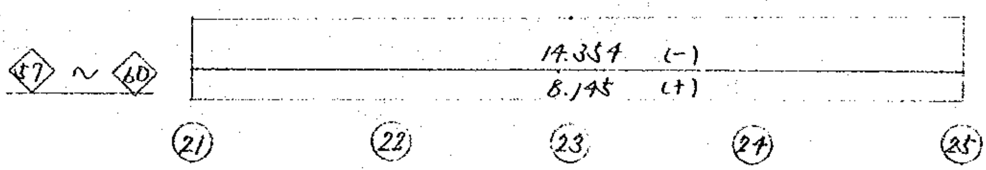


CROSS BEAM

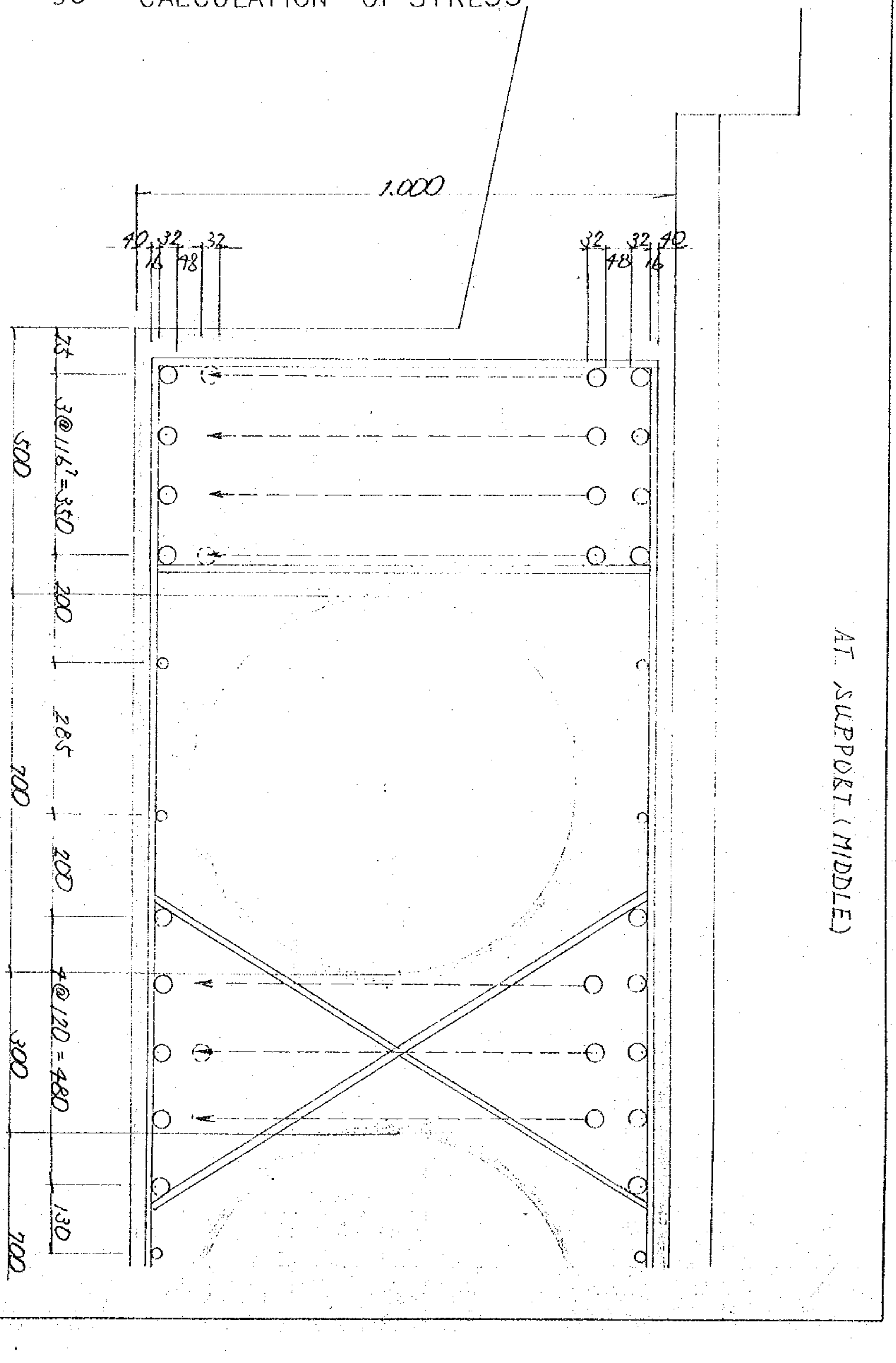
MOMENT (t·m)







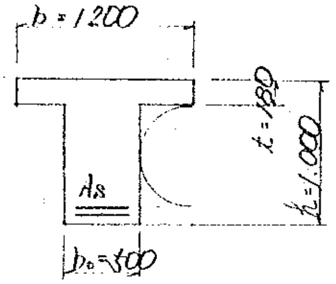
§3 CALCULATION OF STRESS



1. DESIGN OF MAIN GIRDER

(1) EDGE GIRDER ⟨1⟩ ~ ⟨8⟩ AND ⟨33⟩ ~ ⟨40⟩

1) AT MIDSPAN



$M = 85.242 \ t\cdot m$

$d' = \frac{22 \times 4 + 15.2 \times 2}{4 + 2} = 9.9 \ cm$

$d = h - d' = 100 - 9.9 = 90.1 \ cm$

$A_s = 6 - \phi 32 = 8 \times 8.04 = 48.24 \ cm^2$

$np = \frac{15 \times 48.24}{120 \times 90.1} = 0.0699$

$x = \frac{n \cdot d \cdot A_s + b t^2}{n A_s + b t} = 36.07 \ cm$

NEUTRAL AXIS EXSIT AT WEB

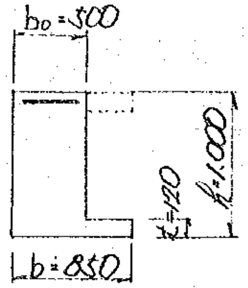
$k = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = 0.333$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.914$

$\sigma_s = \frac{M}{A_s \cdot j \cdot d} = \frac{85.242 \times 10^5}{48.24 \times 0.914 \times 90.1} = 2146 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$

$\sigma_c = \frac{k}{n(1-k)} \sigma_s = \frac{0.333}{15 \times (1 - 0.333)} \times 2146 = 71.4 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$

2) AT SUPPORT



$M = 101.470\ t\cdot m \quad (112.744 \times 0.90 = 101.470)$

$d' = \dfrac{7.2\times4 + 15.2\times4}{4+4} = 11.2\ cm$

$d = 100 - 11.2 = 88.8\ cm$

$A_s = 8 - \Phi32 = 8\times8.04 = 64.32\ cm^2$

$$x = -\frac{t(b-b_0)+nA_s}{b_0} + \sqrt{\left\{\frac{t(b-b_0)+nA_s}{b_0}\right\}^2 + \frac{t^2(b-b_0)+2nA_s d}{b_0}}$$

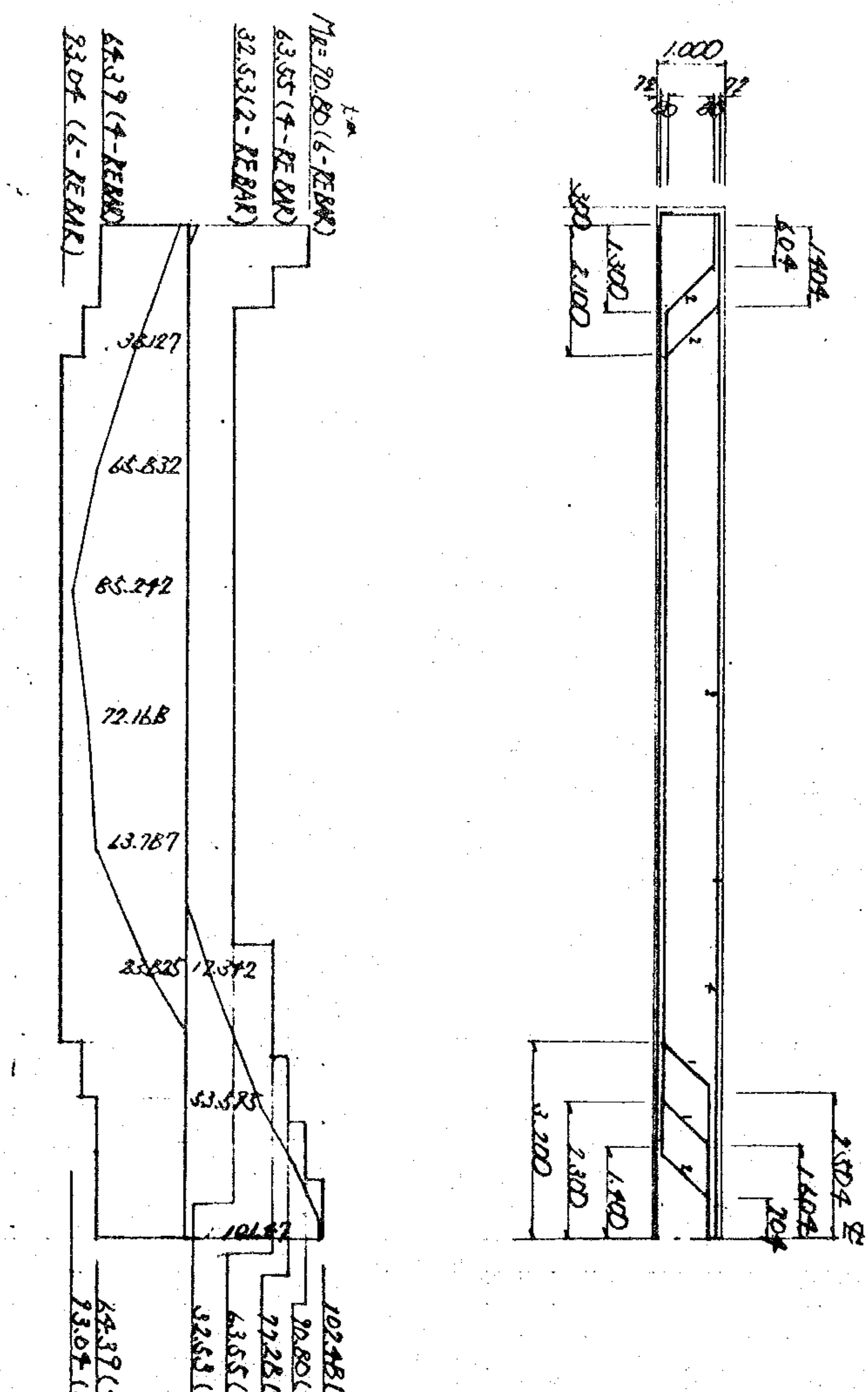
$= 37.84\ cm$

$$I = \frac{1}{3}\left\{bx^3-(b-b_0)(x-t)^3\right\} + nA_s\cdot(d-x)^2$$

$= 3839369\ cm^4$

$$\sigma_c = \frac{M}{I}x = \frac{101.47\times10^5}{3839369}\times37.84 = 100\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$$

$$\sigma_s = \frac{nM}{I}(d-x) = \frac{15\times101.47\times10^5}{3839369}\times(88.8-37.84) = 2020\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$$


Mr=90.80(6-REBAR)
63.55(4-REBAR)
32.53(2-REBAR)
64.39(4-REBAR)
93.04(6-REBAR)
38.127
65.832
85.242
72.168
43.787
23.825
12.342
90.80(6-REBAR)
77.28(5-REBAR)
63.55(4-REBAR)
32.53(2-REBAR)
64.39(4-REBAR)
93.04(6-REBAR)
1.000
1.300
2.100
3.200
2.300
1.400

3) CALCULATION OF SHEAR STRESS

i). $\tau = \dfrac{S}{b \cdot d} = \dfrac{S}{50 \times 90.1}$

	SHEAR (t)	SHEAR STRESS (kg/cm²)
1	105.060	22.40
2	89.172	19.01
3	44.960	9.59
4	41.930	8.95
5	15.844	3.38

ii). RESISTIBLE SHEAR FORCE

$$V = \frac{0.87 \cdot f_{sy} \cdot A_{sv} \cdot d}{S_0} + V_c$$

V ; RESISTIBLE SHEAR FORCE

$V_c = \upsilon_c \cdot b \cdot d$

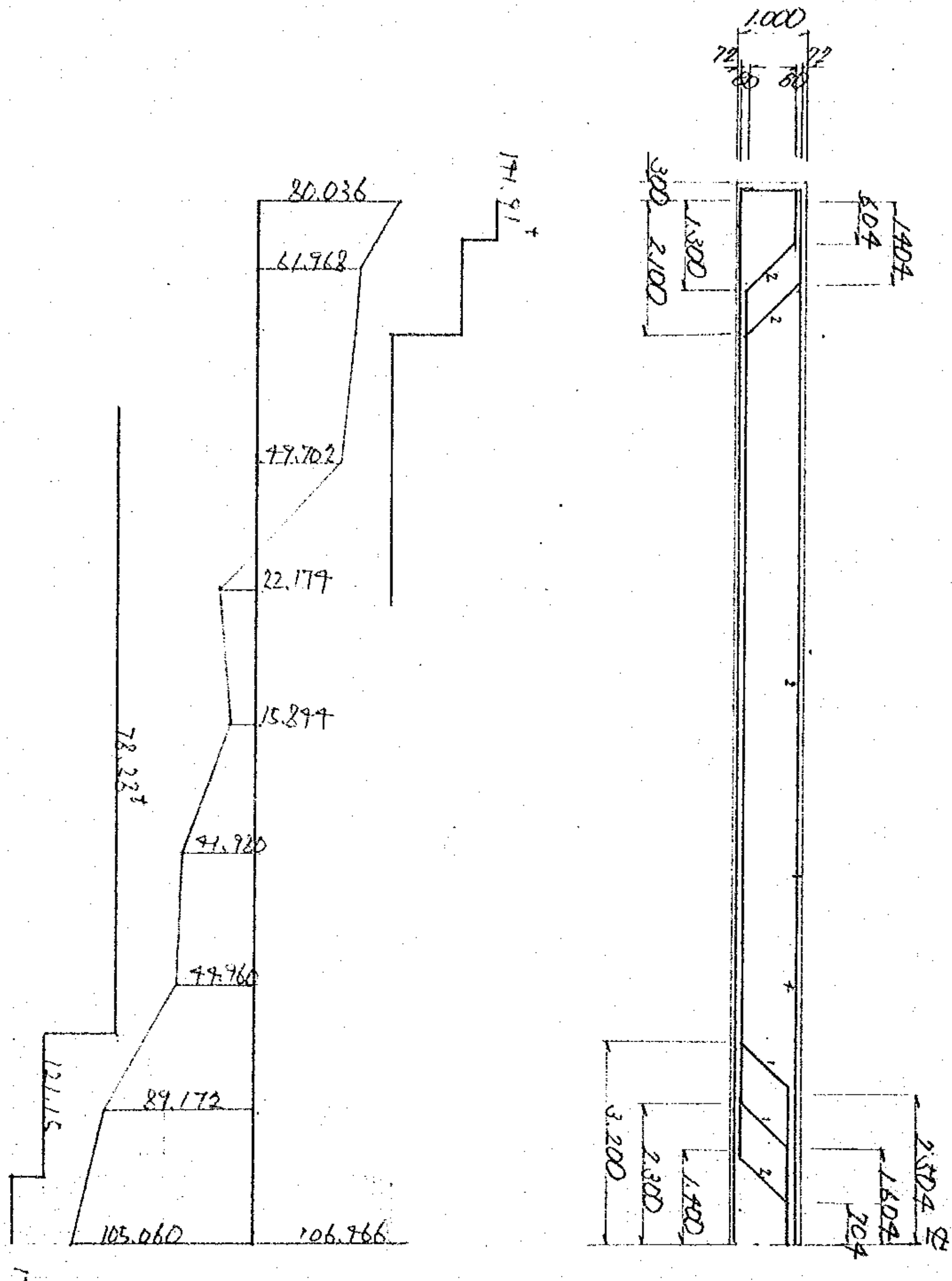
υ_c ; ULTIMATE SHEAR STRESS

S_0 ; THE SPACING OF REINFORCING BAR

A_{sv} ; CROSS SECTION AREA OF REINFORCING BAR

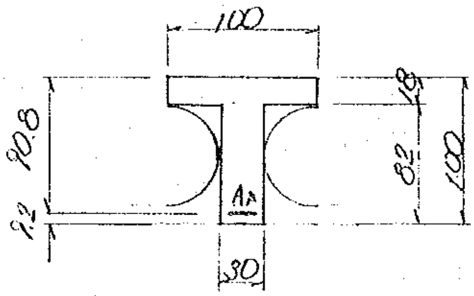
f_{sy} ; CHARACTERISTIC STRENGTH OF REINFORCING BAR. 4180 kg/cm^2

	A_c (cm²)	υ_c (kg/cm²)	V_c (t)	A_{sv} (cm²/m)	V (t)
1	64.32	6.65	50.95	Φ16 ctc 150 26.800	141.91
2	48.24	7.28	32.80	Φ16 ctc 300 Φ32 ctc 900	121.15
3	〃	〃	〃	Φ16 ctc 300 13.400	78.28
4	〃	〃	〃	〃	〃
5	〃	〃	〃	〃	〃


80.036
61.968
49.702
22.174
15.894
41.980
49.960
89.172
105.060
106.966
78.22t
171.91t
12.115
171.91t
1.000
72
22
80
80
300
2.100
1.300
604
1404
3.200
2.300
1.400
2504
1604
704

(2) INTERIOR GIRDER

1). AT MIDSPAN



$M = 83.844 \ t\cdot m$

$d' = \dfrac{7.2\times 5 + 15.2\times 1}{5+1} = 8.5 \ cm$

$d = 100 - 8.5 = 91.5 \ cm$

$A_s = 6 - \phi 32 = 6 \times 8.04 = 48.24 \ cm^2$

$np = \dfrac{15 \times 48.24}{100 \times 91.5} = 0.0791$

$x = \dfrac{n \cdot d \cdot A_s + b t^2}{n A_s + b t} = 39.1 \ cm$

NEUTRAL AXIS EXISTE AT WEB

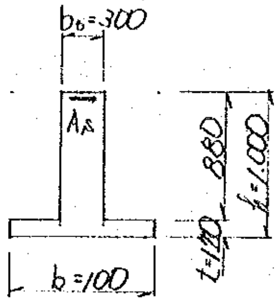
$k = \dfrac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = 0.357$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\dfrac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.914$

$\sigma_s = \dfrac{M}{A_s \cdot j \cdot d} = \dfrac{83.844\times 10^5}{48.24 \times 0.914 \times 91.5} = 2078 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$

$\sigma_c = \dfrac{k}{n(1-k)}\sigma_s = \dfrac{0.357}{15\times(1-0.357)} \times 2078 = 76.9 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$

2). AT SUPPORT (MIDDLE)



$M = 100.133^{\,t\cdot m} \quad (111.259 \times 0.90 = 100.133^{\,t\cdot m})$

$d' = \dfrac{7.2 \times 5 + 15.3 \times 3}{5+3} \qquad = 10.2 \text{ cm}$

$d = 100 - 10.2 \qquad = 89.8 \text{ cm}$

$A_s = 8 - \phi 32 = 8 \times 8.04 \qquad = 64.32 \text{ cm}^2$

$$x = -\frac{t(b-b_o)+nA_s}{b_o} + \sqrt{\left\{\frac{t(b-b_o)+nA_s}{b_o}\right\}^2 + \frac{t^2(b-b_o)+2nA_s\cdot d}{b_o}}$$

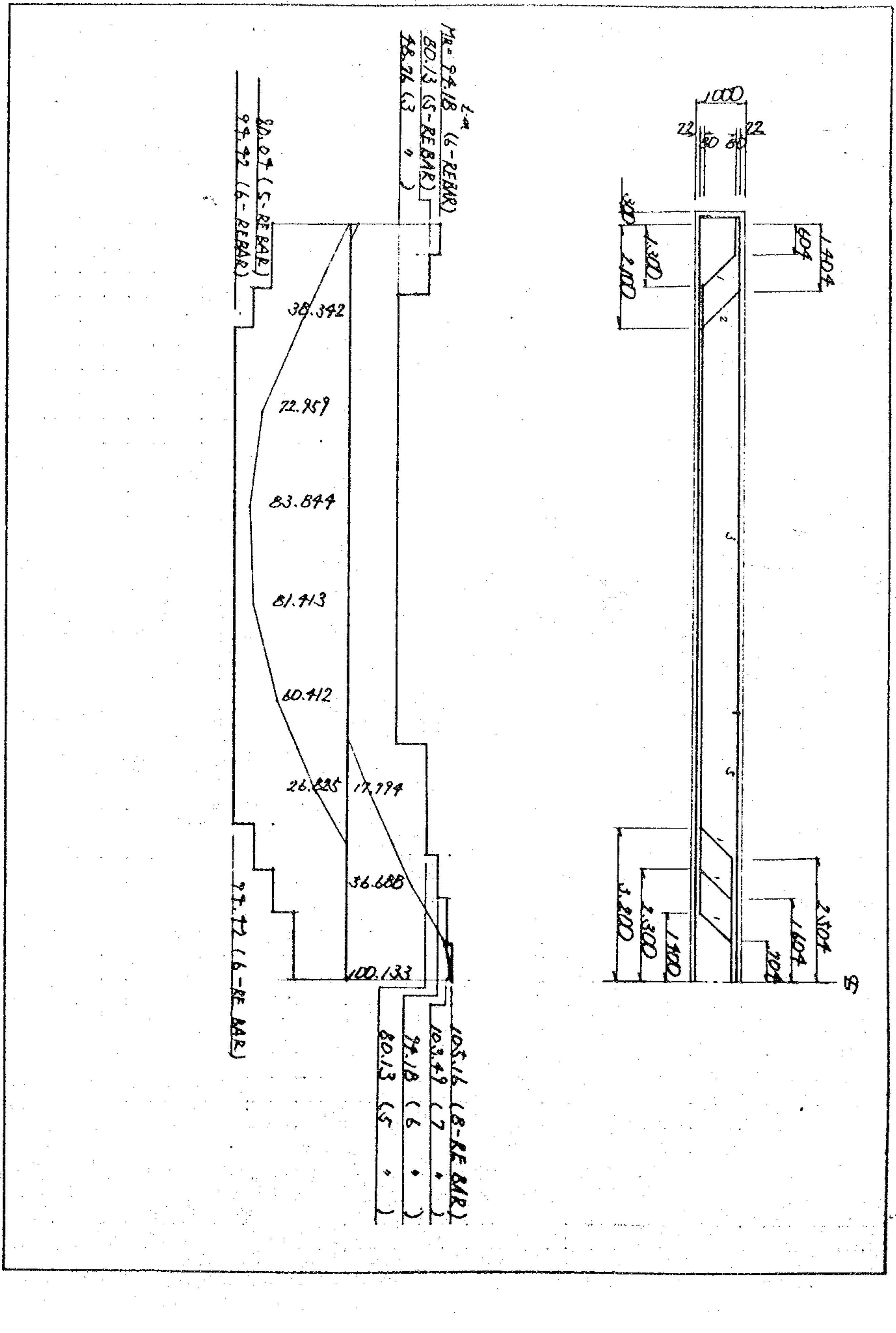
$= 38.5 \text{ cm}$

$$I = \frac{1}{3}\{bx^3-(b-b_o)(x-t)^3\}+nA_s\cdot(d-x)^2$$

$= 4\,007\,050 \text{ cm}^4$

$\sigma_c = \dfrac{M}{I}x = \dfrac{100.133\times10^5}{4007050}\times38.5 \qquad = 96.2 \text{ kg/cm}^2 < \sigma_{ca} = 101 \text{ kg/cm}^2$

$\sigma_s = \dfrac{nM}{I}(d-x) = \dfrac{15\times100.133\times10^5}{4007050}\times(89.8-38.5) = 1923 \text{ kg/cm}^2 < \sigma_{sa} = 2340 \text{ kg/cm}^2$


Mu= 94.18 (6-REBAR)
80.13 (5-REBAR)
58.76 (3 ")
80.07 (5-REBAR)
94.92 (6-REBAR)
38.342
72.959
83.844
81.413
60.412
26.825
17.794
36.688
100.133
97.92 (6-REBAR)
105.16 (8-REBAR)
103.49 (7 ")
97.18 (6 ")
80.13 (5 ")
1000
22
80
80
22
300
1300
2100
604
1404
3200
2300
1400
2504
1604
704

3. CALCULATION OF SHEAR STRESS

i). $\tau = \frac{S}{b \cdot d} = \frac{S}{30 \times 89.8}$

	SHEAR (t)	SHEAR STRESS (kg/cm^2)
1	80.978	30.09
2	74.606	26.08
3	60.034	21.56
4	40.056	14.39
5	30.396	11.03

ii). RESISTIBLE SHEAR FORCE

$$V = \frac{0.87 \cdot f_{sv} \cdot A_{sv} \cdot d}{S_v} + V_c$$

V ; RESISTIBLE SHEAR FORCE

V_c ; $v_c \cdot b \cdot d$

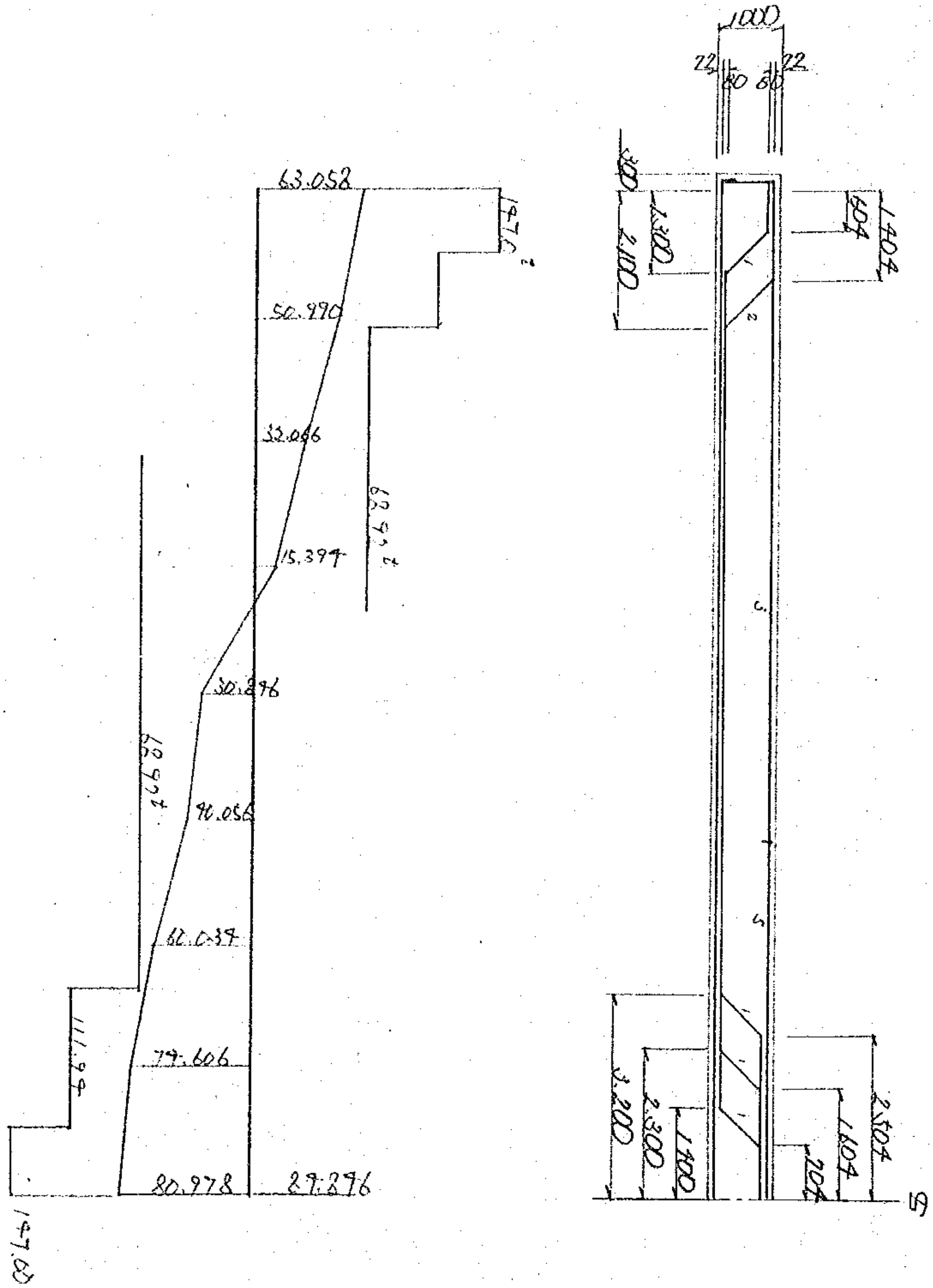
v_c ; ULTIMATE SHEAR STRESS

S_v ; THE SPACING OF REINFORCING BAR

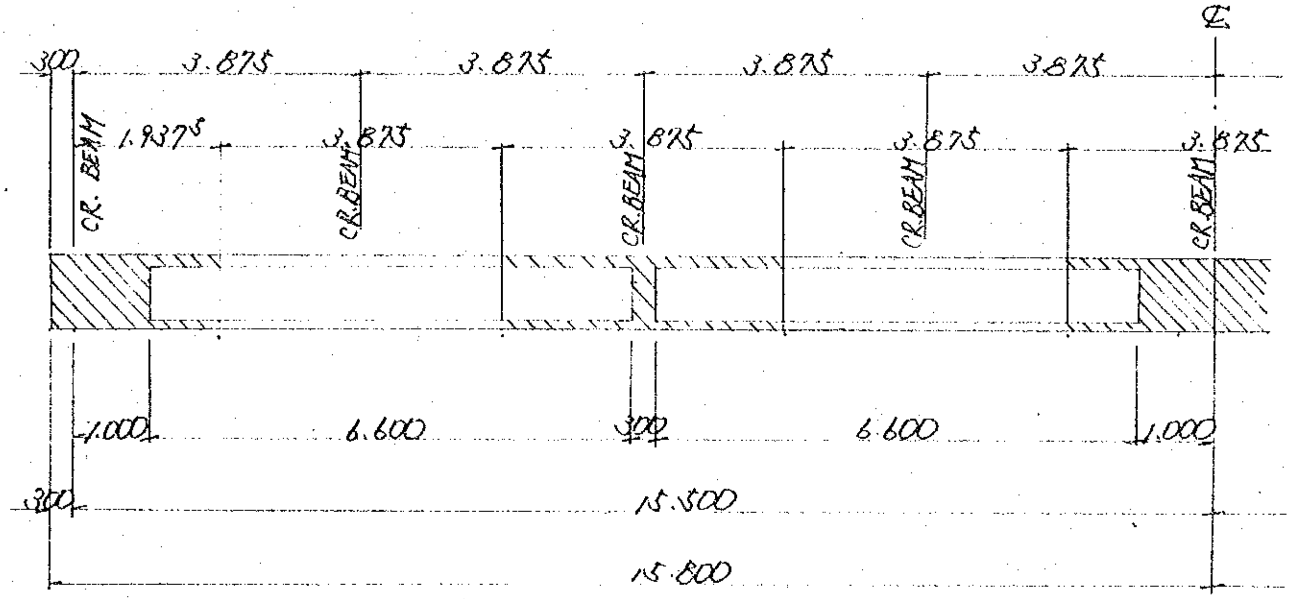
A_{sv} ; CROSS SECTION AREA OF REINFORCING BAR

f_{sy} ; CHARACTERISTIC STRENGTH OF REINFORCING BAR 4180 kg/cm^2

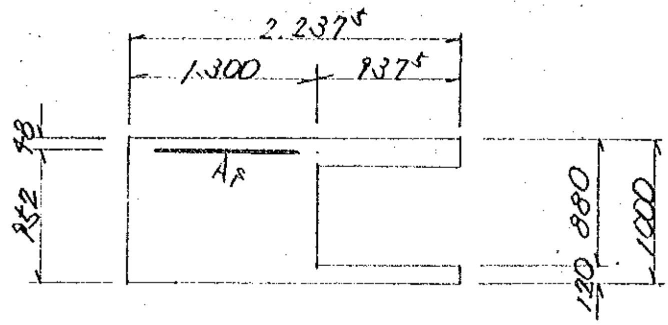
	A_c (cm^2)	v_c (kg/cm^2)	V_c (t)	A_{sv} (cm^2/m)	V (t)
1	64.32	6.27	56.34	Φ16 c/c 150 26.800	147.00
2	48.24	8.76	53.59	Φ16 c/c 300 Φ22 c/c 900	111.94
3	〃	〃	〃	Φ16 c/c 300 13.900	68.92
4	〃	〃	〃	〃	〃
5	〃	〃	〃	〃	〃


63.058
50.990
15.394
30.296
62.034
79.606
80.978
29.296
147.80
111.94
1000
22
80
80
22
2100
1300
604
1404
2300
1400
2504
1604
204

§§ 3 DESIGN OF CROSS BEAM



(1) ㊶ ~ ㊹



(RESISTIBLE WIDTH 130cm).

$M = 10.175\ t\cdot m$

$d' = \qquad = 4.8\ cm$

$d = 100 - 4.8 = 95.2\ cm$

$A_s = 8 - \Phi 16 = 8 \times 2.01 = 16.08\ cm^2$

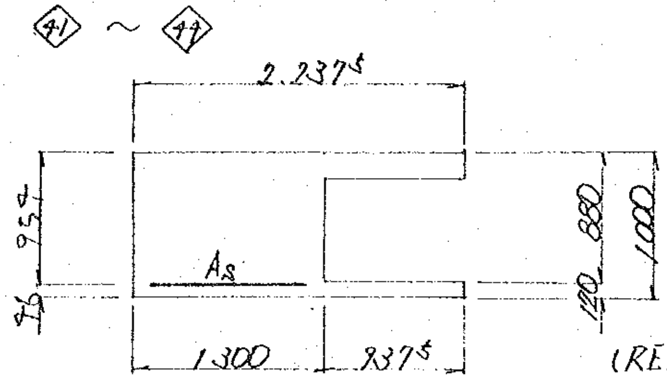
$np = \dfrac{15 \times 16.08}{130 \times 95.2} = 0.0195$

$k = \sqrt{2np + (np)^2} - np = 0.179$

$j = 1 - \dfrac{k}{3} = 0.940$

$\sigma_c = \dfrac{2M}{k \cdot j \cdot b \cdot d^2} = \dfrac{2 \times 10.175 \times 10^5}{0.179 \times 0.940 \times 130 \times 95.2^2} = 10.3\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

$\sigma_s = n\sigma_c \cdot \dfrac{1-k}{k} = 15 \times 10.3 \times \dfrac{1 - 0.179}{0.179} = 709\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$



(RESISTIBLE WIDTH 130 cm)

$M = 6.656^{t\cdot m}$

$d' = \quad = 4.6$ cm

$d = 100 - 4.6 = 95.4$ cm

$A_s = 8 - \phi 12 = 9.04^{cm^2}$

$np = \frac{15 \times 9.04}{130 \times 95.4} = 0.0110$

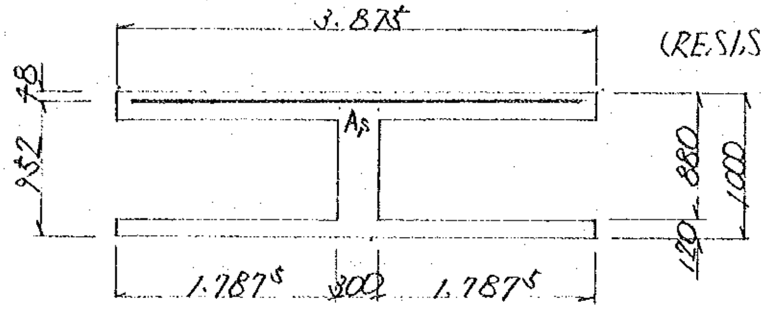
$k = \sqrt{2np + (np)^2} - np = 0.138$

$j = 1 - \frac{k}{3} = 0.954$

$\sigma_c = \frac{2M}{k \cdot j \cdot b \cdot d^2} = \frac{2 \times 6.656 \times 10^5}{0.138 \times 0.954 \times 130 \times 95.4^2} = 8.6\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

$\sigma_s = n\sigma_c \frac{1-k}{k} = 15 \times 8.6 \times \frac{1 - 0.138}{0.138} = 806\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$

(2) ⟨49⟩ ~ ⟨52⟩



(RESISTIBLE WIDTH 387 cm)

$M = 25.169$ t·m.

$d' = \qquad = 4.8$ cm

$d = 100 - 4.8 = 95.2$ cm

$A_s = 25 - \phi 16 = 50.25$ cm²

$np = \dfrac{15 \times 50.25}{387 \times 95.2} = 0.0205$

$x = \dfrac{n d A_s + b \cdot t^2}{n A_s + bt} = 25.78$ cm

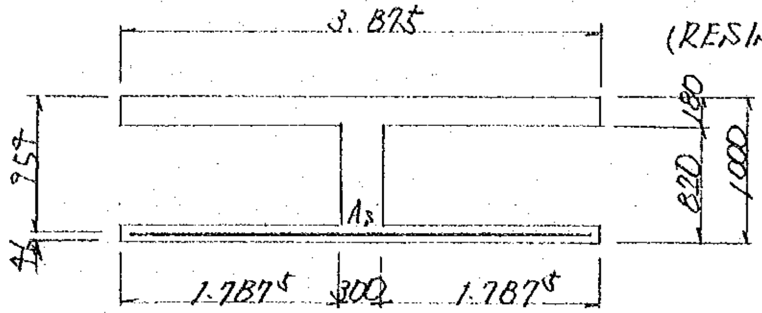
NEUTRAL AXIS , EXISTES AT WEB

$k = \dfrac{np + \frac{1}{2} \cdot (t/d)^2}{np + t/d} = 0.194$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\dfrac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.947$

$\sigma_s = \dfrac{M}{A_s \cdot j \cdot d} = \dfrac{25.169 \times 10^5}{50.25 \times 0.947 \times 95.2} = 556$ kg/cm² $< \sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \dfrac{k}{n(1-k)} \sigma_s = \dfrac{0.194}{15 \times (1 - 0.194)} \times 556 = 8.9$ kg/cm² $< \sigma_{ca} = 101$ kg/cm²



(RESISTIBLE WIDTH 387cm)

$M = 9.497 \ t \cdot m$

$d' = \qquad = 4.6 \ cm$

$d = 100 - 4.6 = 95.4 \ cm$

$As = 25 - \Phi 12 = 28.25 \ cm^2$

$$nP = \frac{15 \times 28.25}{387 \times 95.2} = 0.0115$$

$$x = \frac{n d As + b t^2}{n As + b t} = 22.43 \ cm$$

NEUTRAL AXIS EXISTES AT WEB

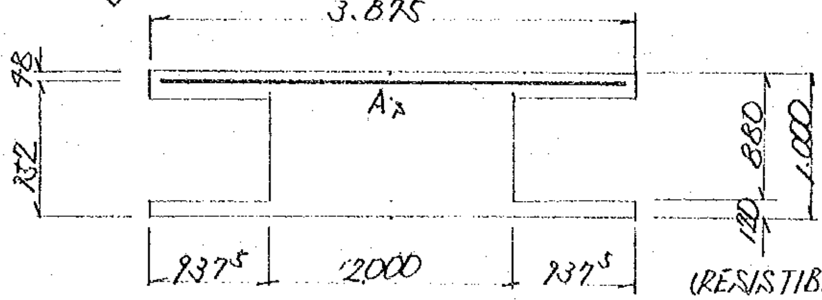
$$k = \frac{nP + 1/2\,(t/d)^2}{nP + t/d} = 0.146$$

$$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.963$$

$$\sigma_s = \frac{M}{As \cdot j \cdot d} = \frac{9.497 \times 10^5}{28.25 \times 0.963 \times 95.4} = 366 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$$

$$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.146}{15 \times (1-0.146)} \times 366 = 4.2 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$$

(3) ◇57 ～ ◇60



(RESISTIBLE WIDTH 200cm)

$M = 14.354$ t·m

$d' = \qquad\qquad = 4.8$ cm

$d = 100 - 4.8 \qquad = 95.2$ cm

$A_s = 13 - \Phi 16 = 13 \times 2.01 \quad = 26.13$ cm²

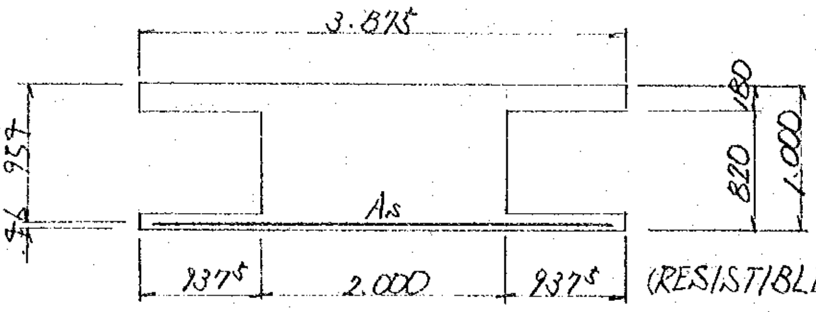
$$np = \frac{15 \times 26.13}{200 \times 95.2} = 0.0206$$

$$k = \sqrt{2np + (np)^2} - np = 0.183$$

$$j = 1 - \frac{k}{3} = 0.939$$

$$\sigma_c = \frac{2M}{k \cdot j \cdot bd^2} = \frac{2 \times 14.354 \times 10^5}{0.183 \times 0.939 \times 200 \times 95.2^2} = 9.2 \text{ kg/cm}^2 < \sigma_{ca} = 101 \text{ kg/cm}^2$$

$$\sigma_s = n \cdot \sigma_c \cdot \frac{1-k}{k} = 15 \times 9.2 \times \frac{1 - 0.183}{0.183} = 616 \text{ kg/cm}^2 < \sigma_{sa} = 2340 \text{ kg/cm}^2$$



(RESISTIBLE WIDTH 200cm)

$M = 8.145^{\ t\cdot m}$

$d' = \qquad = 4.6^{\ cm}$

$d = \qquad = 95.4^{\ cm}$

$A_s = 13 - \phi 12 = 13 \times 1.13 \quad = 14.69^{\ cm^2}$

$np = \dfrac{15 \times 14.69}{200 \times 95.4} = \quad = 0.0115$

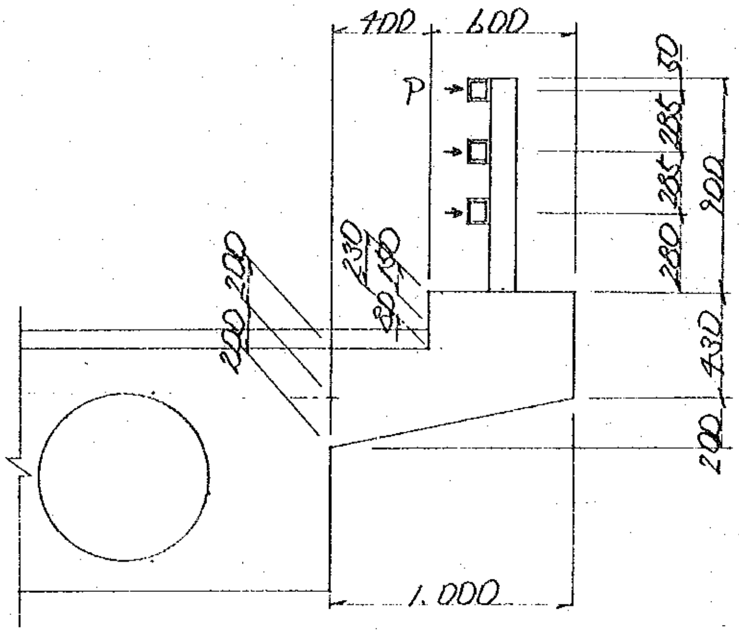
$k = \sqrt{2 \cdot np + (np)^2} - np \quad = 0.141$

$j = 1 - \dfrac{k}{3} \quad = 0.953$

$\sigma_c = \dfrac{2M}{k \cdot j \cdot b \cdot d^2} = \dfrac{2 \times 8.145 \times 10^5}{0.141 \times 0.953 \times 200 \times 95.4^2} = 6.7\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

$\sigma_s = n \sigma_c \dfrac{1-k}{k} = 15 \times 6.7 \times \dfrac{1 - 0.141}{0.141} = 612\ kg/cm^2 < \sigma_{sa} = 2\,340\ kg/cm^2$

§§ 4 DESIGN OF CANTILEVER SLAB



(1) BENDING MOMENT DUE TO DEAD LOAD

		(P t)		(X m)	(M KN·m)
RAIL		= 1.100	×	0.700	0.770
CURB	0.60 × 0.23 × 23.60	= 3.257	×	0.700	2.280
PAVEMENT	0.08 × 0.40 × 22.60	= 0.723	×	0.200	0.145
SLAB (1)	0.20 × 1.00 × 23.60	= 4.720	×	0.500	2.360
SLAB (2)	½ × 0.20 × 1.00 × 23.60	= 2.360	×	0.333	0.786
		12.160 (KN)			6.341 (KN·m/m)

(2) BENDING MOMENT DUE TO COLLISION LOAD

COLLISION LOAD 65 KN

$$P = 65/3 = 21.667 \text{ KN}$$

INTERVAL OF POST 2.0 M

$$M = P \cdot Y \cdot 1/2.0$$

$$= 21.667 \times (0.71 + 0.995 + 1.28) \times 1/2.0 = 32.338 \text{ KN·m/m}$$

(3) BENDING MOMENT DUE TO LIVE LOAD

$$M_x = \frac{P}{\pi} \cdot \frac{1}{1 + (\frac{y}{u})^2}$$

$(y = 0)$.

$P = 112.5$ KN

$$M_x = \frac{112.5}{\pi} = 35.81 \ KN \cdot m/m.$$

(4) TOTAL BENDING MOMENT AND SHEAR

$\Sigma M = 6.341 + 32.338 + 35.81 = 74.489^{KN \cdot m} = 7.601^{t \cdot m}$

$\Sigma S = 12.160 + 112.500 = 124.660^{KN} = 12.720^{t}$

(5) CALCULATION OF STRESS

$\Phi 16$ ctc 150 $\qquad A_s = 2.01 \times 100/15 = 13.40 \ cm^2$

$$p = \frac{A_s}{b \cdot d} = \frac{13.40}{100 \times 35.2} = 0.00381 \quad , n = 15.$$

$$x = \frac{nA_s}{b} \cdot \left(-1 + \sqrt{1 + \frac{2b \cdot d}{nA_s}}\right) = 10.054 \ cm$$

$$k = \sqrt{2np + (np)^2} - np = 0.285$$

$$j = 1 - x/3 \cdot d = 0.904$$

$$\sigma_c = \frac{2 \cdot M}{k \cdot j \cdot b \cdot d^2} = 47 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$$

$$\sigma_s = \frac{M}{A_s \cdot j \cdot d} = 1781 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$$

$$\tau = \frac{S}{b \cdot d \times 1.25} = 2.89 \ kg/cm^2 < \tau_a = 3.0 \ kg/cm^2$$

3. R.C. Voided Slab Bridge (M.J. A-Line 3-BR)

CONTENTS

§§ 1 DESIGN CONDITION

§ I. DESIGN CONDITION

TYPE	RC SIMPLE VOIDED SLAB BRIDGE
BRIDGE LENGTH	17 100
GIRDER LENGTH	17 000
SPAN	16 400
WIDTH	15 673 (MEAN)
LIVE LOAD	BS I53
	HA LOADING
	HB LOADING 37.5 UNITS
	FOOTWAY LOADING 5 KN/M^2
	VEHICLE COLLISION WITH GUARDRAIL ACCORDING TO NAARSA

ULTIMATE LOAD FACTORS

HA LOADING	I.5 D + 2.5 L
	2 (D + L)
HB LOADING	I.5 D + 2.0 L

§ 2. MATERIAL STRENGTH AND PERMISSIBLE STRESS

1. CONCRETE

MAIN SLAB

SPECIFIED WORKS CUBE STRENGTH

AT 28 DAYS — 30 N/mm^2 (306 kg/cm^2)

PERMISSIBLE COMPRESSIVE STRESS

BENDING COMPRESSION — 10 N/mm^2 (101 kg/cm^2)

SHEAR — 0.87 N/mm^2 (8.9 kg/cm^2)

2. REIN FORCEMENT

HOT ROLLED YIELD BARS

SPECIFIED CHARACTERISTIC STRENGTH

f_{su} = 410 N/m^2 (4180 kg/cm^2)

PERMISSIBLE TENSILE STRESS

f_{sa} = 230 N/mm^2 (2340 kg/cm^2)