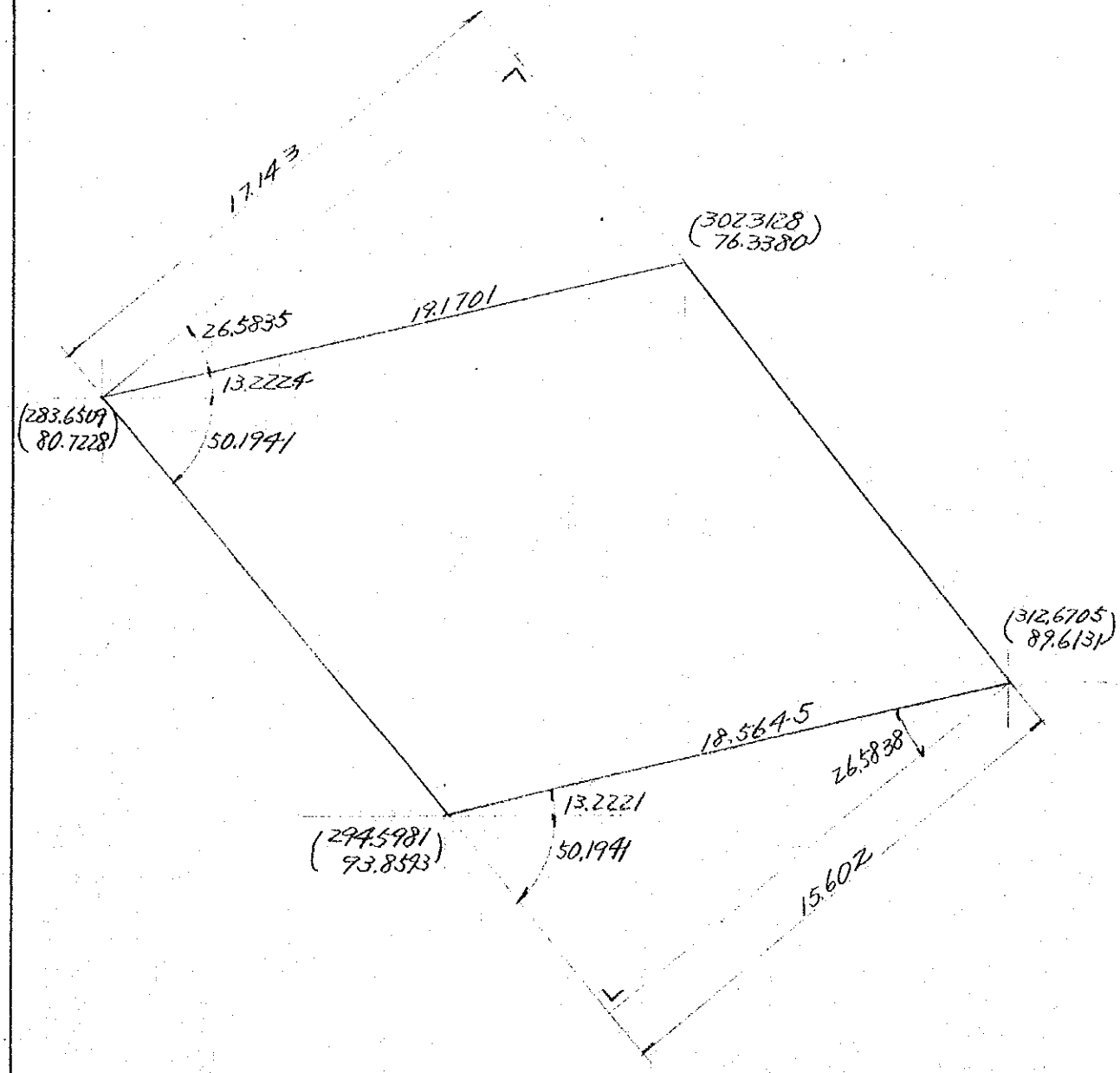
§§2 DESIGN OF MAIN SLAB

§1 PREPARATION

1 GENERAL STRUCTURE

(1) DETERMINATION OF GROSS WIDTH



$\sqrt{(312.6705-294.5981)^2+(93.8593-89.6131)^2} = \sqrt{18.0724^2+4.4246^2}$

$= 18.5645$

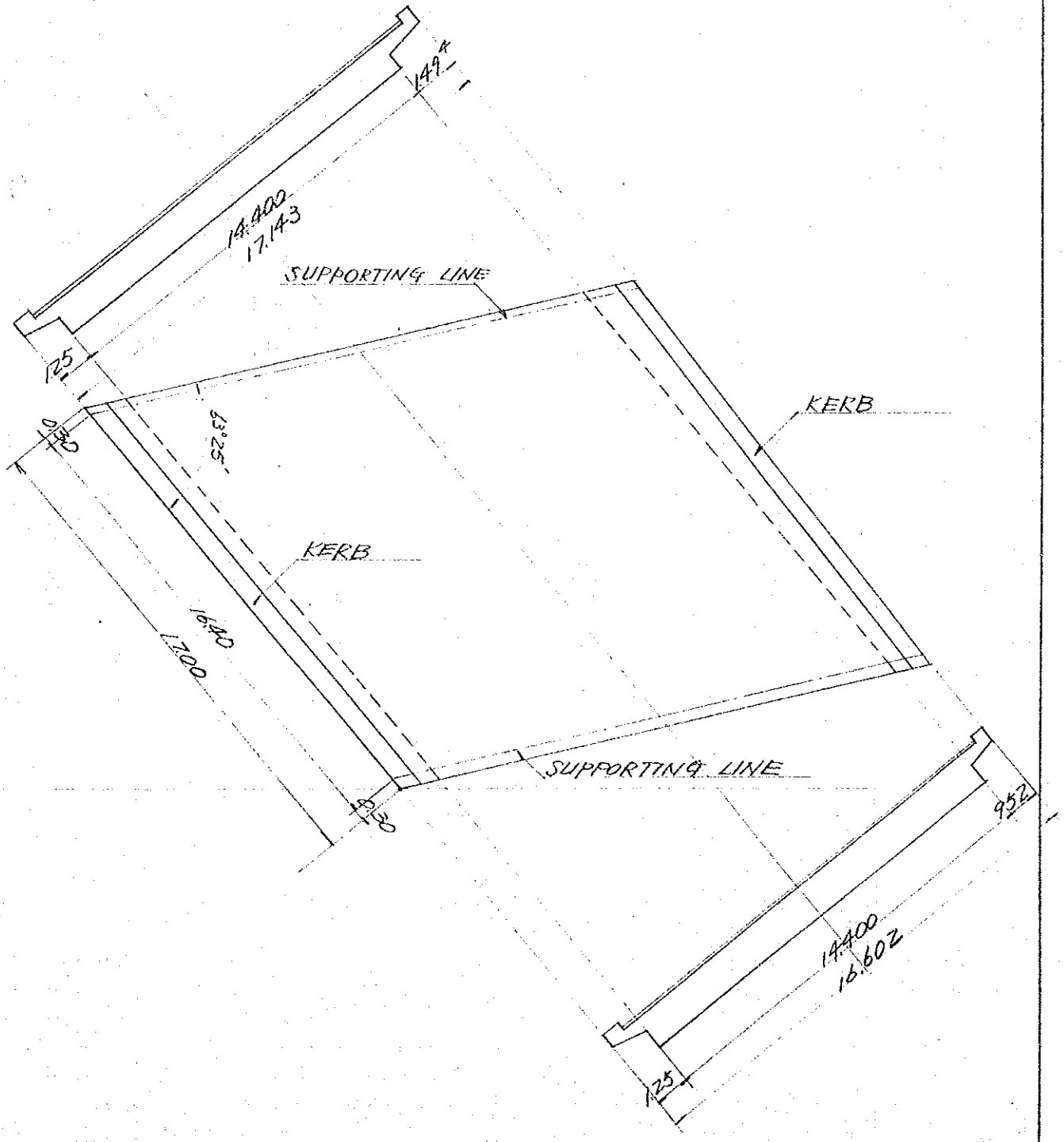
$18.5645 \times \sin(13.2221+50.1941) = 16.602$

$\sqrt{(302.3128-283.6509)^2+(80.7228-76.3380)^2} = \sqrt{18.6619^2+4.3848^2}$

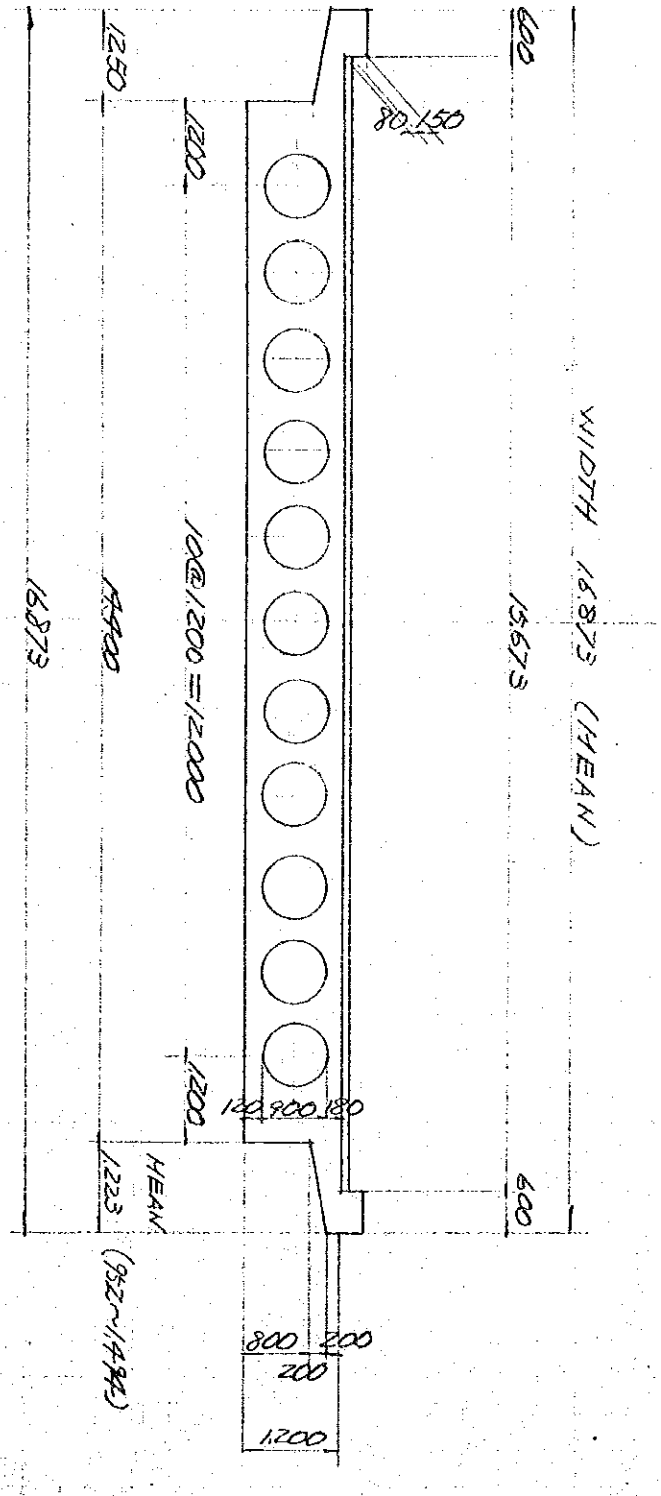
$= 19.1701$

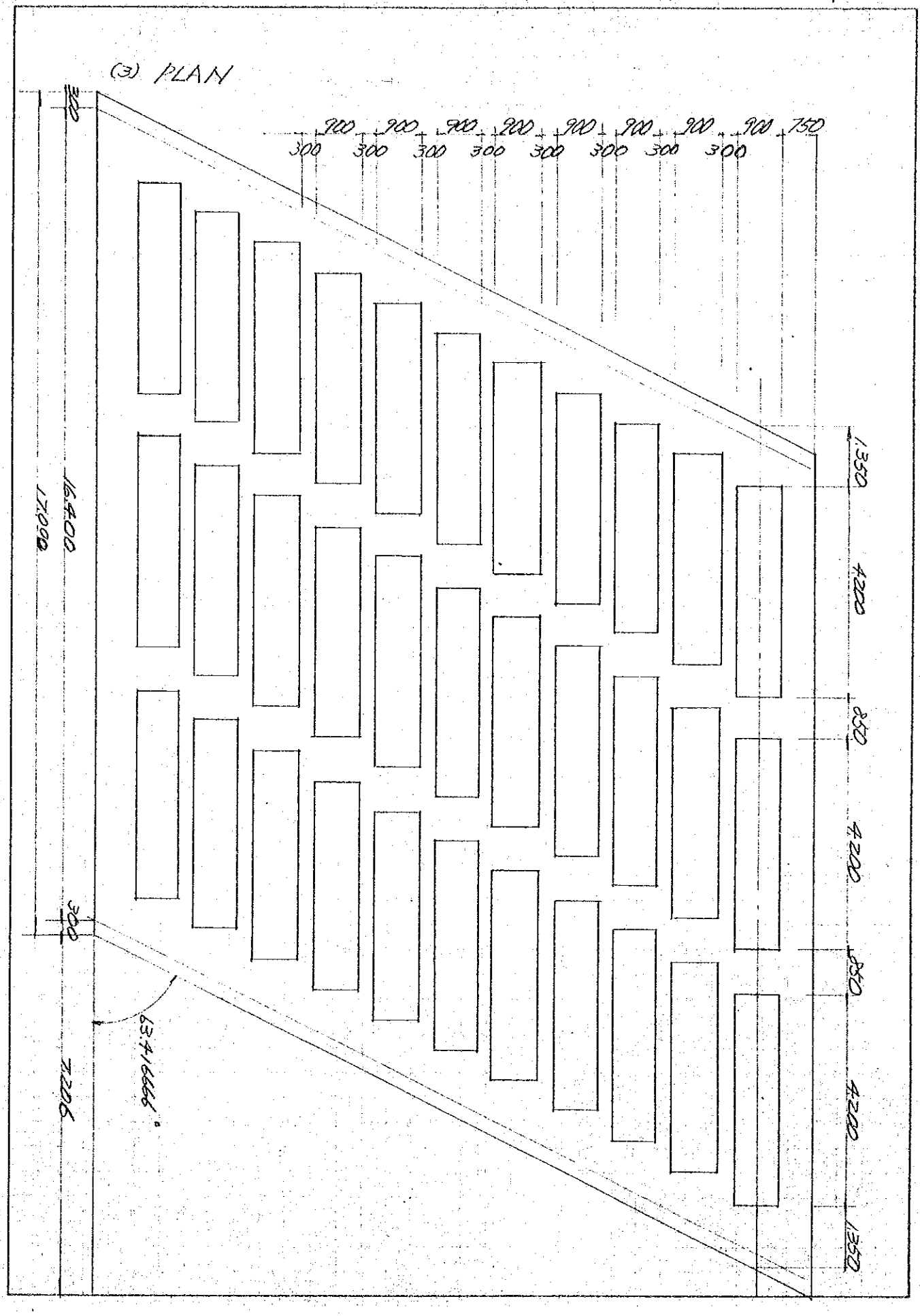
$19.1701 \times \cos 26.5835 = 17.143$

MEAN WIDTH $= \frac{16.602+17.143}{2} = 16.873$ m

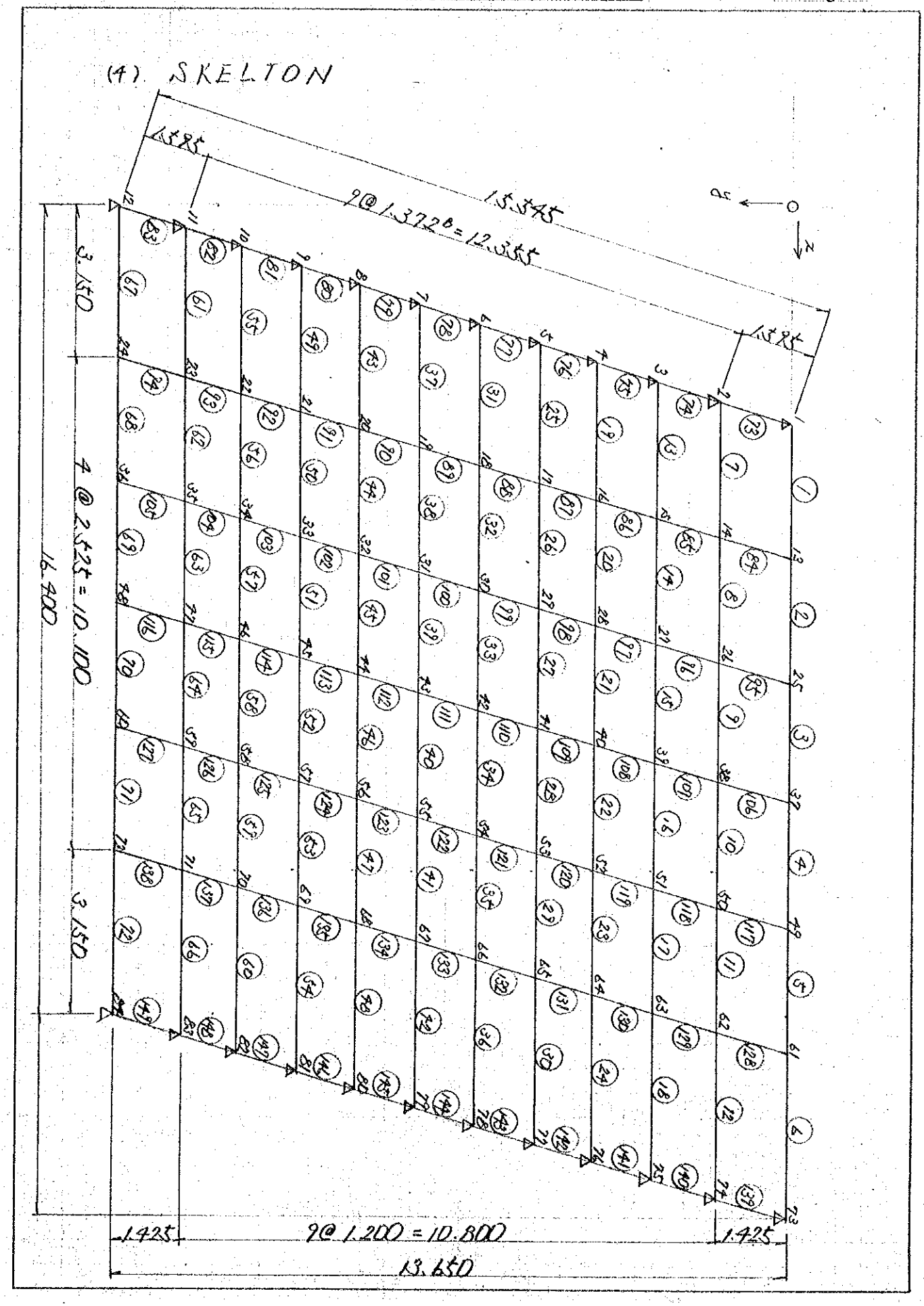

149'-
14.400
17.143
SUPPORTING LINE
1.25
1.0
1.0
43°25'
KERB
KERB
16.40
17.00
SUPPORTING LINE
9.52
14.400
16.602
1.25

(2) SECTION


600
80 150
1250
1200
10@1,200 = 12,000
16,873
15,673
WIDTH 16,873 (MEAN)
1200
140 900 180
600
MEAN
1223
(932~1494)
800 200
200
1,200


(3) PLAN
900 900 900 900 900 900 900 900 750
300 300 300 300 300 300 300 300
300
16400
17000
300
7200
63.4/6666°
1350
4200
850
4200
850
4200
1350

(4) SKELTON


1.525
2@1.372=12.345
15.345
1.525
N
3.150
7@2.525=10.100
16.400
3.150
1.425
2@1.200=10.800
1.425
13.650

(5) CO-ORDINATE

	X	Y		X	Y		X	Y
1	6.830	0	29	9.991	5.025	57	12.639	9.825
2	6.117	1.425	30	9.390	6.225	58	12.039	11.025
3	5.517	2.625	31	8.790	7.425	59	11.438	12.225
4	4.916	3.825	32	8.190	8.625	60	10.725	13.650
5	4.316	5.025	33	7.589	9.825	61	20.080	0
6	3.715	6.225	34	6.989	11.025	62	19.367	1.425
7	3.115	7.425	35	6.386	12.225	63	18.767	2.625
8	2.515	8.625	36	5.675	13.650	64	18.166	3.825
9	1.914	9.825	37	15.030	0	65	17.566	5.025
10	1.314	11.025	38	14.317	1.425	66	16.965	6.225
11	0.713	12.225	39	13.717	2.625	67	16.365	7.425
12	0	13.650	40	13.116	3.825	68	15.765	8.625
13	9.980	0	41	12.516	5.025	69	15.164	9.825
14	9.267	1.425	42	11.915	6.225	70	14.564	11.025
15	8.667	2.625	43	11.315	7.425	71	13.963	12.225
16	8.066	3.825	44	10.715	8.625	72	13.250	13.650
17	7.466	5.025	45	10.114	9.825	73	23.230	0
18	6.865	6.225	46	9.514	11.025	74	22.517	1.425
19	6.265	7.425	47	8.913	12.225	75	21.917	2.625
20	5.665	8.625	48	8.200	13.650	76	21.316	3.825
21	5.064	9.825	49	17.555	0	77	20.716	5.025
22	4.464	11.025	50	16.842	1.425	78	20.115	6.225
23	3.863	12.225	51	16.242	2.625	79	19.515	7.425
24	3.150	13.650	52	15.641	3.825	80	18.915	8.625
25	12.505	0	53	15.041	5.025	81	18.314	9.825
26	11.792	1.425	54	14.440	6.225	82	17.714	11.025
27	11.192	2.625	55	13.840	7.425	83	17.113	12.225
28	10.591	3.825	56	13.240	8.625	84	16.400	13.650

2 CALCULATION OF I AND J OF MAIN GIRDER

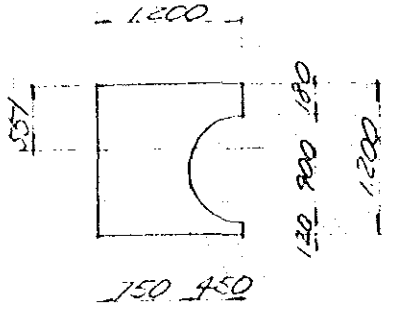
(1) CENTER OF GRAVITY IN TOTAL SECTION

	$b \times h = A$	y	Ay
1	$1.40 \times 1.20 = 1.680$	0.60	1.0080
2	$1.25 \times 0.20 = 0.250$	0.10	0.0250
3	$\frac{1.25 \times 0.20}{2} = 0.125$	0.267	0.0334
4	$1.223 \times 0.20 = 0.245$	0.10	0.0245
5	$\frac{1.223 \times 0.20}{2} = 0.122$	0.267	0.0326
6	$-\pi \times 0.45^2 \times 1.1 = -1.978$	0.63	-1.4087
Σ	11.024		0.0748

$$y_G = \frac{0.0748}{11.024} = 0.551\ m$$

(2) CALCULATION OF I

EDGE GIRDER



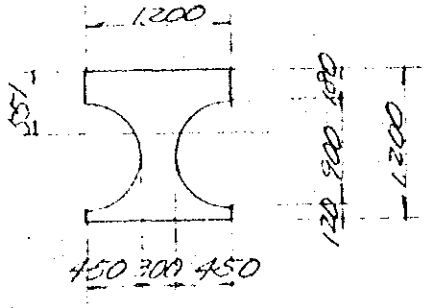
	$b \times h = A$	y	Ay	Ay^2	I_G
1	$1.20 \times 1.20 = 1.440$	0.60	0.864	0.5184	0.1728
2	$-\frac{0.45^2}{2} \times \pi = -0.318$	0.63	-0.200	-0.1262	-0.0161
Σ	1.122		0.664	0.3922	0.1567

$$y_G' = \frac{0.664}{1.122} = 0.592\ m \qquad \Delta y = 0.592 - 0.551 = 0.041\ m$$

$$I_G = 0.1567 + 0.3922 - 1.122 \times 0.592^2 = 0.1557\ m^4$$

$$I_o = 0.1557 + 1.122 \times 0.041^2 = 0.1576\ m^4$$

INTERIOR GIRDER



	b x h = A	y	Ay	Ay²	Ig
①	1.20×1.20 = 1.440	0.60	0.864	0.5184	0.1728
②	−0.45²×π = −0.636	0.63	−0.401	−0.2524	−0.0322
Σ	0.804		0.463	0.2660	0.1406

$y_g' = \frac{0.463}{0.804} = 0.576^m$ $\quad \Delta y = 0.576 - 0.551 = 0.025^m$

$I_g = 0.1406 + 0.2660 - 0.804 \times 0.576^2 = 0.1399^{m^4}$

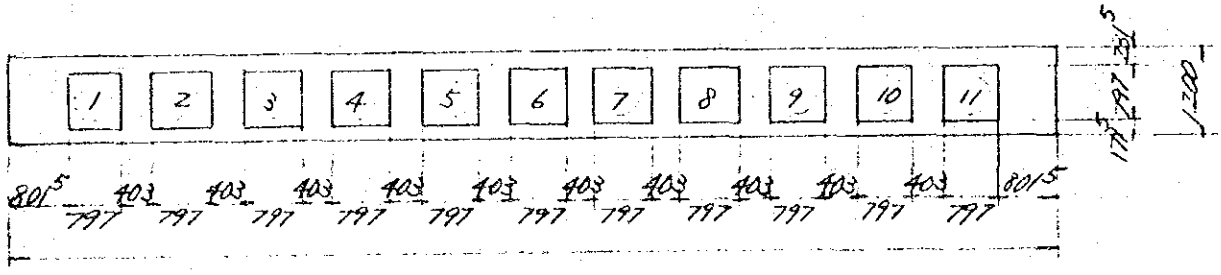
$I_o = 0.1399 + 0.804 \times 0.025^2 = 0.1404^{m^4}$

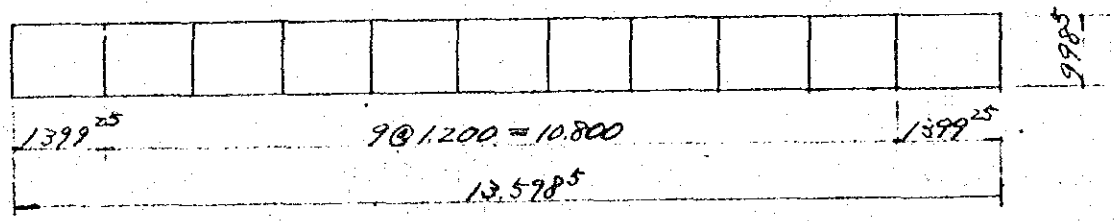
(3) TORSIONAL RIGIDITY J

AREA OF HOLLOW CIRCLE $A = 0.45^2\pi = 0.636^{m^2}$

EQUIVALENT SQUARE $a = \sqrt{0.636} = 0.797^m$

$\Delta b = (0.70 - 0.797) \times 1/2 = 0.0515^m$





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

X_i IS OBTAINED SOLVING FOLLOWING SIMULTANEOUS EQUATIONS

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	$= A$
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}	a_{45}							$2F_4$
5				a_{54}	a_{55}	a_{56}						$2F_5$
6					a_{65}	a_{66}	a_{67}					$2F_6$
7						a_{76}	a_{77}	a_{78}				$2F_7$
8							a_{87}	a_{88}	a_{89}			$2F_8$
9								a_{98}	a_{99}	$a_{9\,10}$		$2F_9$
10									$a_{10\,9}$	$a_{10\,10}$	$a_{10\,11}$	$2F_{10}$
11										$a_{11\,10}$	$a_{11\,11}$	$2F_{11}$

WHERE

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

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

$$a_{11} = a_{11\,11} = \frac{0.998^5}{0.801^5} + \frac{0.998^5}{0.403} + \frac{1.399^{25}}{0.231^5} + \frac{1.399^{25}}{0.1715}$$

$$= 1.246 + 2.478 + 6.044 + 8.159 \qquad = 17.927$$

$$a_{22} = a_{10.10} = \frac{0.998^5 \times 2}{0.403} + \frac{1.200}{0.231^5} + \frac{1.200}{0.1715}$$

$$= 4.955 + 5.184 + 6.997 \qquad = 17.136$$

$$a_{12} = a_{21} = \qquad = -\frac{0.998^5}{0.403} \qquad = -2.478$$

$$F_i = b_i h_i$$

$F_1 = F_{11} = 1.399^{25} \times 0.998^5 = 1.397$ $\qquad 2F_1 = 2 \times 1.397 = 2.794$

$F_2 = F_{10} = 1.20 \times 1 = 1.198$ $\qquad 2F_2 = 2 \times 1.198 = 2.396$

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	= A
1	17927	-2478										2.194
2	-2478	17136	-2478									2.346
3		-2478	17136	-2478								"
4			-2478	17136	-2478							"
5				-2478	17136	-2478						"
6					-2478	17136	-2478					"
7						-2478	17136	-2478				"
8							-2478	17136	-2478			"
9								-2478	17136	-2478		"
10									-2478	17136	-2478	"
11										-2478	17927	2.794

$X_1 = X_{11} = 0.18276$

$X_2 = X_{10} = 0.19465$

$X_3 = X_9 = 0.19641$

$X_4 = X_8 = 0.19667$

$X_5 = X_6 = X_7 = 0.19671$

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

$$= 2 \left\{ \begin{array}{l} 0.18276 \times 1.397 \times 2 \\ 0.19465 \times 1.198 \times 2 \\ 0.19641 \times " \times 1 \\ 0.19667 \times " \times 1 \\ 0.19671 \times " \times 3 \end{array} \right\} = 2 \times \left\{ \begin{array}{l} 0.5106 \\ 0.4664 \\ 0.4706 \\ 0.4712 \\ 0.7070 \end{array} \right\} = 2 \times 2.6258 = 5.2516$$

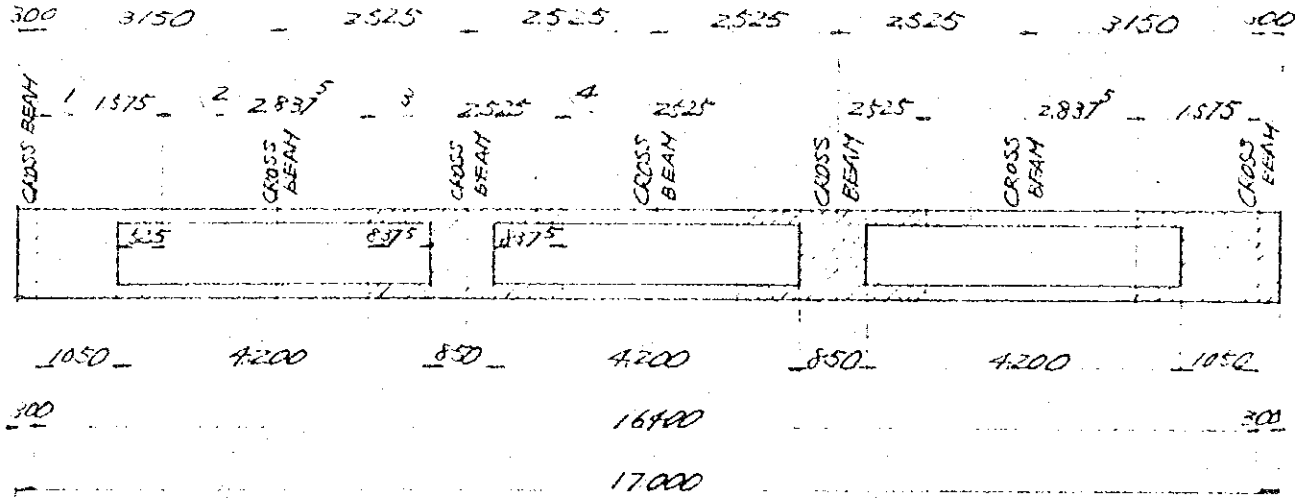
TORSIONAL RIGIDITY PER A MAIN GIRDER

$$J = \frac{\Pi}{n} = \frac{5.2516}{12} = 0.4376 \ m^4$$

3 CALCULATION OF I AND J OF TRANSVERSE BEAM

(1) CALCULATION OF I

i) CENTER OF GRAVITY IN TOTAL SECTION

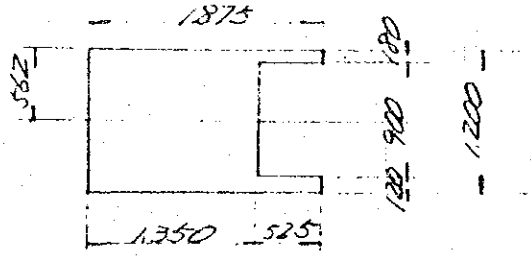


	b × h = A	y	Ay
1)	17.00 × 1.20 = 20.400	0.60	12.2400
2)	-12.60 × 0.90 = -11.340	0.63	-7.1442
Σ	9060		5.0958

$$y' = \frac{5.0958}{9.060} = 0.562\ m$$

ii) CALCULATION OF I

(1) 7



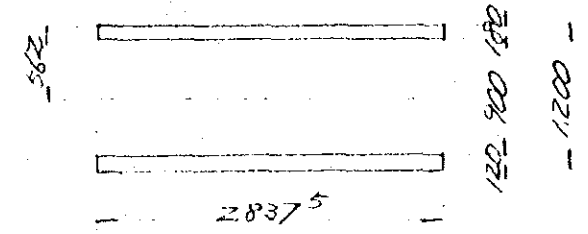
	b × h = A	y	Ay	Ay²	Ig
1)	1.875 × 1.20 = 2.250	0.60	1.350	0.8100	0.2700
2)	-0.525 × 0.90 = -0.473	0.63	-0.298	-0.1877	-0.0319
Σ	1.777		1.052	0.6223	0.2381

$y_G = \frac{1.052}{1.772} = 0.592^m$ $\quad \Delta y = 0.592 - 0.592 = 0$

$I_G = 0.2381 + 0.6223 - 1.777 \times 0.594^2 = 0.2334^{m4}$

$I_o = 0.2334 + 1.777 \times 0^2 = 0.2334^{m4}$

(2) (6)



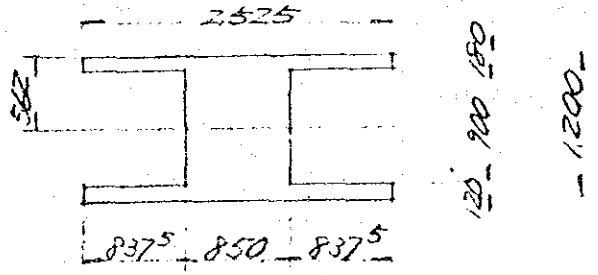
	$b \times h = A$	y	Ay	Ay^2	I_G
(1)	$2837.5 \times 1.20 = 3405$	0.60	2.043	1.2258	0.4086
(2)	$-2.837.5 \times 0.90 = -2.554$	0.63	-1.609	-1.0137	-0.1724
Σ	0.851		0.434	0.2121	0.2362

$y_G = \frac{0.434}{0.851} = 0.510^m$ $\quad \Delta y = 0.562 - 0.510 = 0.052^m$

$I_G = 0.2362 + 0.2121 - 0.851 \times 0.510^2 = 0.2270^{m4}$

$I_o = 0.2270 + 0.851 \times 0.052^2 = 0.2293^{m4}$

(3) (5)



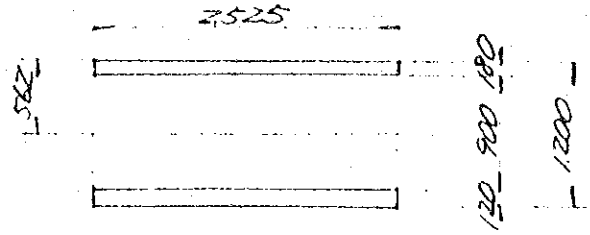
	$b \times h = A$	y	Ay	Ay^2	I_G
(1)	$2.525 \times 1.20 = 3030$	0.60	1.818	1.0908	0.3636
(2)	$-1.675 \times 0.90 = -1.508$	0.63	-0.950	-0.5985	-0.1018
Σ	1.522		0.868	0.4923	0.2618

$y_G = \frac{0.868}{1.522} = 0.570^m$ $\quad \Delta y = 0.570 - 0.562 = 0.008^m$

$I_G = 0.2618 + 0.4923 - 1.522 \times 0.570^2 = 0.2596^{m4}$

$I_o = 0.2596 + 1.522 \times 0.008^2 \qquad = 0.2597\ m^4$

(1)



	$b \times h = A$	y	Ay	Ay^2	I_G
(1)	$2.525 \times 1.20 = 3.030$	0.60	1.818	1.0908	0.3636
(2)	$-2.525 \times 0.90 = -2.273$	0.63	-1.432	-0.9022	-0.1534
Σ	0.757		0.386	0.1886	0.2102

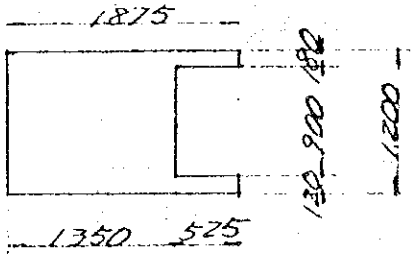
$y_G = \frac{0.386}{0.757} = 0.510 \qquad \Delta y = 0.562 - 0.510 = 0.052\ m$

$I_G = 0.2102 + 0.1886 - 0.757 \times 0.510^2 \qquad = 0.2019\ m^4$

$I_o = 0.2019 + 0.757 \times 0.052^2 \qquad = 0.2039\ m^4$

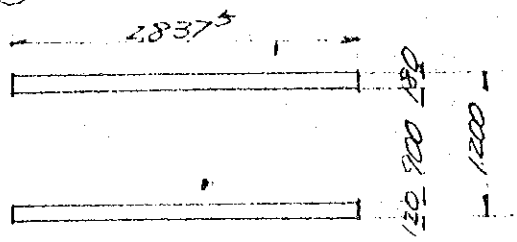
(2) CALCULATION OF TORSIONAL RIGIDITY

(1) (7)



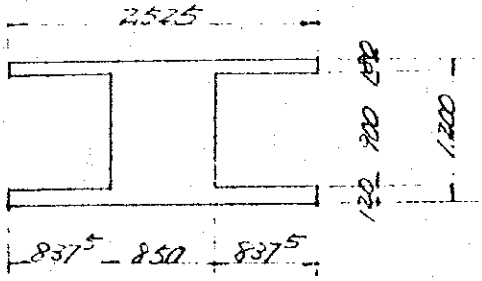
B	t	B/t	β	$\beta B t^3$
1.875	0.18	10.417	0.312	0.0034
1.35	0.90	1.500	0.196	0.1929
1.875	0.12	15.625	0.312	0.0010
Σ				0.1973

② ⑥



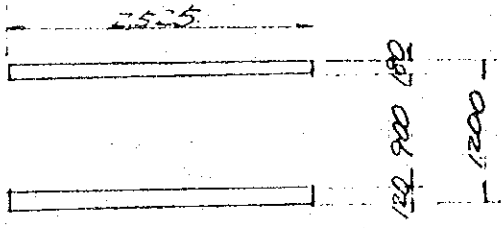
B	t	B/t	β	$\beta B t^3$
2837.5	0.18	15.764	0.312	0.0052
2837.5	0.12	23.646	0.312	0.0015
Σ				0.0067

③ ⑤



B	t	B/t	β	$\beta B t^3$
2.525	0.18	14028	0.312	0.0046
0.90	0.85	1.059	0.149	0.0824
2.525	0.12	21042	0.312	0.0014
Σ				0.0884

④



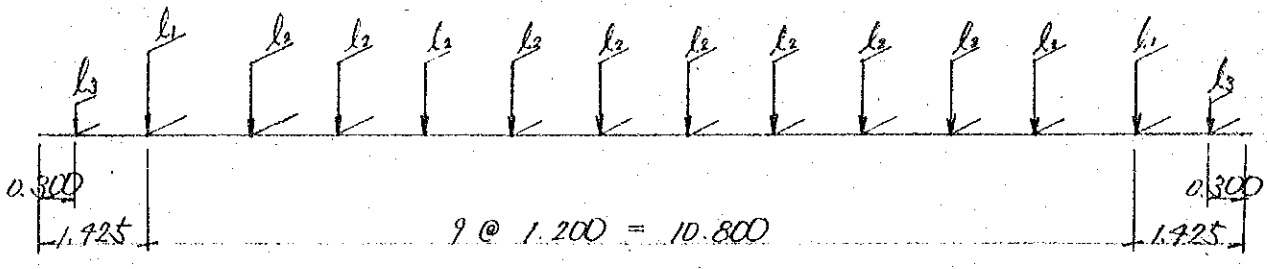
B	t	B/t	β	$\beta B t^3$
2.525	0.18	14028	0.312	0.0046
2.525	0.12	21042	0.312	0.0014
Σ				0.0060

I AND J

MEMBER No	I (m^4)	J (m^4)
①~⑥, ⑰~⑫	0.1576	0.4376
⑦~⑯	0.1404	0.4376
⑬~⑱, ⑲~⑭	0.2350	0.1973
⑭~㉔, ㉘~㉘	0.2293	0.0067
㉕~㉘, ㉗~㉗	0.2597	0.0884
㉖~㉖	0.2039	0.0060

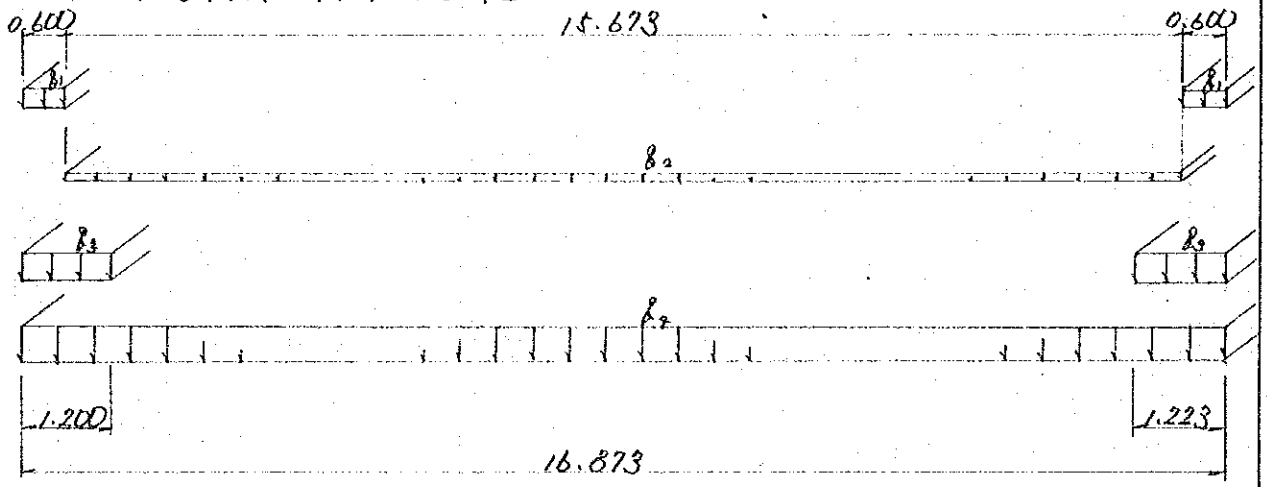
3. DEAD LOAD

1). LINE LOAD



l_1 =	21.380	KN/m	MAIN BEAM
l_2 =	13.673	KN/m	MAIN BEAM
l_3 =	1.100	KN/m	HAND RAIL

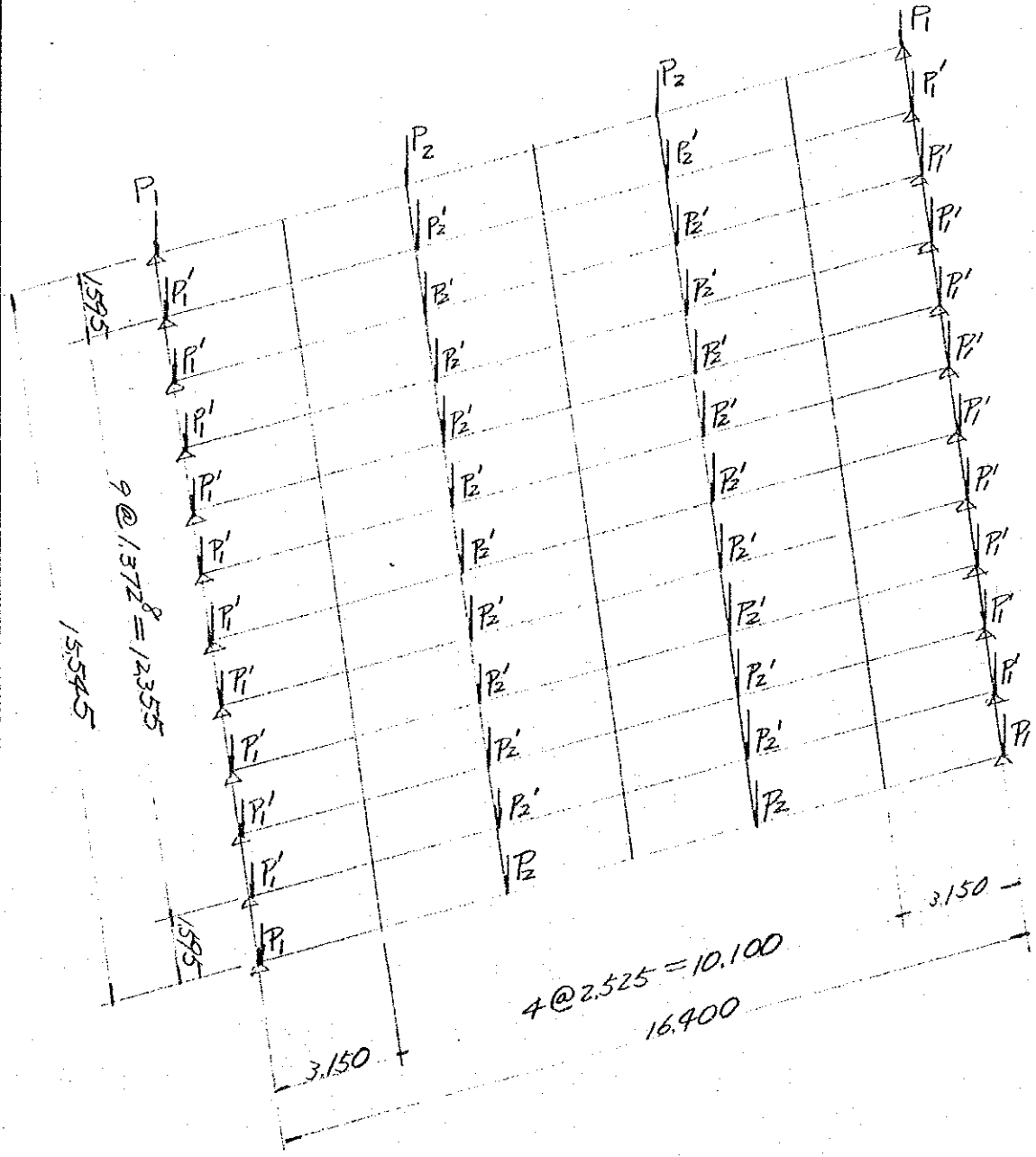
2) UNIFORM LOAD



g_1 =	5.728	KN/m²	CURB
g_2 =	1.808	KN/m²	PAVEMENT
g_3 =	2.832	KN/m²	EXTENDED SLAB
g_4 =	4.248	KN/m²	SLAB

2) CONCENTRATED LOAD.

(CROSS BEAM)



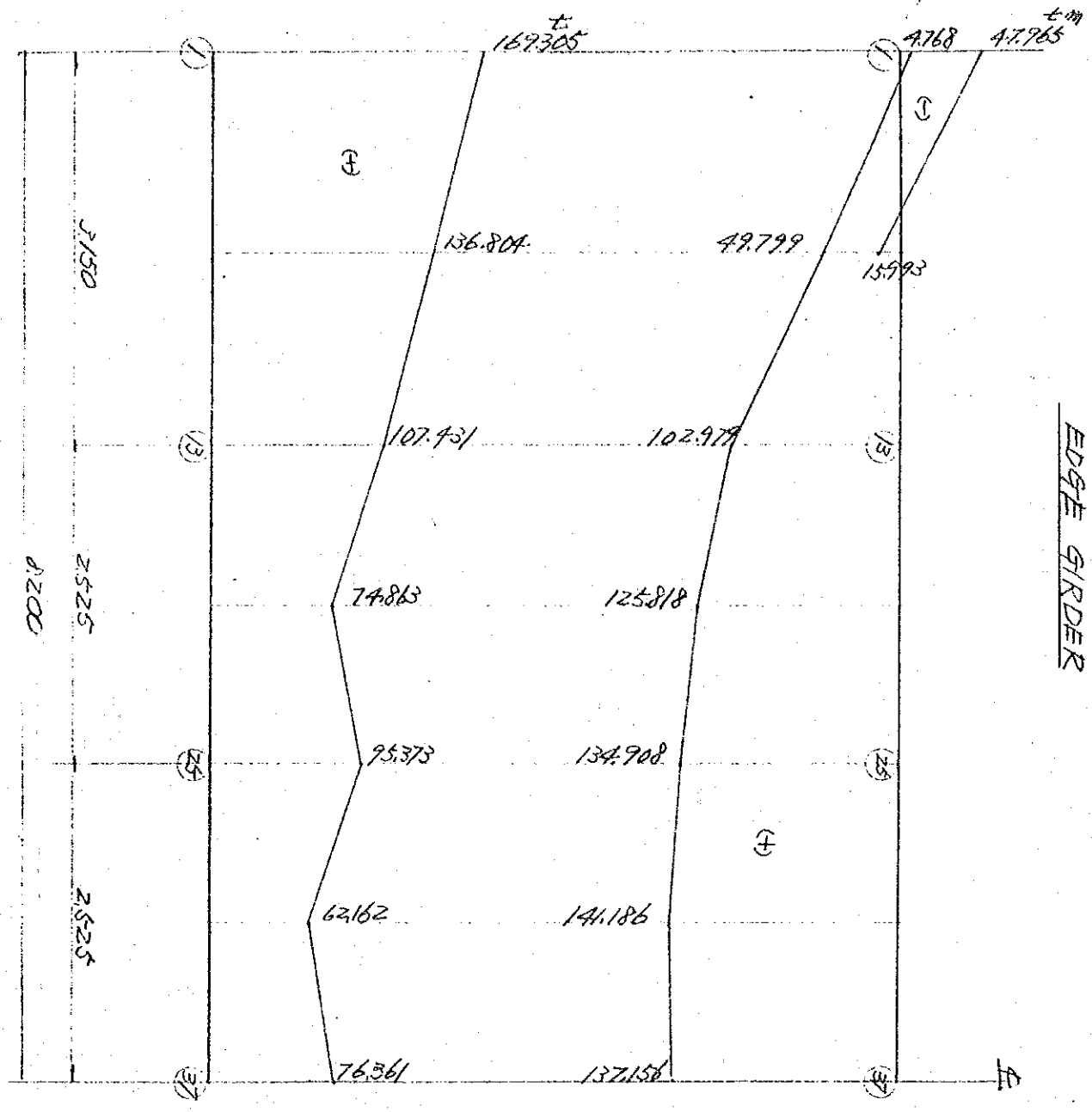
$P_1 = 7.882$ KN

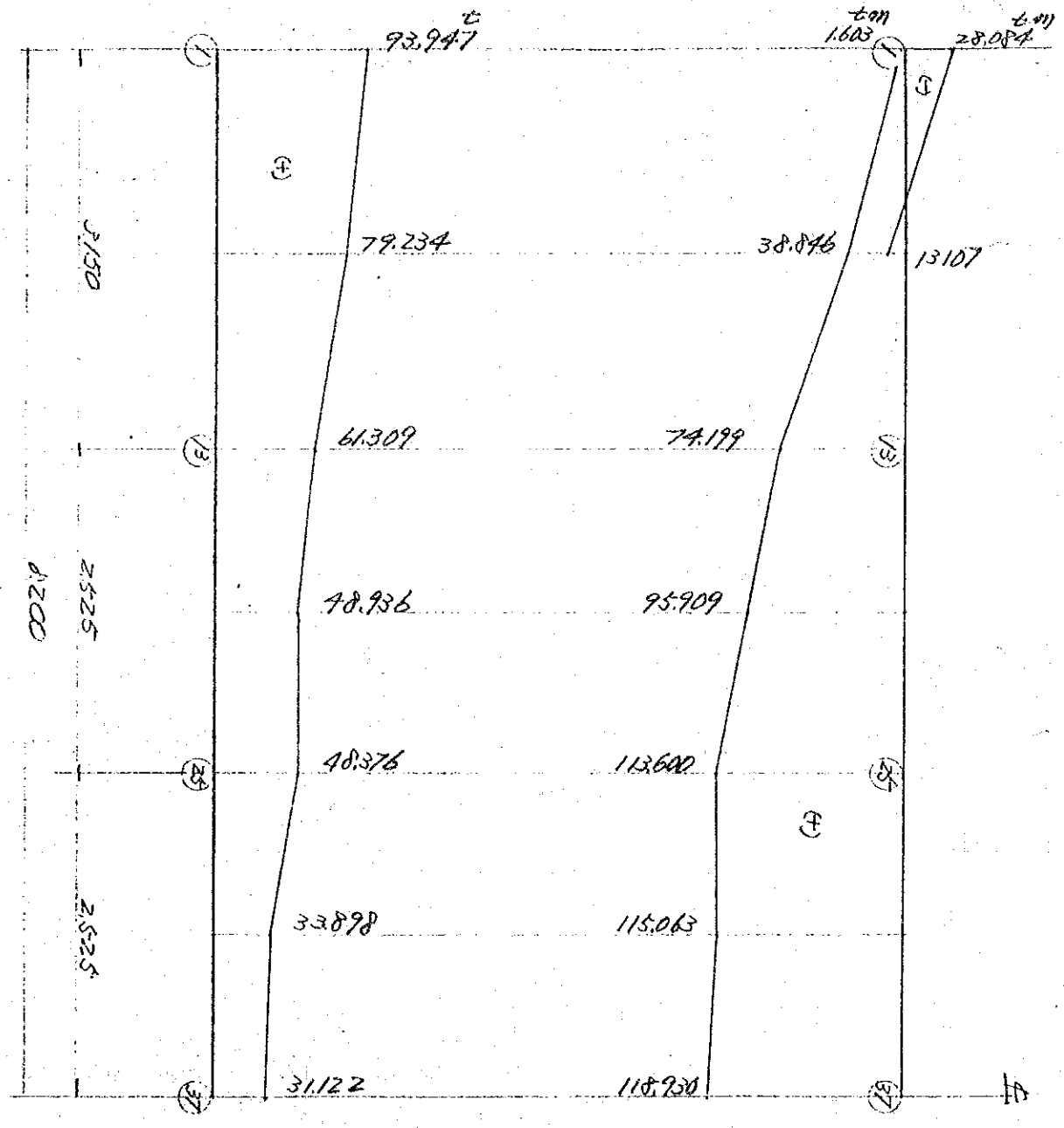
$P_1' = 15.764$ KN

$P_2 = 6.381$ KN

$P_2' = 12.762$ KN

§2 DRAWING OF SECTIONAL FORCE DIAGRAM





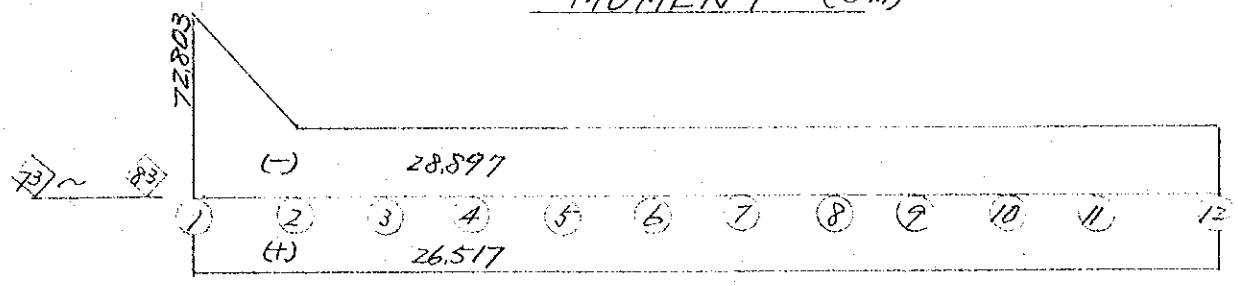
INTERIOR GIRDER

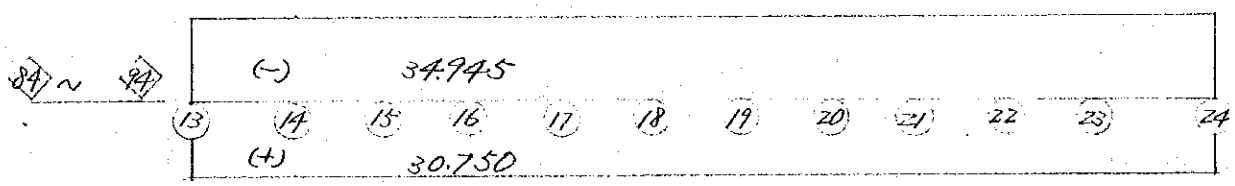
SHEAR (t) (ULTIMATE SHEAR)

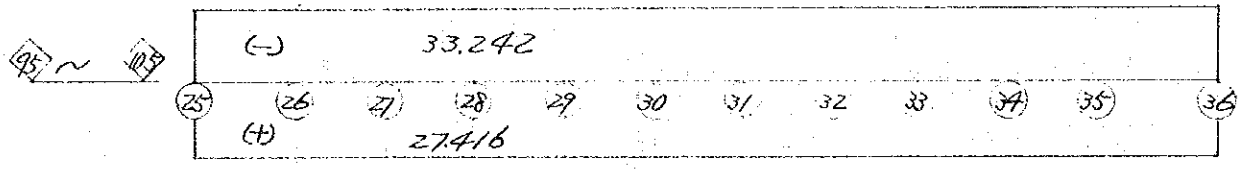
MOMENT (t-m)

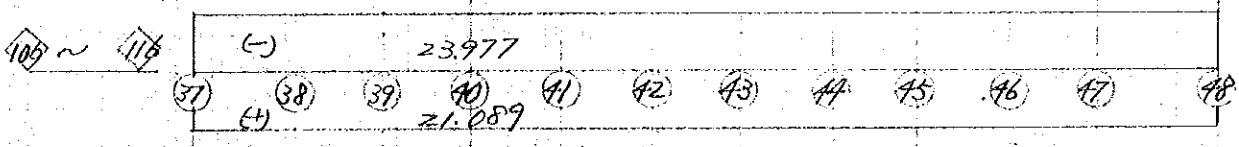
CROSS BEAM

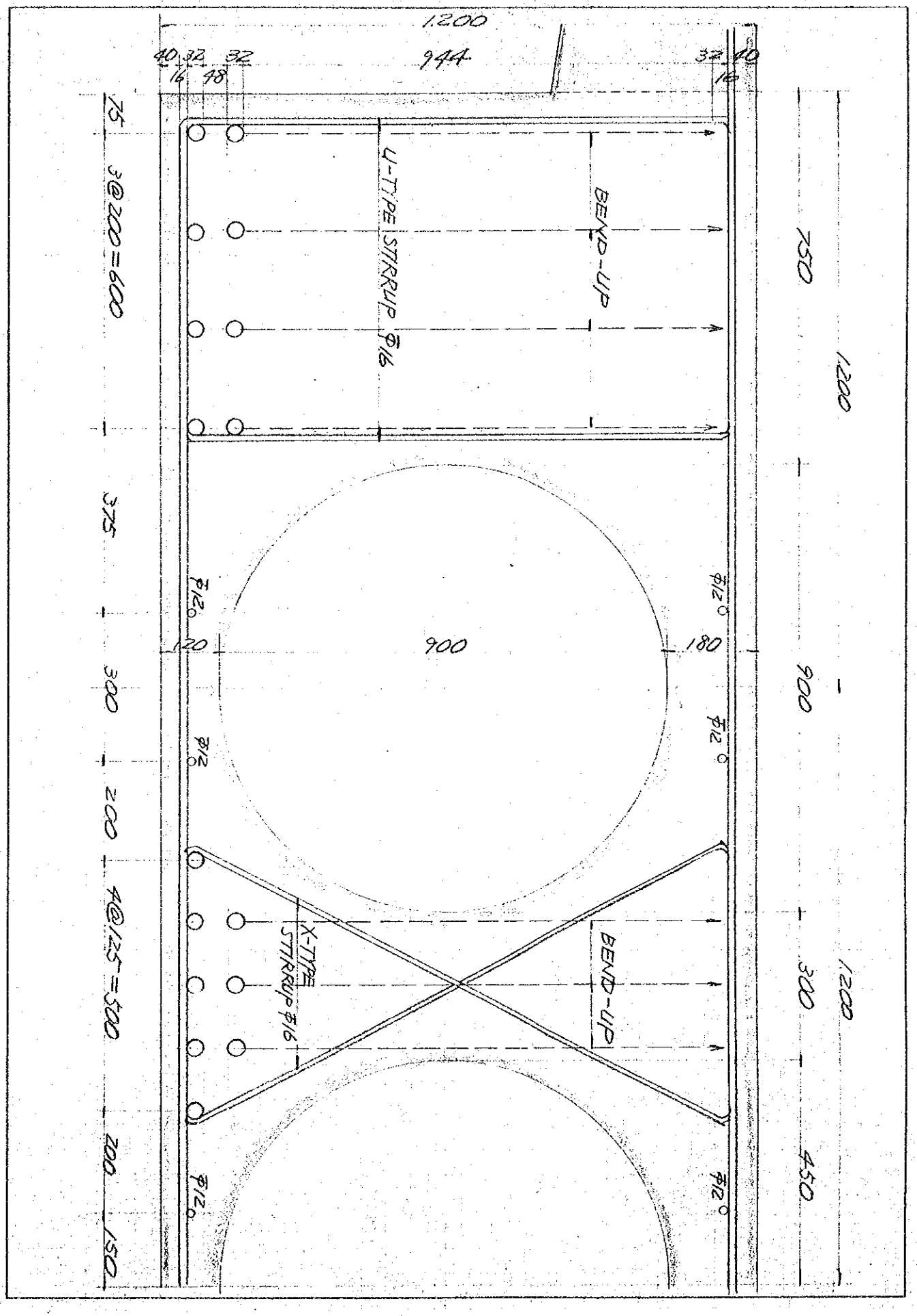
MOMENT (t-m)





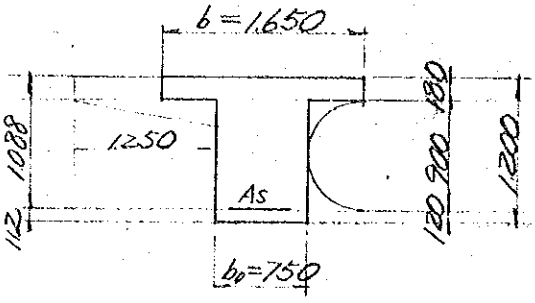





1200
944
40 32 32
16 48
32 40
16
U-TYPE STIRRUP Φ16
BEND-UP
900
Φ12
120
180
X-TYPE STIRRUP Φ16
BEND-UP
75 3@200=600 375 300 200 4@125=500 200 150
750 1200 900 300 450 1200

(1) EDGE GIRDER ◇1~◇6 AND ◇67~◇72

i) AT MIDSPAN



RESISTIBLE WIDTH 165 cm.

M = 141.186 t·m

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

$d = h - d' = 120 - 11.2$ = 108.8 "

$As = 8 - \phi 32 = 8 \times 8.04$ = 64.32 cm²

$np = \frac{15\times64.32}{165\times108.8}$ = 0.0537

$x = \frac{n\,d\,As + b\,t^2}{n\,As + b\,t} = \frac{15\times108.8\times64.32 + 165\times\frac{18^2}{2}}{15\times64.32 + 165\times18}$ = 33.47 cm

NEUTRAL AXIS IS EXISTED AT WEB

$k_c = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0537 + \frac{1}{2}(\frac{18}{108.8})^2}{0.0537 + \frac{18}{108.8}}$ = 0.3075

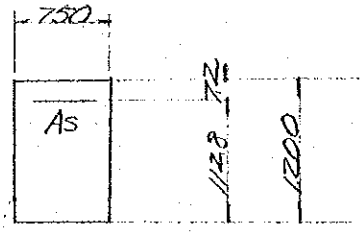
$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k_c - 2\frac{t}{d}}{2k_c - \frac{t}{d}}\right\} = 1 - \frac{1}{3}\times\frac{18}{108.8}\times\left\{\frac{3\times0.3075 - 2\times\frac{18}{108.8}}{2\times0.3075 - \frac{18}{108.8}}\right\}$ = 0.9274

$\sigma_s = \frac{M}{As\,j\,d} = \frac{141.186\times10^5}{64.32\times0.9274\times108.8}$ = 2175 < σ_{sa} = 2340 kg/cm²

$\sigma_c = \frac{k_c}{n(1-k_c)}\sigma_s = \frac{0.3075\times2175}{15\times(1-0.3075)}$ = 64.4 < σ_{ca} = 101 "

(2) EDGE GIRDER

i) AT SUPPORT



RESISTIBLE WIDTH 75^{cm}

$M = -47.965^{t\,m}$

$d' = 7.2^{cm}$

$d = h - d' = 120 - 7.2 = 112.8^{\,"}$

$As = 4 - \phi 32 = 4 \times 8.04 = 32.16^{cm^2}$

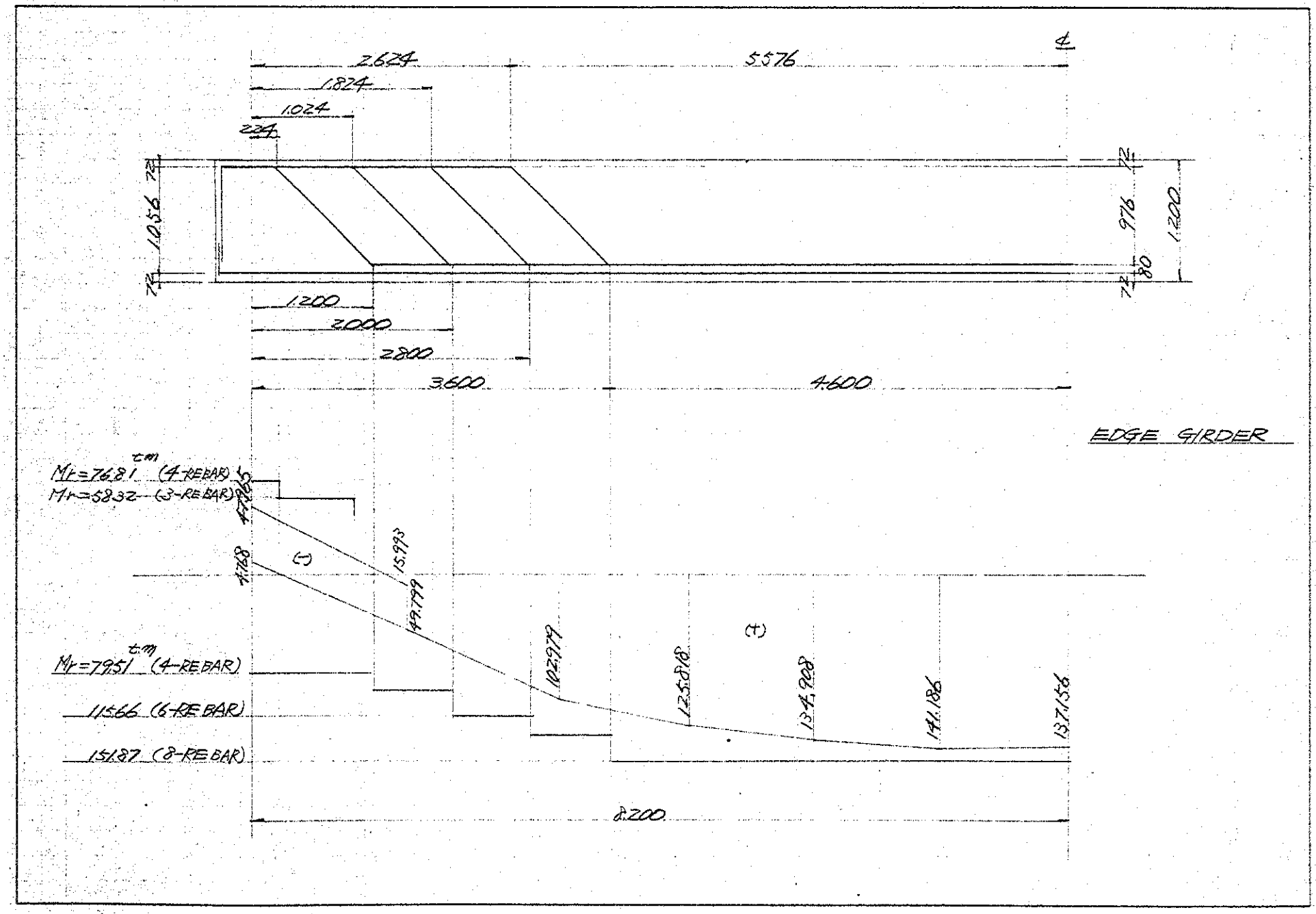
$np = \frac{15 \times 32.16}{75 \times 112.8} = 0.057$

$k = \sqrt{2np + (np)^2} - np = \sqrt{2 \times 0.057 + 0.057^2} - 0.057 = 0.2854$

$j = 1 - \frac{k}{3} = 1 - \frac{0.2854}{3} = 0.9049$

$\sigma c = \frac{2M}{k j b d^2} = \frac{2 \times 47.965 \times 10^5}{0.2854 \times 0.9049 \times 75 \times 112.8^2} = 38.9 < \sigma ca = 101^{\,kg/cm^2}$

$\sigma s = n \sigma c \frac{1-k}{k} = 15 \times 38.9 \times \frac{1-0.2854}{0.2854} = 1461 < \sigma sa = 2340^{\,"}$


2.624
5.576
1.824
1.024
224
1.056
72
72
72
112
976
80
1.200
1.200
2.000
2.800
3.600
4.600
EDGE GIRDER
Mt=76.81 t.m (4-REBAR)
Mr=58.32 (3-REBAR)
4.768
15.993
49.799
Mr=79.51 t.m (4-REBAR)
11.566 (6-REBAR)
15.187 (8-REBAR)
102.979
125.818
134.208
141.186
137.156
8.200

1 POINT Ⓐ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

$\frac{100 A_{st}}{bd}$ $\quad A_{st} = 8-\phi 32 = 8 \times 8.04 = 64.32 \ cm^2$

$b = 75 \ cm$

$d' = \frac{7.2 \times 4 + 15.2 \times 4}{4+4} = 11.2 \ cm$

$d = 120 - 11.2 = 108.8 \ cm$

$\frac{100 A_{st}}{bd} = \frac{100 \times 64.32}{75 \times 108.8} = 0.788$

$\tau_a = \frac{0.12}{0.50} \times 0.288 + 0.38 = 0.449 \ N/mm^2$

$= 4.49 \ kg/cm^2$

$\therefore S_{r1} = \tau_a bd = 4.49 \times 75 \times 108.8 \times 10^{-3} = 36.64 \ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$S_{r2} = \frac{\sigma_{sa}(A_b + 0.707 A_v)}{0.707 v} d$

σ_{sa} $\quad 4180 \times 0.87 = 3.637 \ kg/cm^2$

$A_b = 0 \ cm^2$

$A_v = 2-\phi 16 = 2 \times 2.01 = 4.02 \ cm^2$

$v = 16.8 \ cm$

$d = 108.8 \ cm$

$\therefore S_{r2} = \frac{3.637 \times (0 + 0.707 \times 4.02)}{0.707 \times 16.8} \times 108.8 \times 10^{-3} = 98.07 \ t$

iii) TOTAL RESISTIBLE SHEARING FORCE

$S_r = S_{r1} + S_{r2} = 36.64 + 98.07 = 134.71 \ t$

2. POINT Ⓑ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

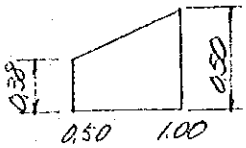
$\frac{100\,Ast}{bd}$ $\quad Ast = 7-\phi 32 = 7\times 8.04 = 56.28\ cm^2$

$b = 75\ cm$

$d' = \frac{7.2\times 4 + 15.2\times 3}{4+3} = 10.6\ cm$

$d = 120 - 10.6 = 109.4\ cm$

$\therefore \frac{100\,Ast}{bd} = \frac{100\times 56.28}{75\times 109.4} = 0.686$



$\tau_a = \frac{0.12}{0.50}\times 0.186 + 0.38 = 0.425\ N/mm^2$

$= 4.25\ kg/cm^2$

$\therefore S_{r1} = \tau_a b d = 4.25\times 75\times 109.4\times 10^{-3} = 34.87\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$S_{r2} = \frac{\sigma_{sa}(A_b + 0.707 A_v)}{0.707 V} d$

$\sigma_{sa} = 3.637\ kg/cm^2$

$A_b = 1-\phi 32 = 1\times 8.04 = 8.04\ cm^2$

$A_v = 5\times 2\times 2.01 = 20.10\ cm^2$

$V = 80\ cm$

$d = 109.4\ cm$

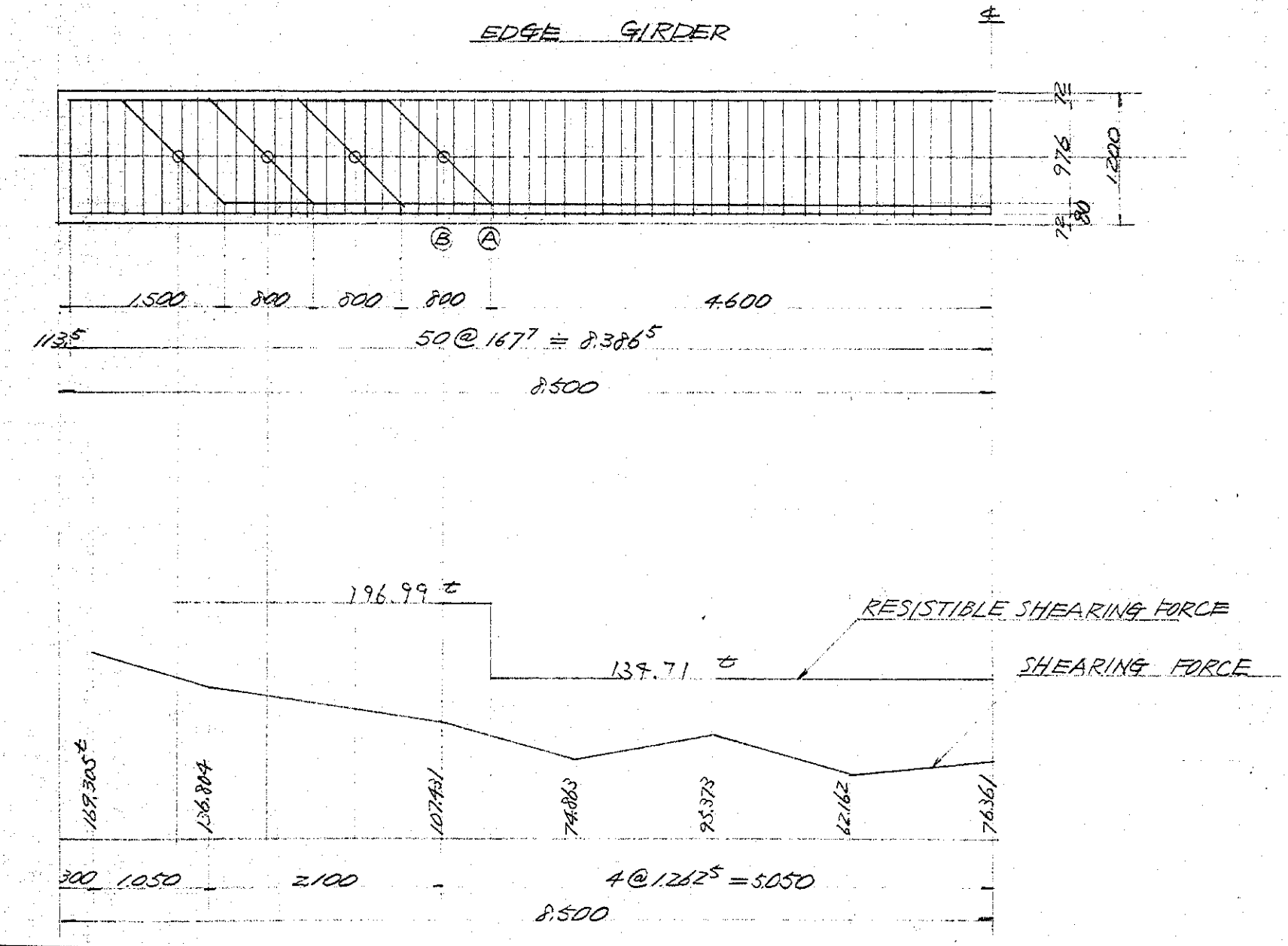
$\therefore S_{r2} = \frac{3.637\times(8.04+0.707\times 20.10)}{0.707\times 80}\times 109.4\times 10^{-3} = 162.12\ t$

iii) TOTAL SHEARING FORCE

$S_r = S_{r1} + S_{r2} = 34.87 + 162.12 = 196.99\ t$

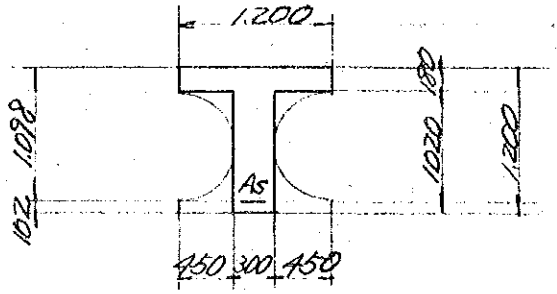
MJ A-LINE 3 BRIDGE

EDGE GIRDER



(1) INTERIOR GIRDER ⑦ ~ ⑫

i) AT MIDSPAN



RESISTIBLE WIDTH 120 cm

$M = 118.930$ t·m

$d' = \frac{7.2 \times 5 + 15.2 \times 3}{5+3}$ $= 10.2$ cm

$d = h - d' = 120 - 10.2$ $= 109.8$ "

$As = 8 - \phi 32 = 8 \times 8.04$ $= 64.32$ cm²

$np = \frac{15 \times 64.32}{120 \times 109.8}$ $= 0.0732$

$x = \frac{ndAs + bt^2}{nAs + bt} = \frac{15 \times 109.8 \times 64.32 + 120 \times \frac{18^2}{2}}{15 \times 64.32 + 120 \times 18}$ $= 40.12$ cm

NEUTRAL AXIS IS EXISTED AT WEB

$k_e = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0732 + \frac{1}{2}(\frac{18}{109.8})^2}{0.0732 + \frac{18}{109.8}}$ $= 0.3654$

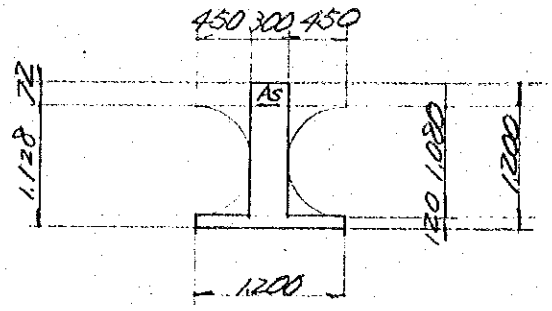
$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k_e - 2\frac{t}{d}}{2k_e - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{18}{109.8} \times \left\{\frac{3 \times 0.3654 - 2 \times \frac{18}{109.8}}{2 \times 0.3654 - \frac{18}{109.8}}\right\} = 0.9259$

$\sigma_s = \frac{M}{Asjd} = \frac{118.93 \times 10^5}{64.32 \times 0.9259 \times 109.8} = 1.819 < \sigma_{sa} = 2.340$ kg/cm²

$\sigma_c = \frac{k_e}{n(1-k_e)}\sigma_s = \frac{0.3654 \times 1.819}{15 \times (1 - 0.3654)} = 69.8 < \sigma_{ca} = 101$ "

(2) INTERIOR GIRDER ◇7 ~ ◇12

ii) AT SUPPORT



RESISTIBLE WIDTH 120 cm

$M = 28,084$ t-m

$d' = \frac{7.2 \times 3 + x}{3 +}$ $= 7.2$ cm

$d = h - d' = 120 - 7.2$ $= 112.8$ "

$As = 3 - \phi 32 = 3 \times 8.04$ $= 24.12$ cm²

$np = \frac{15 \times 24.12}{120 \times 112.8}$ $= 0.0267$

$x = \frac{ndAs + bt^2}{nAs + bt} = \frac{15 \times 112.8 \times 24.12 + 120 \times \frac{12^2}{2}}{15 \times 24.12 + 120 \times 12}$ $= 27.45$ cm

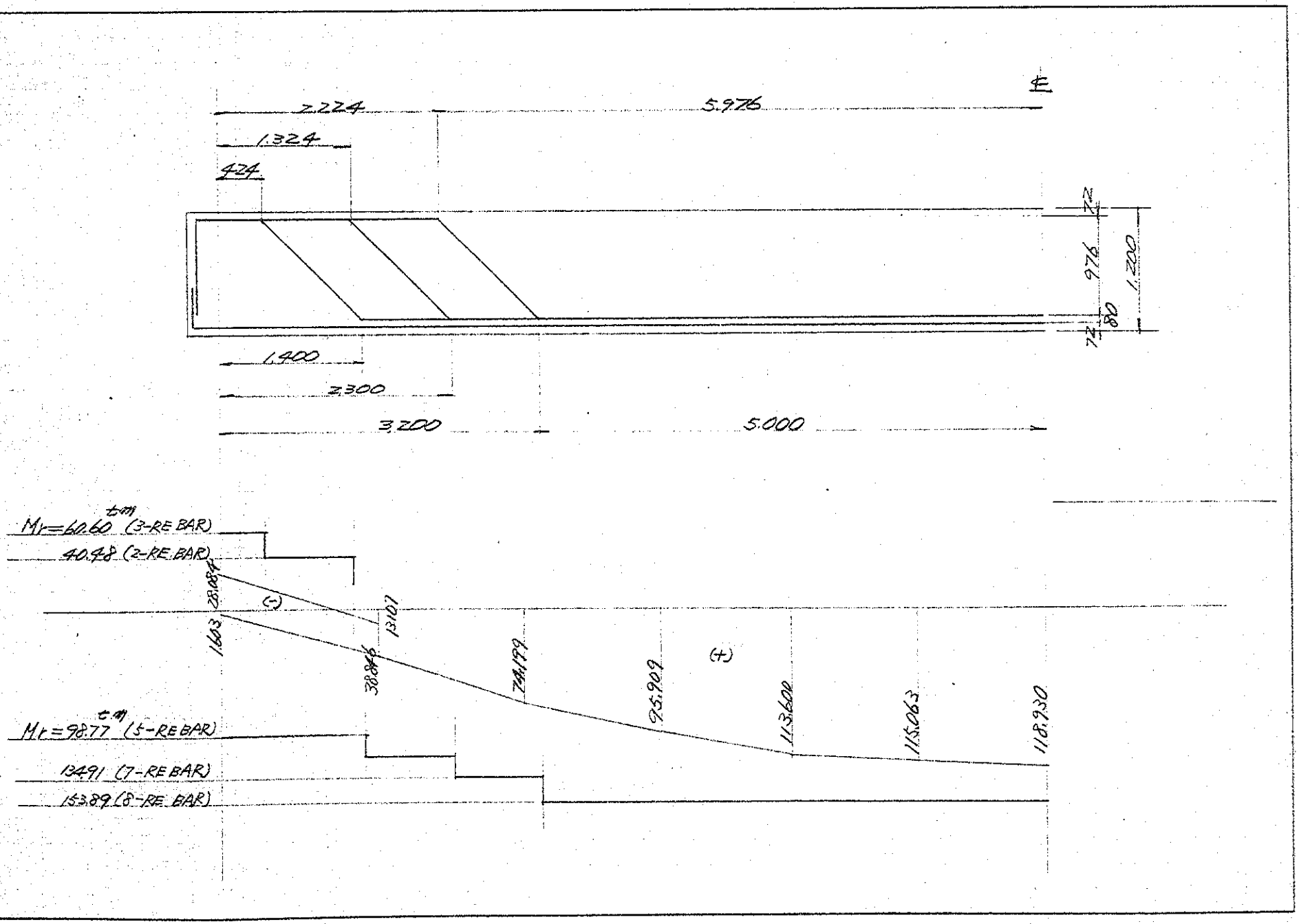
NEUTRAL AXIS IS EXISTED AT WEB

$k = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0267 + \frac{1}{2}(\frac{12}{112.8})^2}{0.0267 + \frac{12}{112.8}}$ $= 0.2431$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{12}{112.8} \times \left\{\frac{3 \times 0.2431 - 2 \times \frac{12}{112.8}}{2 \times 0.2431 - \frac{12}{112.8}}\right\} = 0.9518$

$\sigma_s = \frac{M}{Asjd} = \frac{28.084 \times 10^5}{24.12 \times 0.9518 \times 112.8} = 1.084 < \sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.2431 \times 1.084}{15 \times (1 - 0.2431)} = 23.2 < \sigma_{ca} = 101$ "


E
2.224
5.976
1.324
424
72
976
80
72
1.200
1.400
2.300
3.200
5.000
Mr=60.60 t-m (3-RE BAR)
40.48 (2-RE BAR)
28.084
1.603
13.107
38.846
(-)
(+)
74.199
95.909
113.600
115.063
118.930
Mr=98.77 t-m (5-RE BAR)
134.91 (7-RE BAR)
153.89 (8-RE BAR)

1 POINT Ⓐ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

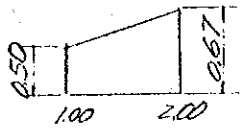
$\frac{100\,Ast}{bd}$ $\quad Ast = 8-\phi 32 = 8\times 8.04 = 64.32\ cm^2$

$b = 30\ cm$

$d' = \frac{7.2\times 5 + 15.2\times 3}{5+3} = 10.2\ cm$

$d = 120 - 10.2 = 109.8\ cm$

$\frac{100\,Ast}{bd} = \frac{100\times 64.32}{30\times 109.8} = 1.953$



$\tau a = \frac{0.17}{1.00}\times 0.953 + 0.50 = 0.662\ N/mm^2$

$= 6.62\ kg/cm^2$

$\therefore Sr_1 = \tau a\, bd = 6.62\times 30\times 109.8\times 10^{-3} = 21.81\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$Sr_2 = \frac{\sigma sa\,(Ab + 0.707\,Av)}{0.707\,V}\,d$

$\sigma sa = 3.637\ kg/cm^2$

$Ab = 0\ cm^2$

$Av = 2-\phi 16 = 2\times 2.01 = 4.02\ cm^2$

$V = 33.55\ cm$

$d = 109.8\ cm$

$\therefore Sr_2 = \frac{3.637\times(0+0.707\times 4.02)}{0.707\times 33.55}\times 109.8\times 10^{-3} = 54.99\ t$

iii) TOTAL RESISTIBLE SHEARING FORCE

$Sr = Sr_1 + Sr_2 = 21.81 + 54.99 = 76.80\ t$

2 POINT Ⓑ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

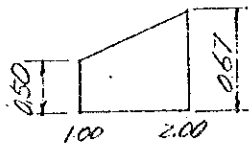
$\frac{100\,Ast}{bd}$ $\quad Ast = 7-\phi 32 = 7\times 8.04 = 56.28\ cm^2$

$b = 30\ cm$

$d' = \frac{7.2\times 5 + 15.2\times 2}{5+2} = 9.5\ cm$

$d = 120 - 9.5 = 110.5\ cm$

$\therefore \frac{100\,Ast}{bd} = \frac{100\times 56.28}{30\times 110.5} = 1.698$



$\tau a = \frac{0.17}{1.00}\times 0.698 + 0.50 = 0.619\ N/mm^2$

$= 6.19\ kg/cm^2$

$\therefore Sr_1 = \tau a\, bd = 6.19\times 30\times 110.5\times 10^{-3} = 20.52\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$Sr_2 = \frac{\sigma sa\,(Ab + 0.707\,Av)}{0.707\,V}\,d$

$\sigma sa = 3.857\ kg/cm^2$

$Ab = 1-\phi 32 = 1\times 8.04 = 8.04\ cm^2$

$Av = 3\times 2\times 2.01 = 12.06\ cm^2$

$V = 90\ cm$

$d = 110.5\ cm$

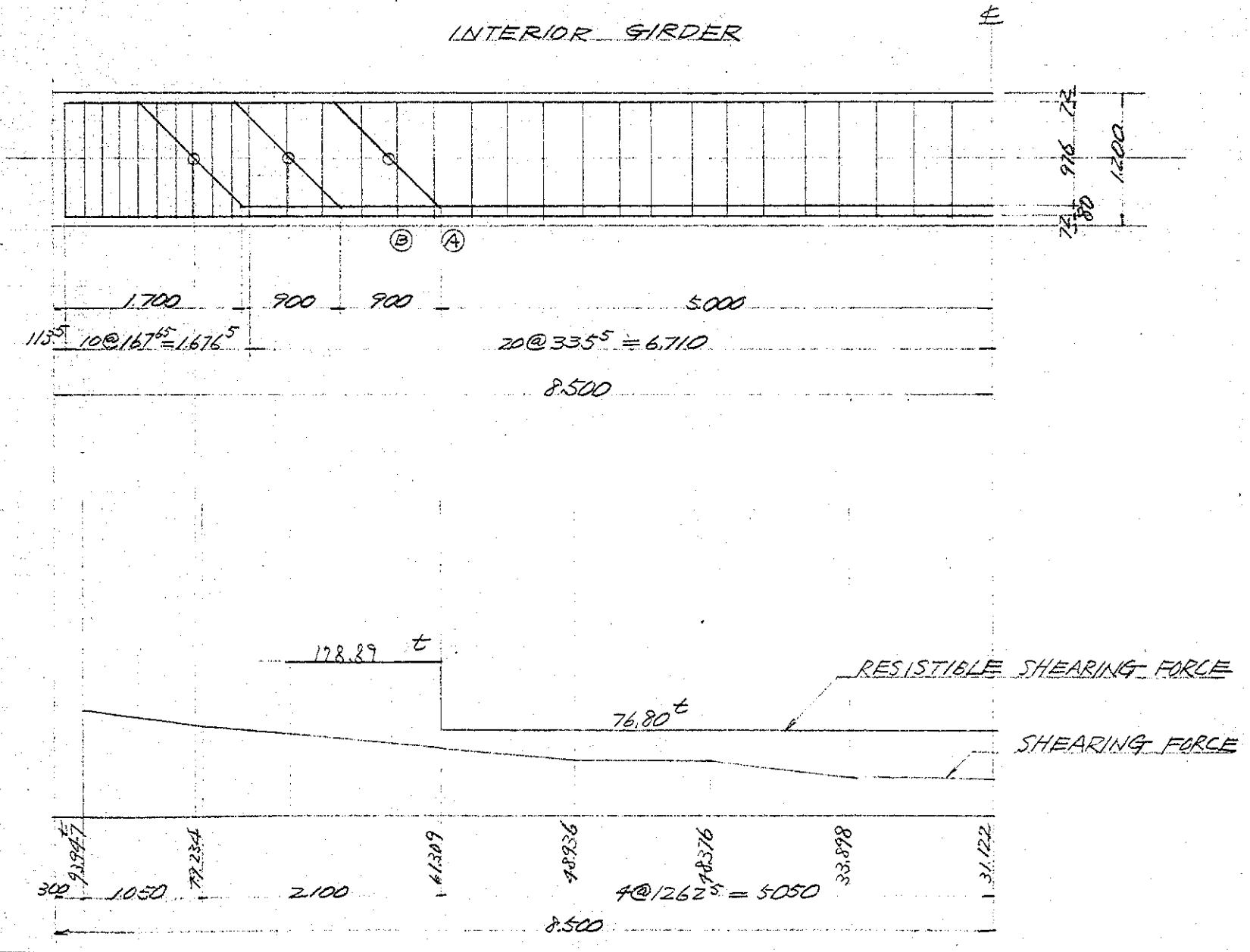
$\therefore Sr_2 = \frac{3.857\times(8.04+0.707\times 12.06)}{0.707\times 90}\times 110.5\times 10^{-3} = 108.37\ t$

iii) TOTAL SHEARING FORCE

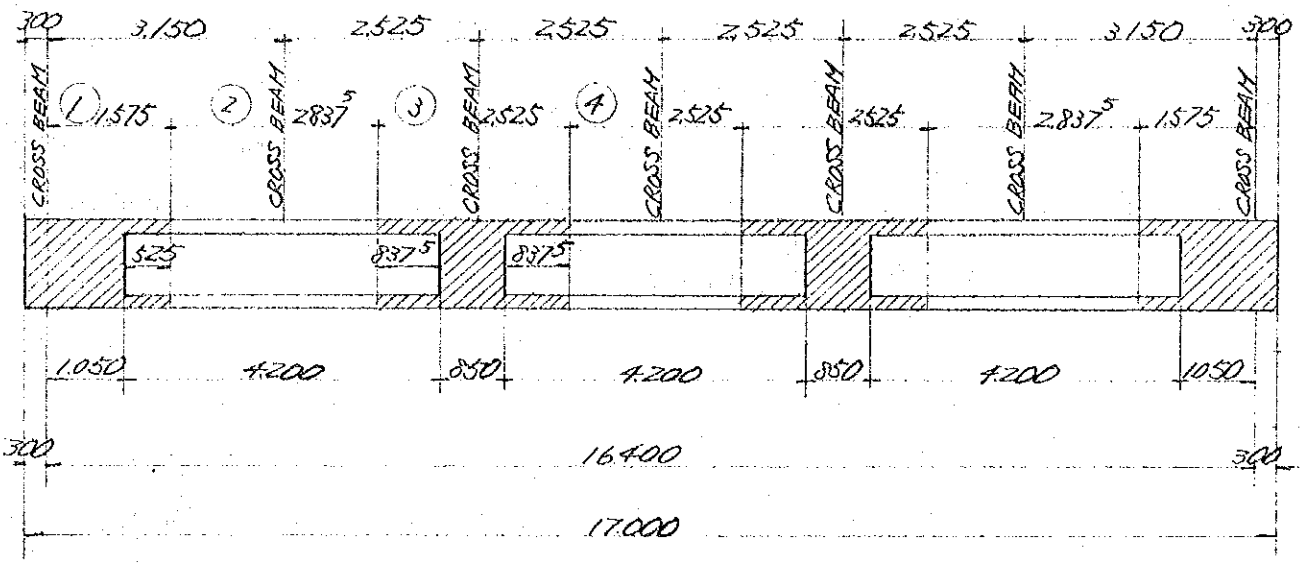
$Sr = Sr_1 + Sr_2 = 20.52 + 108.37 = 128.89\ t$

MJ A-LINE 3 BRIDGE

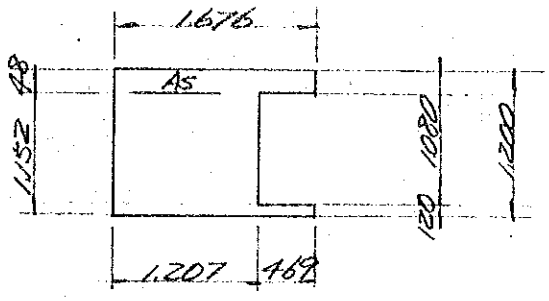
INTERIOR GIRDER



§§ 3 DESIGN OF CROSS BEAM



(1) ◇73 ~ ◇83



$1.875 \times 0.894 = 1.676$

$0.525 \times \,\,\,\, = 0.469$

$1.350 \times \,\,\,\, = 1.207$

RE-BAR $\frac{167.6}{75} = 22$

RESISTIBLE WIDTH 167^{cm}

$M = -72.803^{t\cdot m}$

$d' = \frac{x}{+} + \frac{x}{+} = 4.8^{cm}$

$d = h - d' = 120 - 4.8 = 115.2^{\,"}$

$As = 22 - \phi 16 = 22 \times 2.01 = 44.22^{cm^2}$

$np = \frac{15 \times 44.22}{167 \times 115.2} = 0.0345$

$x = \frac{n d As + b t^2}{n As + b t} = \frac{15 \times 115.2 \times 44.22 + 167 \times \frac{12^2}{2}}{15 \times 44.22 + 167 \times 12} = 33.16^{cm}$

NEUTRAL AXIS IS EXISTED AT WEB

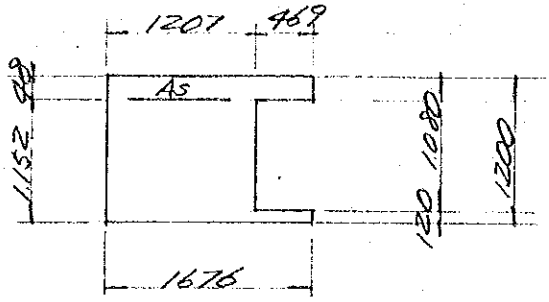
$k_e = \frac{np + \frac{1}{2}\left(\frac{t}{d}\right)^2}{np + \frac{t}{d}} = \frac{0.0345 + \frac{1}{2}\left(\frac{12}{115.2}\right)^2}{0.0345 + \frac{12}{115.2}} = 0.2879$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k_e - 2\frac{t}{d}}{2k_e - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{12}{115.2} \times \left\{\frac{3 \times 0.2879 - 2 \times \frac{12}{115.2}}{2 \times 0.2879 - \frac{12}{115.2}}\right\} = 0.9518$

$\sigma_s = \frac{M}{As\,j\,d} = \frac{72.803 \times 10^5}{44.22 \times 0.9518 \times 115.2} = 1.502 < \sigma_{sa} = 2340^{kg/cm^2}$

$\sigma_c = \frac{k_e}{n(1-k_e)}\sigma_s = \frac{0.2879 \times 1.502}{15 \times (1 - 0.2879)} = 40.5 < \sigma_{ca} = 101^{\,"}$

(2) ◇73 ~ ◇83



RE-BAR $\frac{1676}{15} = 11$

RESISTISLE WIDTH 167 cm

$M = -28.897$ t-m

$d' = \frac{x \cdot t}{t} \cdot \frac{x}{\quad}$ $= 4.8$ cm

$d = h - d' = 120 - 4.8$ $= 115.2$ "

$As = 11 - \phi 16 = 11 \times 2.01$ $= 22.11$ cm²

$np = \frac{15 \times 22.11}{167 \times 115.2}$ $= 0.0172$

$x = \frac{n d As + b t^2}{n As + b t} = \frac{15 \times 115.2 \times 22.11 + 167 \times \frac{12^2}{2}}{15 \times 22.11 + 167 \times 12}$ $= 21.51$ cm

NEUTRAL AXIS IS EXISTED AT WEB

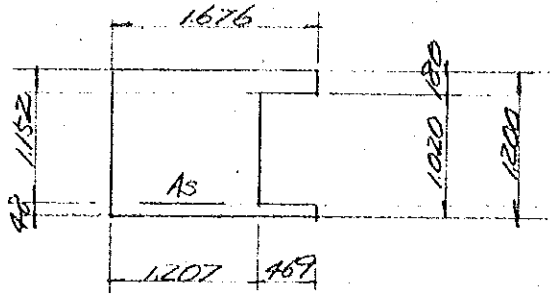
$fc = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0172 + \frac{1}{2}(\frac{12}{115.2})^2}{0.0172 + \frac{12}{115.2}}$ $= 0.1864$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3fc - 2\frac{t}{d}}{2fc - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{12}{115.2} \times \left\{\frac{3 \times 0.1864 - 2 \times \frac{12}{115.2}}{2 \times 0.1864 - \frac{12}{115.2}}\right\} = 0.9546$

$\sigma_s = \frac{M}{As\,jd} = \frac{28.897 \times 10^5}{22.11 \times 0.9546 \times 115.2} = 1.188 < \sigma_{sa} = 2,340$ kg/cm²

$\sigma_c = \frac{fc}{n(1-fc)}\sigma_s = \frac{0.1864 \times 1.188}{15 \times (1 - 0.1864)} = 18.1 < \sigma_{ca} = 101$ "

(3) ◇73 ~ ◇83



RE-BAR $= \frac{1676}{15} = 11$

RESISTIBLE WIDTH 167 cm

$M = +26.517$ t·m

$d' = \frac{x \cdot \frac{x}{2}}{x} = 48$ cm

$d = h - d' = 120 - 48 = 115.2$ "

$As = 11 - \phi 16 = 11 \times 2.01 = 22.11$ cm²

$np = \frac{15 \times 22.11}{167 \times 115.2} = 0.0172$

$x = \frac{ndAs + b\frac{t^2}{2}}{nAs + bt} = \frac{15 \times 115.2 \times 22.11 + 167 \times \frac{18^2}{2}}{15 \times 22.11 + 167 \times 18} = 19.55$ cm

NEUTRAL AXIS IS EXISTED AT WEB

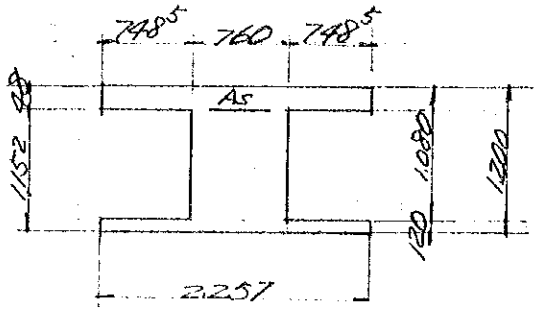
$k = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0172 + \frac{1}{2}(\frac{18}{115.2})^2}{0.0172 + \frac{18}{115.2}} = 0.1695$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{18}{115.2} \times \left\{\frac{3 \times 0.1695 - 2 \times \frac{18}{115.2}}{2 \times 0.1695 - \frac{18}{115.2}}\right\} = 0.9441$

$\sigma_s = \frac{M}{As \cdot j \cdot d} = \frac{26.517 \times 10^5}{22.11 \times 0.9441 \times 115.2} = 1.103 < \sigma_{sa} = 2.340$ kg/cm²

$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.1695 \times 1103}{15 \times (1 - 0.1695)} = 15.0 < \sigma_{ca} = 101$ "

(4) ◇95 ~ ◇105



2.525 × 0.894 = 2.257

0.8375 × 〃 = 0.7485

0.850 × 〃 = 0.760

RE-BAR $\frac{225}{15}$ = 15

RESISTIBLE WIDTH 225 cm

$M = -33.242$ t·m

$d' = \frac{x + x}{+}$ = 4.8 cm

$d = h - d' = 120 - 4.8$ = 115.2 〃

$As = 15 - \phi 16 = 15 \times 2.01$ = 30.15 cm²

$np = \frac{15 \times 30.15}{225 \times 115.2}$ = 0.0174

$x = \frac{ndAs + bt^2}{nAs + bt} = \frac{15 \times 115.2 \times 30.15 + 225 \times \frac{12^2}{2}}{15 \times 30.15 + 225 \times 12}$ = 21.67 cm

NEUTRAL AXIS IS EXISTED AT WEB

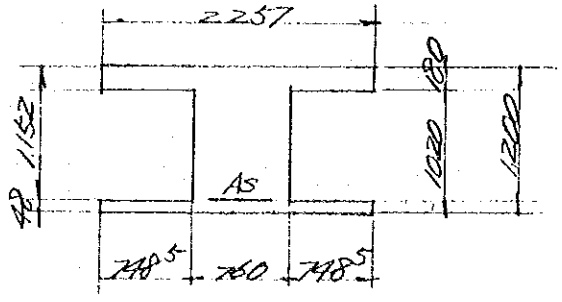
$fe = \frac{np + \frac{1}{2}(\frac{t}{d})^2}{np + \frac{t}{d}} = \frac{0.0174 + \frac{1}{2}(\frac{12}{115.2})^2}{0.0174 + \frac{12}{115.2}}$ = 0.1878

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3fe - 2\frac{t}{d}}{2fe - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{12}{115.2} \times \left\{\frac{3 \times 0.1878 - 2 \times \frac{12}{115.2}}{2 \times 0.1878 - \frac{12}{115.2}}\right\} = 0.9546$

$\sigma_s = \frac{M}{As \cdot j \cdot d} = \frac{33.242 \times 10^5}{30.15 \times 0.9546 \times 115.2} = 1003 < \sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \frac{fe}{n(1 - fe)} \sigma_s = \frac{0.1878 \times 1003}{15 \times (1 - 0.1878)} = 15.5 < \sigma_{ca} = 101$ 〃

(5) ◇95 ~ ◇105



RESISTIBLE WIDTH 225 cm

$M = 27.416$ t·m

$d' = \frac{x}{t} \; t \; \frac{x}{}$ $= 4.8$ cm

$d = h - d' = 120 - 4.8$ $= 115.2$ "

$As = 15 - \phi 16 = 15 \times 2.01$ $= 30.15$ cm²

$np = \frac{15 \times 30.15}{225 \times 115.2}$ $= 0.0174$

$x = \frac{nd\,As + b\frac{t^2}{2}}{n\,As + bt} = \frac{15 \times 115.2 \times 30.15 + 225 \times \frac{18^2}{2}}{15 \times 30.15 + 225 \times 18}$ $= 19.67$ cm

NEUTRAL AXIS IS EXISTED AT WEB

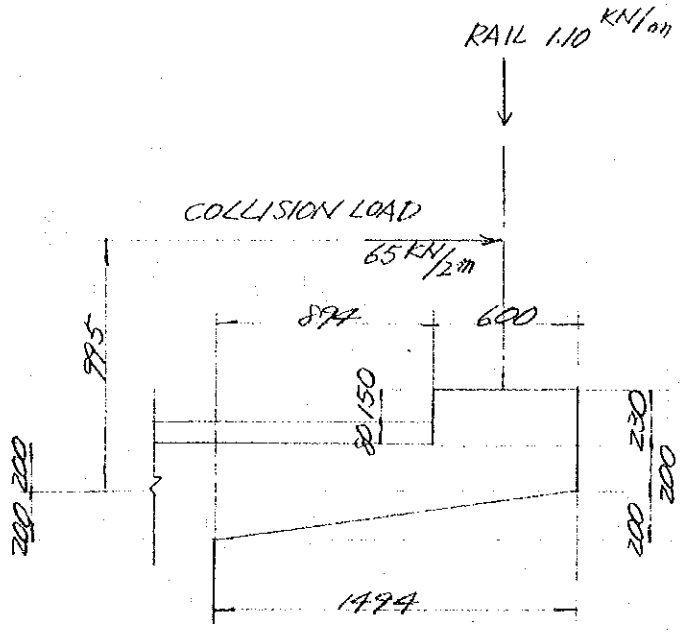
$k_c = \frac{np + \frac{1}{2}\left(\frac{t}{d}\right)^2}{np + \frac{t}{d}} = \frac{0.0174 + \frac{1}{2}\left(\frac{18}{115.2}\right)^2}{0.0174 + \frac{18}{115.2}}$ $= 0.1705$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k_c - 2\frac{t}{d}}{2k_c - \frac{t}{d}}\right\} = 1 - \frac{1}{3} \times \frac{18}{115.2} \times \left\{\frac{3 \times 0.1705 - 2 \times \frac{18}{115.2}}{2 \times 0.1705 - \frac{18}{115.2}}\right\} = 0.9439$

$\sigma_s = \frac{M}{As\,jd} = \frac{27.416 \times 10^5}{30.15 \times 0.9439 \times 115.2} = 836 < \sigma_{sa} = 2{,}340$ kg/cm²

$\sigma_c = \frac{k_c}{n(1-k_c)}\sigma_s = \frac{0.1705 \times 836}{15 \times (1 - 0.1705)} = 11.5 < \sigma_{ca} = 101$ "

§§ 4 DESIGN OF CANTILEVER SLAB



	FORCE (KN)	ARM (m)	M (KN.m)
RAIL	1.10	1.194	1.313
KERB	0.6×0.23×23.6 = 3.257	1.194	3.889
WEARING	0.08×0.894×22.6 = 1.616	0.447	0.722
SLAB	0.20×1.494×23.6 = 7.052	0.747	5.268
SLAB	0.20×1.494×½×23.6 = 3.526	0.498	1.756
LIVE LOAD	※ 112.50	—	35.810
	ΣV = 129.051		—
COLLISION LOAD	$\frac{6500}{z}$	× 0.995	32.338
	ΣH = 32.500	ΣM =	81.096

※ BENDING MOMENT DUE TO LIVE LOAD

$$M_z = \frac{P}{\pi} \frac{1}{1+\left(\frac{y}{u}\right)^2}$$

$P = 112.5$ KN.

$y = 0$

$u = 0.894 - 0.250 = 0.694$

$$\therefore M_z = \frac{112.5}{\pi} = 35.810 \text{ KN m}$$

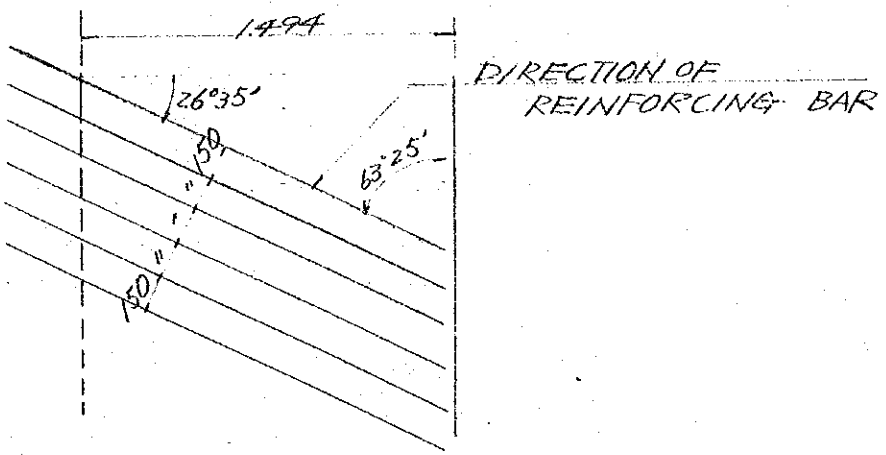
※ COLLISION LOAD ARM $\frac{1}{3}(0.71+0.995+1.280)=0.995$

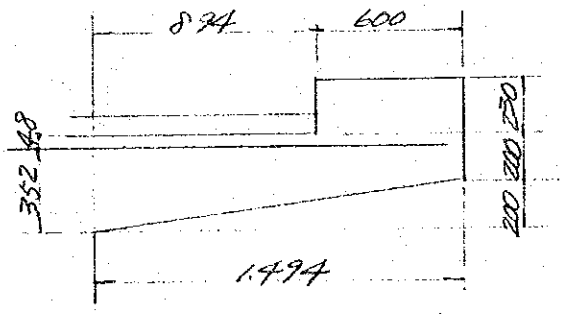
POST INTERVAL 2.00 m

$S=\frac{1}{1.25}\times 129.051=103.24^{KN}=10.53^{t}$

$M=\ \ "\ \times 81.096=64.88^{KN-m}=6.62^{t-m}$

N = NEGLECTED





$As=(6.67-\phi 16)\times\cos(26°-35')=6.67\times 2.01\times 0.894=11.99^{cm^2}$

$np=\frac{15\times 11.99}{100\times 35.2}=0.051$

$ke=\sqrt{2np+(np)^2}-np=\sqrt{2\times 0.051+0.051^2}-0.051=0.272$

$j=1-\frac{ke}{3}=1-\frac{0.272}{3}=0.909$

$\sigma_c=\frac{2M}{kejbd^2}=\frac{2\times 6.62\times 10^5}{0.272\times 0.909\times 100\times 35.2^2}=43.2^{kg/cm^2}<\sigma_{ca}=101^{kg/cm^2}$

$\sigma_s=n\sigma_c\frac{1-ke}{ke}=15\times 43.2\times\frac{1-0.272}{0.272}=1.734^{"}<\sigma_{sa}=2340^{"}$

$\tau=\frac{S}{bj}=\frac{10.53\times 10^3}{100\times 35.2}=2.99^{kg/cm^2}$

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

CONTENTS

§§ 1 DESIGN CONDITION

§ I. DESIGN CONDITION

TYPE	RC SIMPLE VOIDED SLAB BRIDGE
BRIDGE LENGTH	17 292
GIRDER LENGTH	17 192
SPAN	17 592
WIDTH	8 900
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

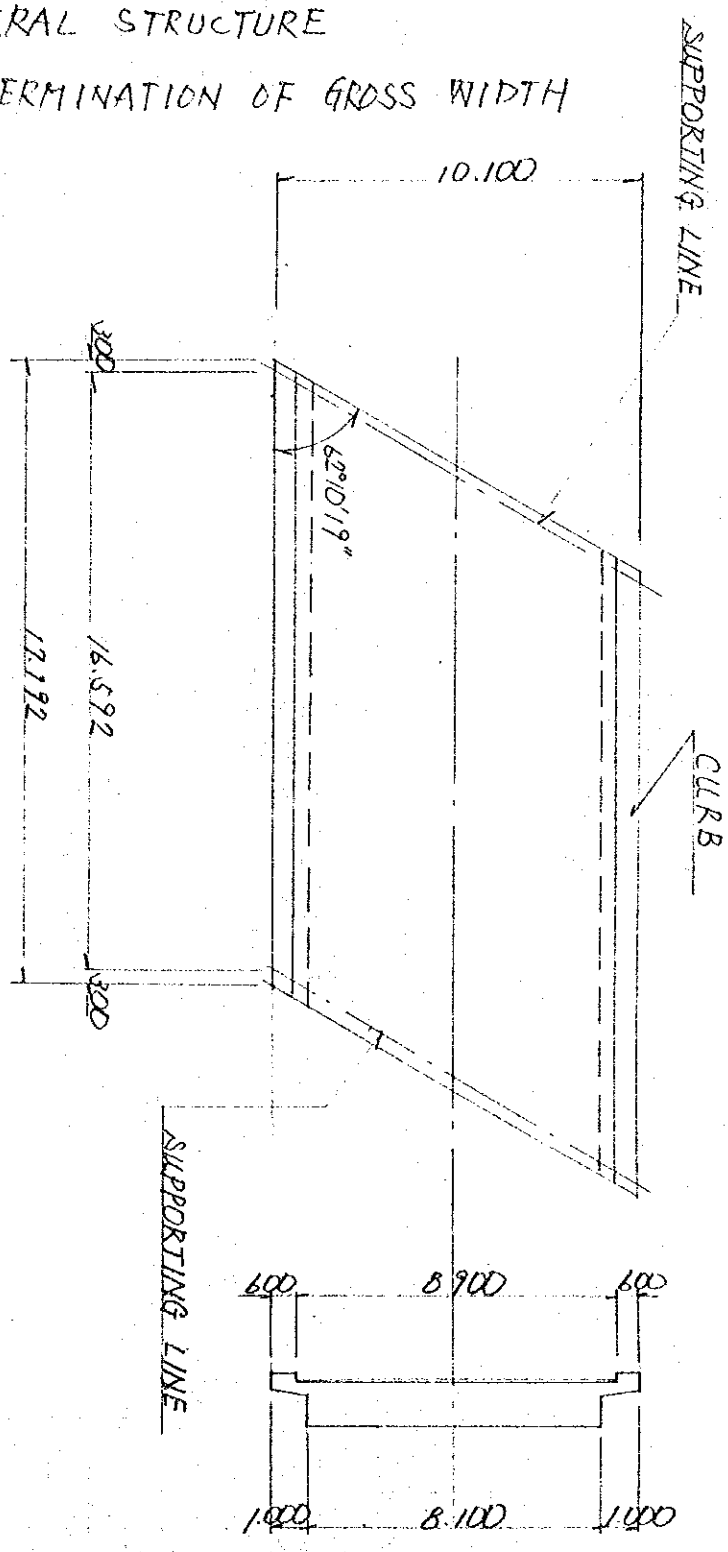
f_{sa} = 230 N/mm^2 (2340 kg/cm^2)

§§ 2 DESIGN OF MAIN SLAB

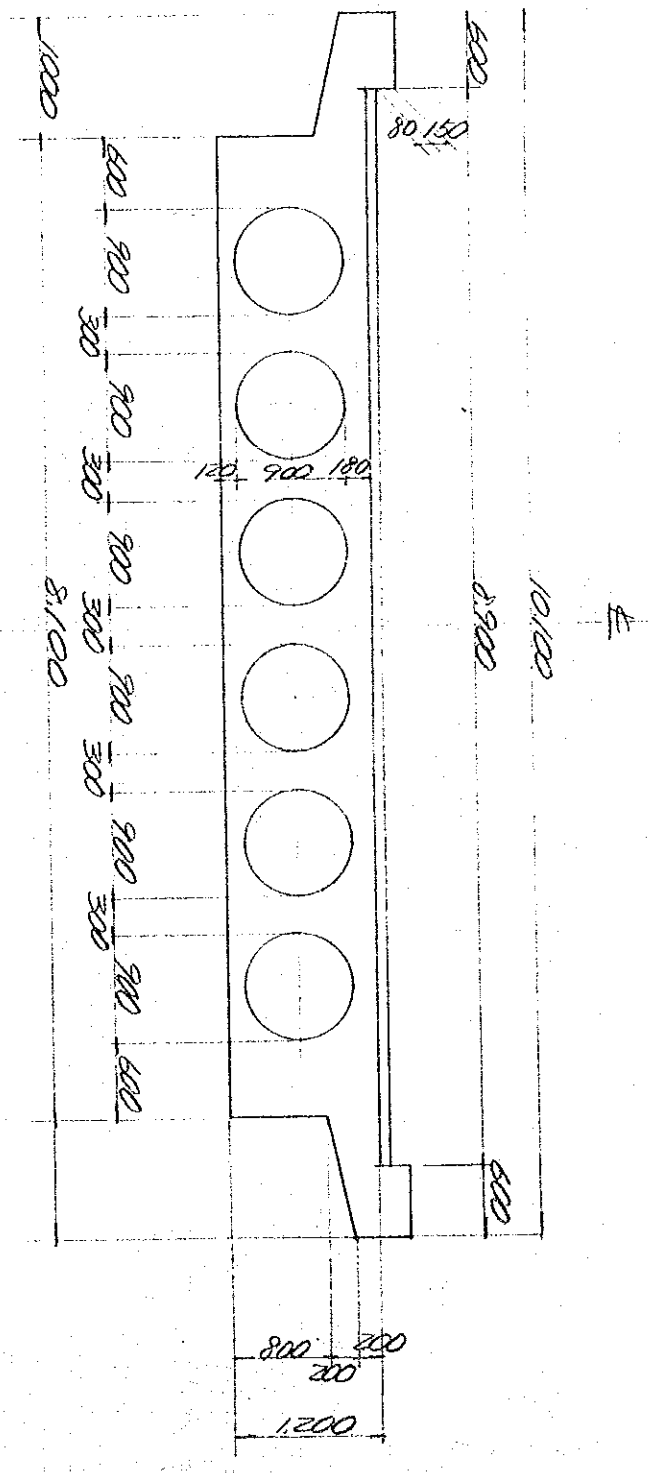
§1 PREPARATION

1. GENERAL STRUCTURE

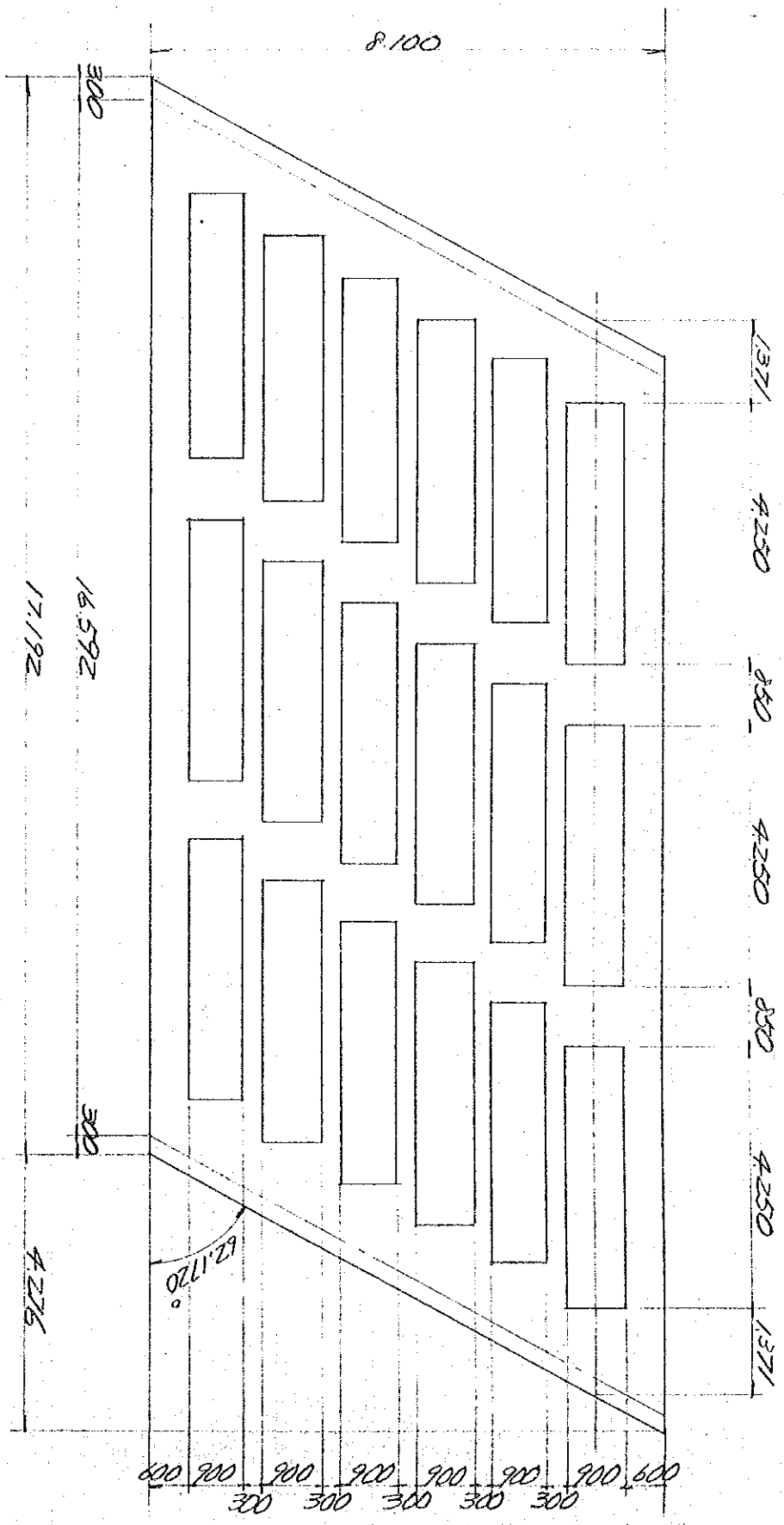
(1) DETERMINATION OF GROSS WIDTH



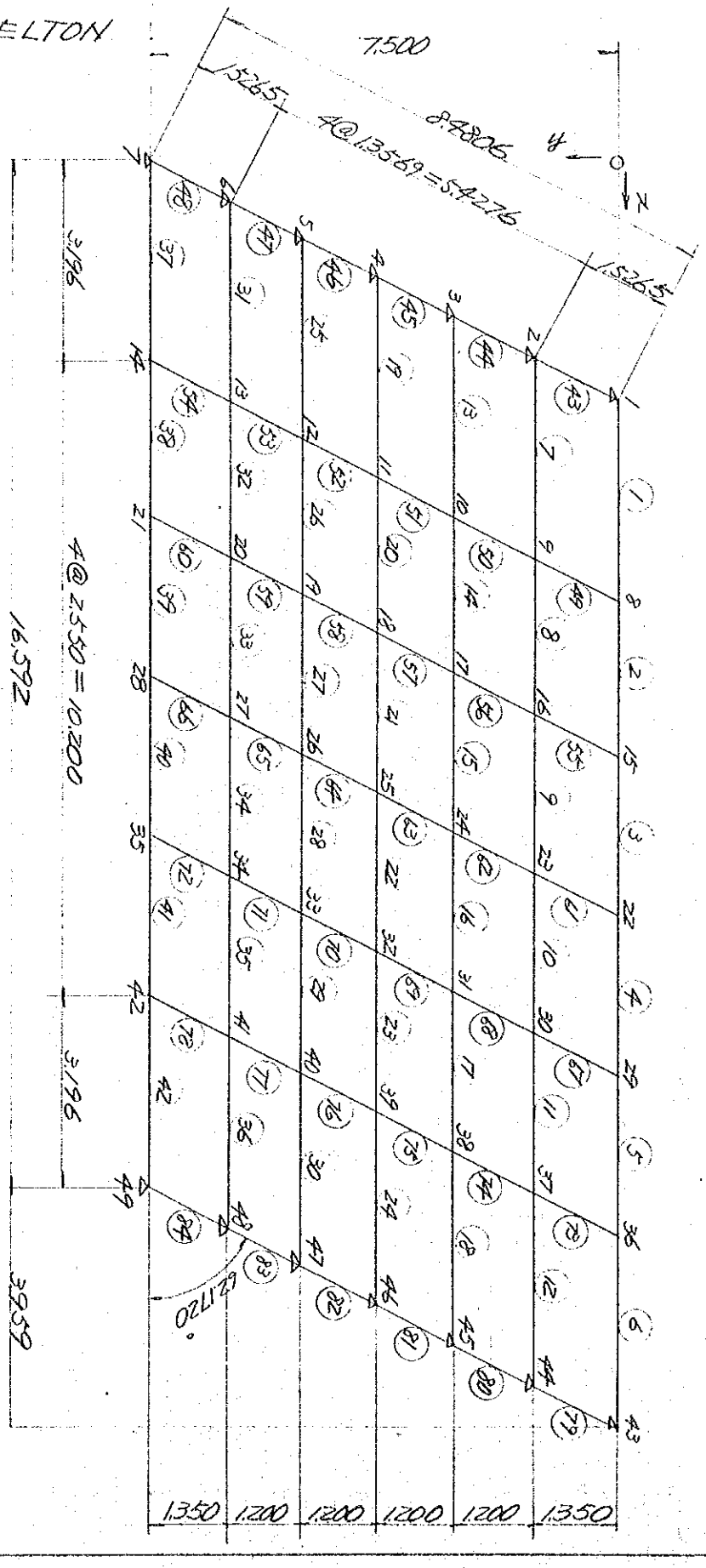
(2) SECTION


1000
600
900
300
900
300
700
300
700
300
700
300
600
8100
80 150
120 900 180
8300
10100
600
800
200
200
1200

(3) PLAN


8.100
300
16.592
17.192
300
4.276
62.1720°
1371
4250
450
4250
450
4250
1371
600 900 900 900 900 900 900 600
300 300 300 300 300

(4) SKELTON


7.500
5265
4@1.3569=5.4276
8.4806
5265
3196
4@2.550=10.200
16.592
3196
3252
62°20'
1350
1200
1200
1200
1200
1350

CO-ORDINATE

	X	Y		X	Y
1	3.959	0	26	9.642	4.950
2	3.246	1.350	27	9.009	6.150
3	2.613	2.550	28	8.296	7.500
4	1.979	3.750	29	14.805	0
5	1.346	4.950	30	14.092	1.350
6	0.713	6.150	31	13.459	2.550
7	0	7.500	32	12.825	3.750
8	7.155	0	33	12.192	4.950
9	6.442	1.350	34	11.559	6.150
10	5.809	2.550	35	10.846	7.500
11	5.175	3.750	36	17.355	0
12	4.542	4.950	37	16.642	1.350
13	3.909	6.150	38	16.009	2.550
14	3.196	7.500	39	15.375	3.750
15	9.705	0	40	14.742	4.950
16	8.992	1.350	41	14.109	6.150
17	8.359	2.550	42	13.396	7.500
18	7.725	3.750	43	20.551	0
19	7.092	4.950	44	19.838	1.350
20	6.459	6.150	45	19.205	2.550
21	5.746	7.500	46	18.571	3.750
22	12.255	0	47	17.938	4.950
23	11.542	1.350	48	17.305	6.150
24	10.909	2.550	49	16.592	7.500
25	10.275	3.750			

2. CALCULATION OF I AND J OF MAIN GIRDER

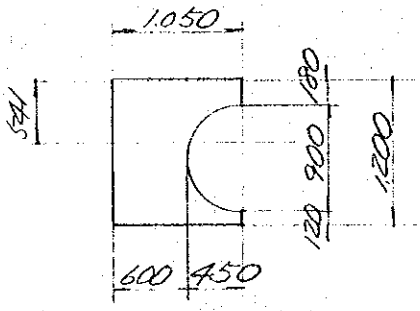
(1) CENTER OF GRAVITY IN TOTAL SECTION

	$b \times h = A$	y	Ay
(1)	$8.10 \times 1.20 = 9.720$	0.60	5.8320
(2)	$1.00 \times 0.20 \times 2 = 0.400$	0.10	0.0400
(3)	$\frac{1.00 \times 0.20}{2} \times 2 = 0.200$	0.267	0.0534
(4)	$-0.45^2 \pi \times 6 = -3.817$	0.63	-2.4047
Σ	6.503		3.5207

$$y_G = \frac{3.5207}{6.503} = 0.541\ m$$

(2) CALCULATION OF I

EDGE CIRDER



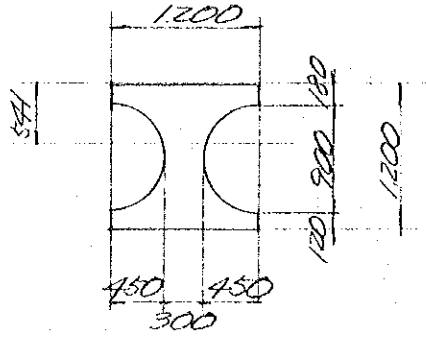
	$b \times h = A$	y	Ay	Ay^2	I_G
(1)	$1.05 \times 1.20 = 1.260$	0.60	0.756	0.4536	0.1512
(2)	$-0.45^2 \times \frac{\pi}{2} = -0.318$	0.63	-0.200	-0.1262	-0.0161
Σ	0.942		0.556	0.3274	0.1351

$$y_G' = \frac{0.556}{0.942} = 0.590\ m \qquad \Delta y = 0.590 - 0.541 = 0.049\ m$$

$$I_G = 0.1351 + 0.3274 - 0.942 \times 0.590^2 = 0.1346\ m^4$$

$$I_o = 0.1346 + 0.942 \times 0.049^2 = 0.1369\ m^4$$

INTERIOR GIRDER



	$b \times h_2 = A$	y	Ay	Ay^2	I_G
(1)	$1.20 \times 1.20 = 1.440$	0.60	0.864	0.5184	0.1728
(2)	$-0.45^2 \times \pi = -0.636$	0.63	-0.401	-0.2524	-0.0322
Σ	0.804		0.463	0.2660	0.1406

$$y_G = \frac{0.463}{0.804} = 0.576^{m} \qquad \Delta y = 0.576 - 0.541 = 0.035^{m}$$

$$I_G = 0.1406 + 0.2660 - 0.804 \times 0.576^2 = 0.1399^{m^4}$$

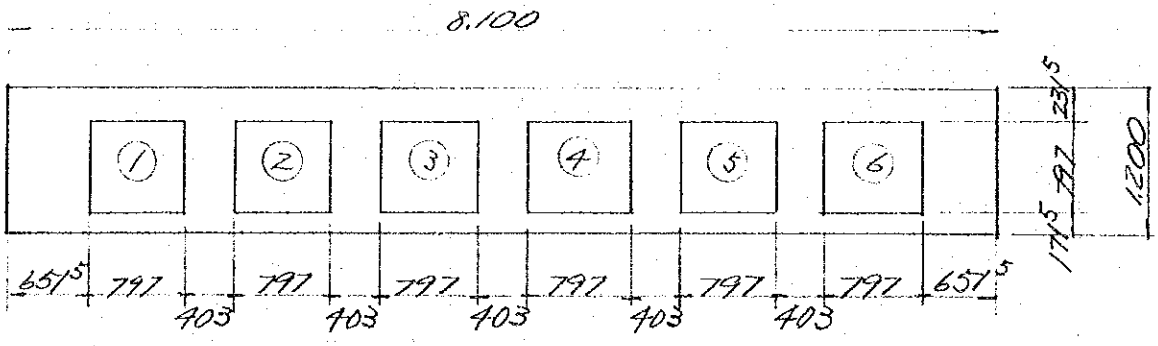
$$I_o = 0.1399 + 0.804 \times 0.035^2 = 0.1409^{m^4}$$

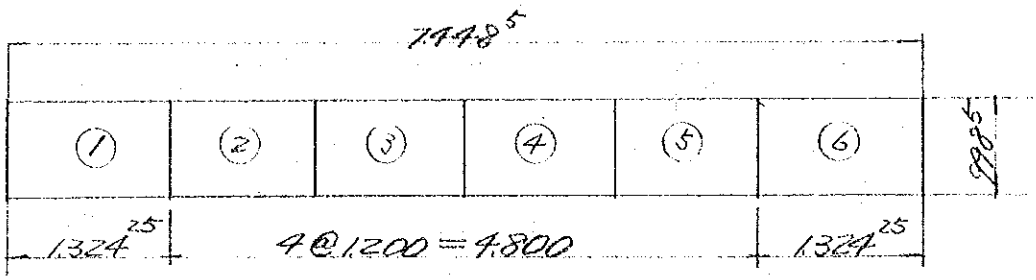
(3) TORSIONAL RIGIDITY J

AREA OF HOLLOW CIRCLE $A = 0.45^2\pi = 0.636^{m^2}$

EQUIVALENT SQUARE $a = \sqrt{0.636} = 0.797^{m}$

$\Delta b = (0.90 - 0.797) \times 1/2 = 0.0515^{m}$





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

X_i IS OBTAINED SOLVING FOLLOWING SIMULTANEOUS EQUATIONS

	X_1	X_2	X_3	X_4	X_5	X_6	= 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}	a_{45}		$2F_4$
(5)				a_{54}	a_{55}	a_{56}	$2F_5$
(6)					a_{65}	a_{66}	$2F_6$

WHERE

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

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

$$a_{11} = a_{66} = \frac{0.998^5}{0.651^5} + \frac{0.998^5}{0.403} + \frac{1.324^{25}}{0.231^5} + \frac{1.324^{25}}{0.171^5}$$

$$= 1.533 + 2.478 + 5.720 + 7.722 \qquad = 17.453$$

$$a_{22} = \cdots a_{55} = \frac{0.998^5}{0.403} \times 2 + \frac{1.200}{0.231^5} + \frac{1.200}{0.171^5}$$

$$= 4.955 + 5.184 + 6.997 \qquad = 17.136$$

$$a_{12} = a_{21} = \cdots a_{56} = a_{65} = -\frac{0.998^5}{0.403} = -2.478$$

$F_i = b_i h_i$

$F_1 = F_6 = 1.324^{25} \times 0.998^5 = 1.322 \qquad 2F_1 = 2 \times 1.322 = 2.644$

$F_2 = \cdots F_5 = 1.200 \times 0.998^5 = 1.198 \qquad 2F_2 = 2 \times 1.198 = 2.396$

	X_1	X_2	X_3	X_4	X_5	X_6	$= A$
①	17.453	-2.478					2.644
②	-2.478	17.136	-2.478				2.396
③		-2.478	17.136	-2.478			2.396
④			-2.478	17.136	-2.478		2.396
⑤				-2.478	17.136	-2.478	2.396
⑥					-24.78	17.453	2.644

$X_1 = X_6 = 0.1791$

$X_2 = X_5 = 0.1941$

$X_3 = X_4 = 0.1963$

$$J = 2\sum_{i=1}^{6} X_i F_i = 2\{0.1791 \times 1.322 \times 2 + (0.1941 + 0.1963) \times 2 \times 1.198\}$$

$$= 2(0.4735 + 0.9354) = 2.8178$$

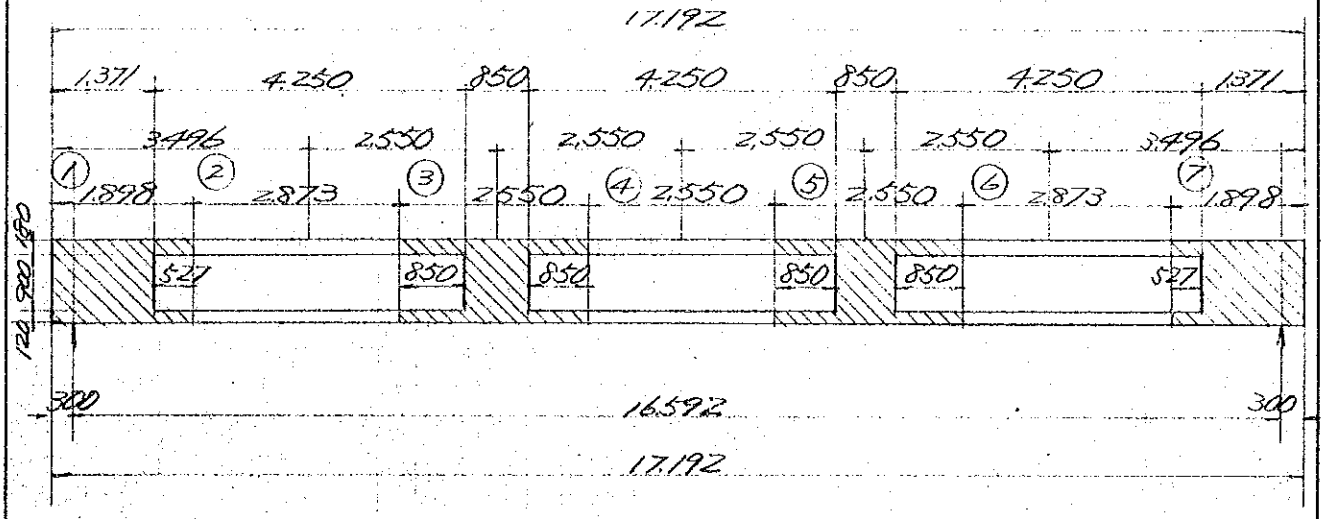
TORSIONAL RIGIDITY PER A MAIN GIRDER

$$J = \frac{\mathcal{J}}{n} = \frac{2.8178}{7} = 0.4025 \ m^4$$

2. CALCULATION OF I AND J OF TRANSVERSE BEAM

(1) CALCULATION OF I

1) CENTER OF GRAVITY IN TOTAL SECTION

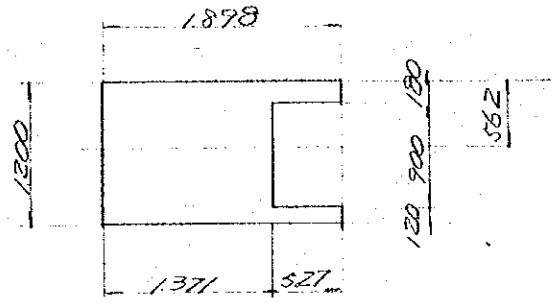


	b x h = A	y	Ay
(1)	17.192 x 1.20 = 20.630	0.60	12.378
(2)	-12.75 x 0.90 = -11.475	0.63	-7.229
Σ	9.155		5.149

$$y_G = \frac{5.149}{9.155} = 0.562\ m$$

ii) CALCULATION OF I

(1) (7)



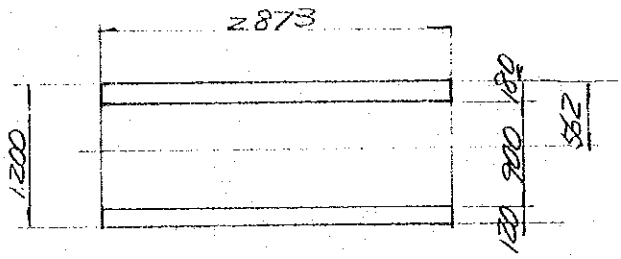
	b x h = A	y	Ay	Ay²	I_G
(1)	1.898 x 1.20 = 2.278	0.60	1.367	0.8201	0.2733
(2)	-0.527 x 0.90 = -0.474	0.63	-0.299	-0.1881	-0.0320
Σ	1.804		1.068	0.6320	0.2413

$$y_G = \frac{1.068}{1.804} = 0.592\ m \qquad \Delta y = 0.592 - 0.562 = 0.030\ m$$

$$I_G = 0.2413 + 0.6320 - 1.804 \times 0.592^2 = 0.2411\ m^4$$

$$I_o = 0.2411 + 1.804 \times 0.030^2 = 0.2427\ m^4$$

(2) (6)



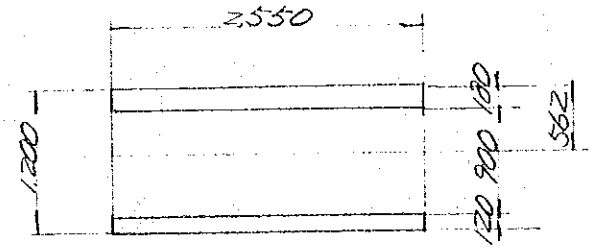
	$b \times h = A$	y	Ay	Ay^2	I_G
①	$2.873 \times 1.20 = 3.448$	0.60	2.069	1.2413	0.4137
②	$-2.873 \times 0.90 = -2.586$	0.63	-1.629	-1.0264	-0.1745
Σ	0.862		0.440	0.2149	0.2392

$$y_G = \frac{0.440}{0.862} = 0.510^{m} \qquad \Delta y = 0.562 - 0.510 = 0.052^{m}$$

$$I_G = 0.2392 + 0.2149 - 0.862 \times 0.510^2 = 0.2299^{m^4}$$

$$I_o = 0.2299 + 0.862 \times 0.052^2 = 0.2322^{m^4}$$

④



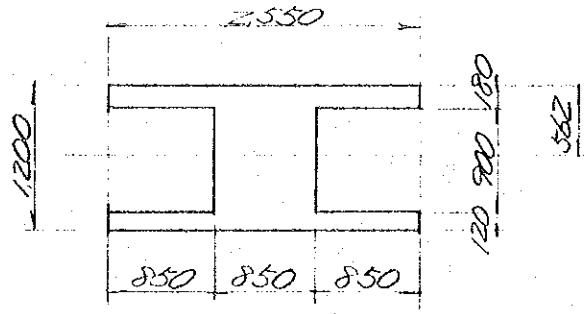
	$b \times h = A$	y	Ay	Ay^2	I_G
①	$2.55 \times 1.20 = 3.060$	0.60	1.836	1.1016	0.3672
②	$-2.55 \times 0.90 = -2.295$	0.63	-1.446	-0.9109	-0.1549
Σ	0.765		0.390	0.1907	0.2123

$$y_G = \frac{0.390}{0.765} = 0.510^{m} \qquad \Delta y = 0.562 - 0.510 = 0.052^{m}$$

$$I_G = 0.2123 + 0.1907 - 0.765 \times 0.510^2 = 0.2040^{m^4}$$

$$I_o = 0.2040 + 0.765 \times 0.052^2 = 0.2061^{m^4}$$

③ ⑤



	$b \times h = A$	y	Ay	Ay^2	I_G
①	$2.55 \times 1.20 = 3.060$	0.60	1.836	1.1016	0.3672
②	$-1.70 \times 0.90 = -1.530$	0.63	−0.964	−0.6073	−0.1033
Σ	1.530	.	0.872	0.4943	0.2639

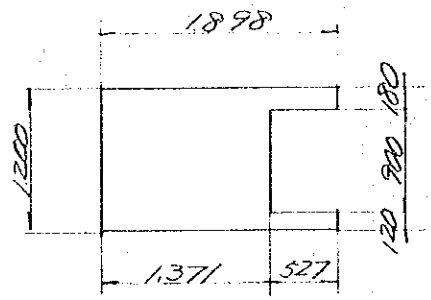
$$y_G' = \frac{0.872}{1.530} = 0.570^m \qquad \Delta y = 0.570 - 0.562 = 0.008^m$$

$$I_G = 0.2639 + 0.4943 - 1.530 \times 0.570^2 = 0.2611^{m4}$$

$$I_o = 0.2611 + 1.530 \times 0.008^2 = 0.2612^{m4}$$

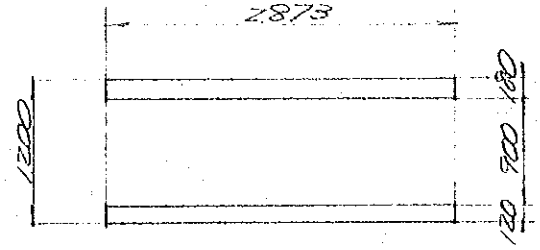
(2) CALCULATION OF TORSIONAL RIGIDITY

① ⑦



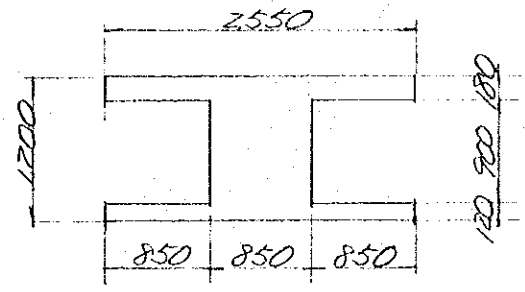
B	t	B/t	β	$\beta B t^3$
1.898	0.18	10.544	0.312	0.0035
1.371	0.90	1.523	0.198	0.1979
1.898	0.12	15.817	0.312	0.0010
Σ	.			0.2024

(2) (6)



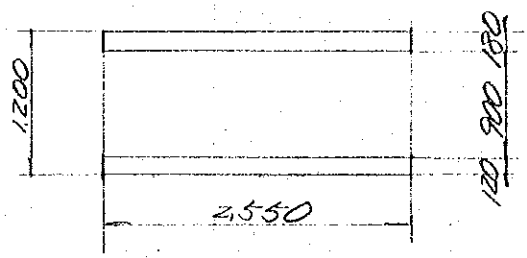
B	t	B/t	β	$\beta B t^3$
2.873	0.18	15.961	0.312	0.0052
2.873	0.12	23.942	0.312	0.0015
Σ				0.0067

(3) (5)



B	t	B/t	β	$\beta B t^3$
2.55	0.18	14.167	0.312	0.0046
0.90	0.85	1.059	0.149	0.0824
2.55	0.12	21.250	0.312	0.0014
Σ				0.0884

(4)

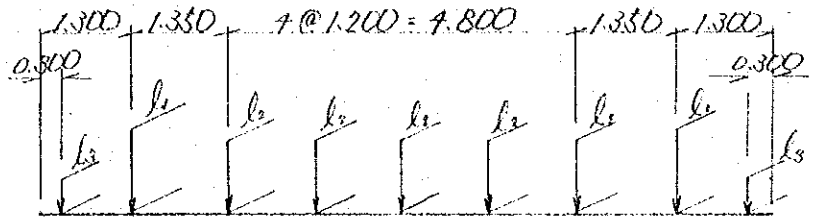


B	t	B/t	β	$\beta B t^3$
2.55	0.18	14.167	0.312	0.0046
2.55	0.12	21.250	0.312	0.0014
Σ				0.0060

MEMBER No.	I (m⁴)	J (m⁴)
①~⑥, ㊲~㊷	0.1369	0.4025
⑦~㊱	0.1409	0.4025
㊸~㊽, ㊾~㊾	0.2427	0.2024
㊾~㊾, ㊸~㊽	0.2322	0.0067
㊺~㊿, ㊼~㊷	0.2612	0.0884
㊶~㊻	0.2061	0.0060

3. DEAD LOAD

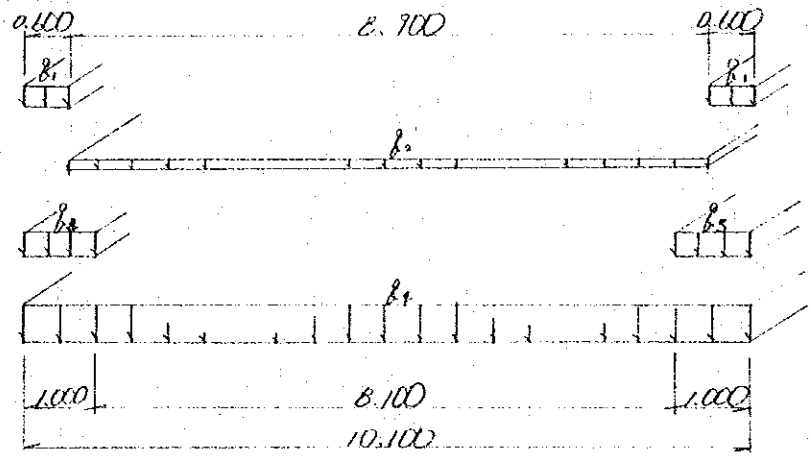
1) LINE LOAD



$l_1 = 17.769$ KN/m
$l_2 = 9.540$ KN/m — MAIN BEAM

$l_3 = 1.100$ KN/m — HAND RAIL

2) UNIFORM LOAD



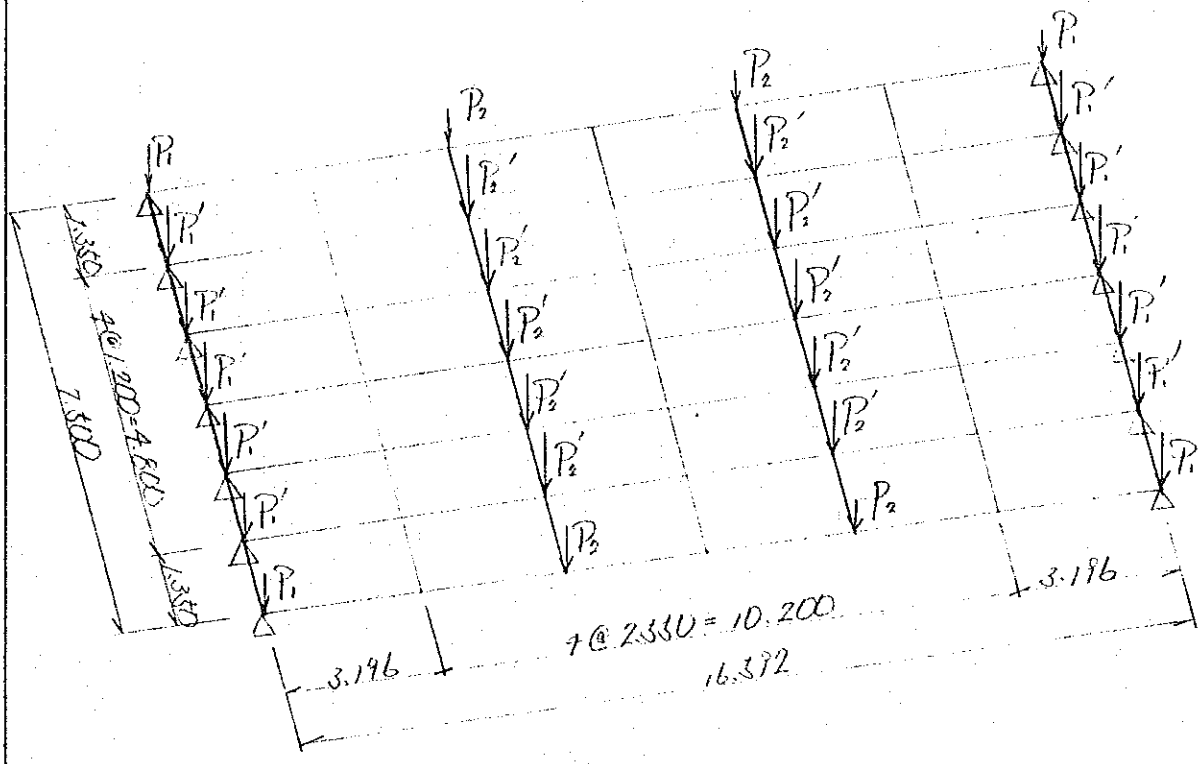
$g_1 = 3.428$ KN/m² — CURB

$g_2 = 1.808$ KN/m² — PAVEMENT

$g_3 = 2.832$ KN/m² — EXTENDED SLAB

$g_4 = 4.248$ KN/m² — SLAB

3) CONCENTRATED LOAD
(CROSS BEAM)



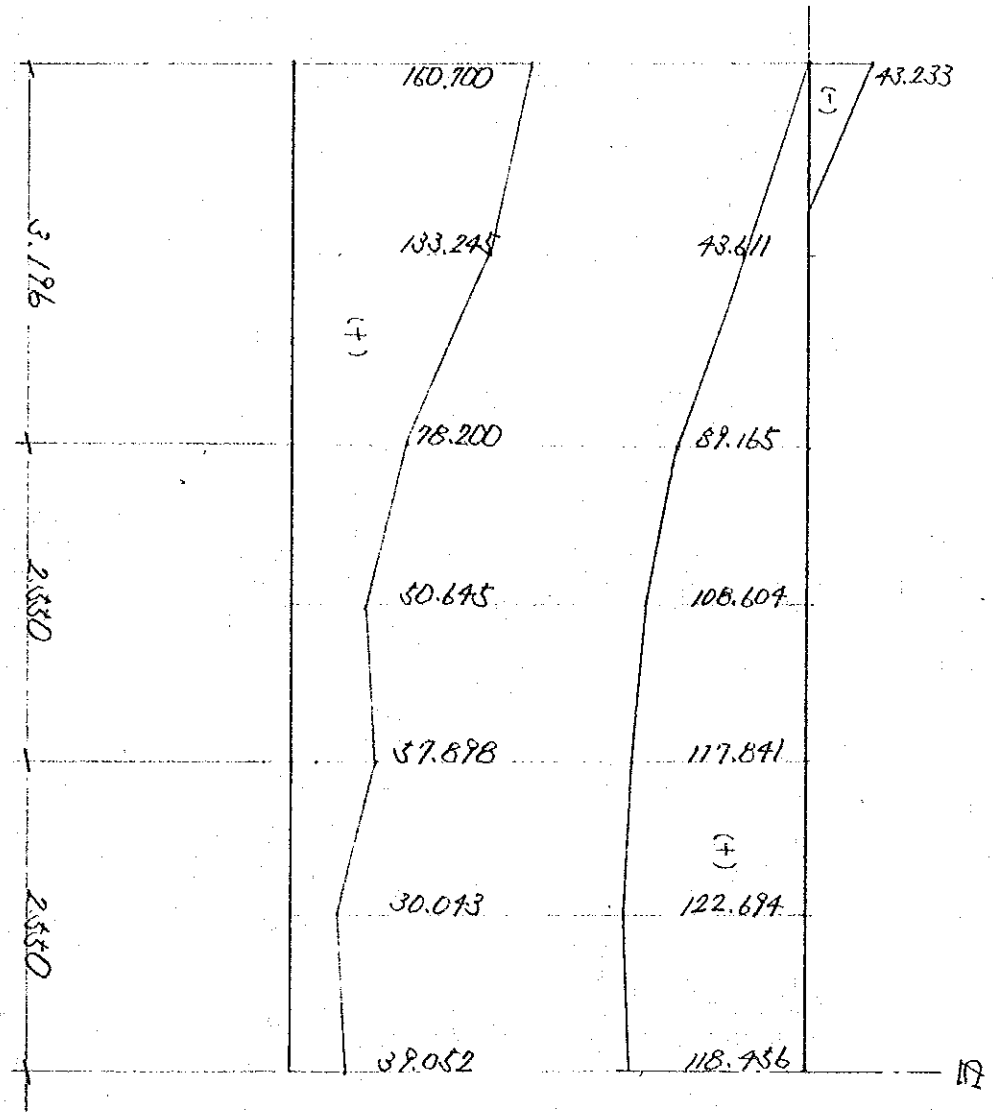
P_1 = 8.040 KN

P_1' = 16.080 KN

P_2 = 6.381 KN

P_2' = 12.762 KN

§2 DRAWING OF SECTIONAL FORCE DIAGRAM



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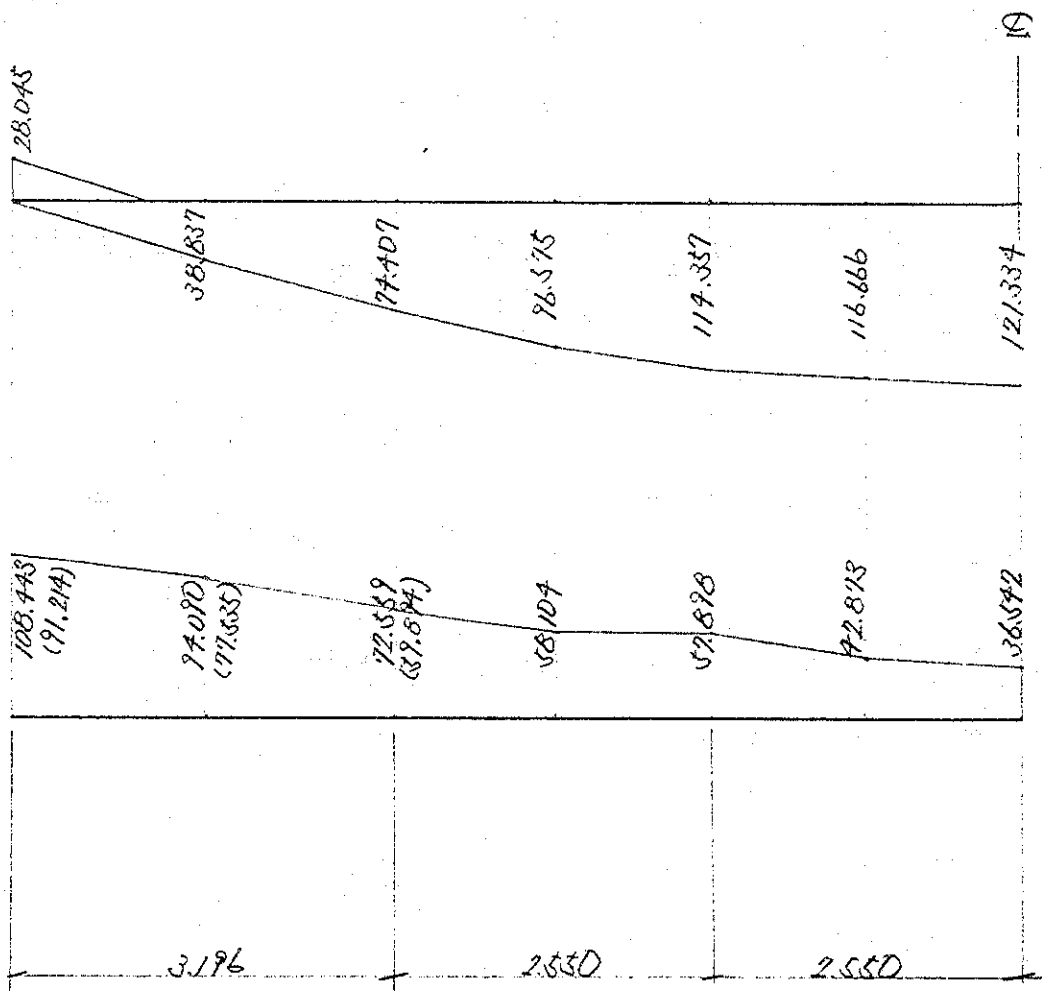
INTERIOR GIRDER



MOMENT (t-m)

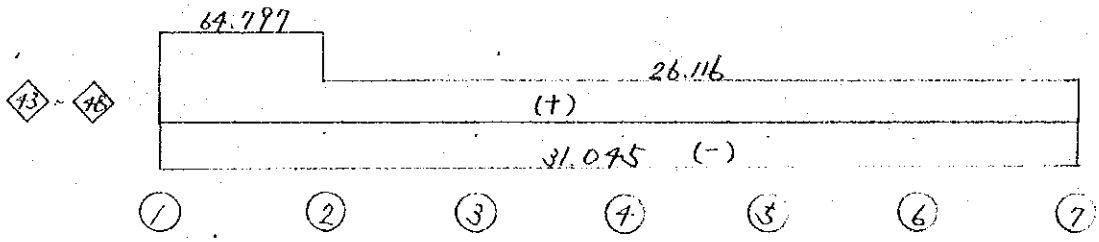
SHEAR (t)
(ULTIMATE SHEAR)

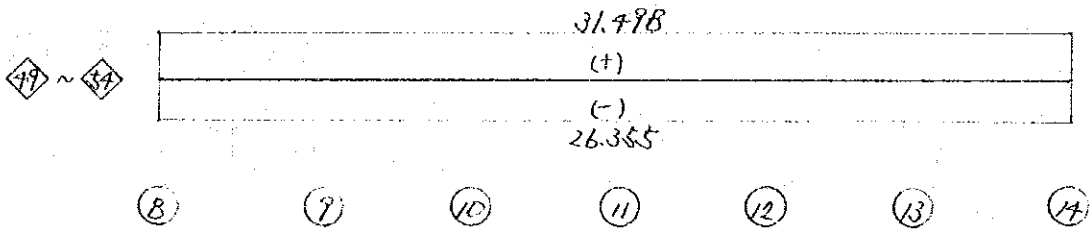
BY H.B LOAD

"( )" INDICATE HA-LOAD

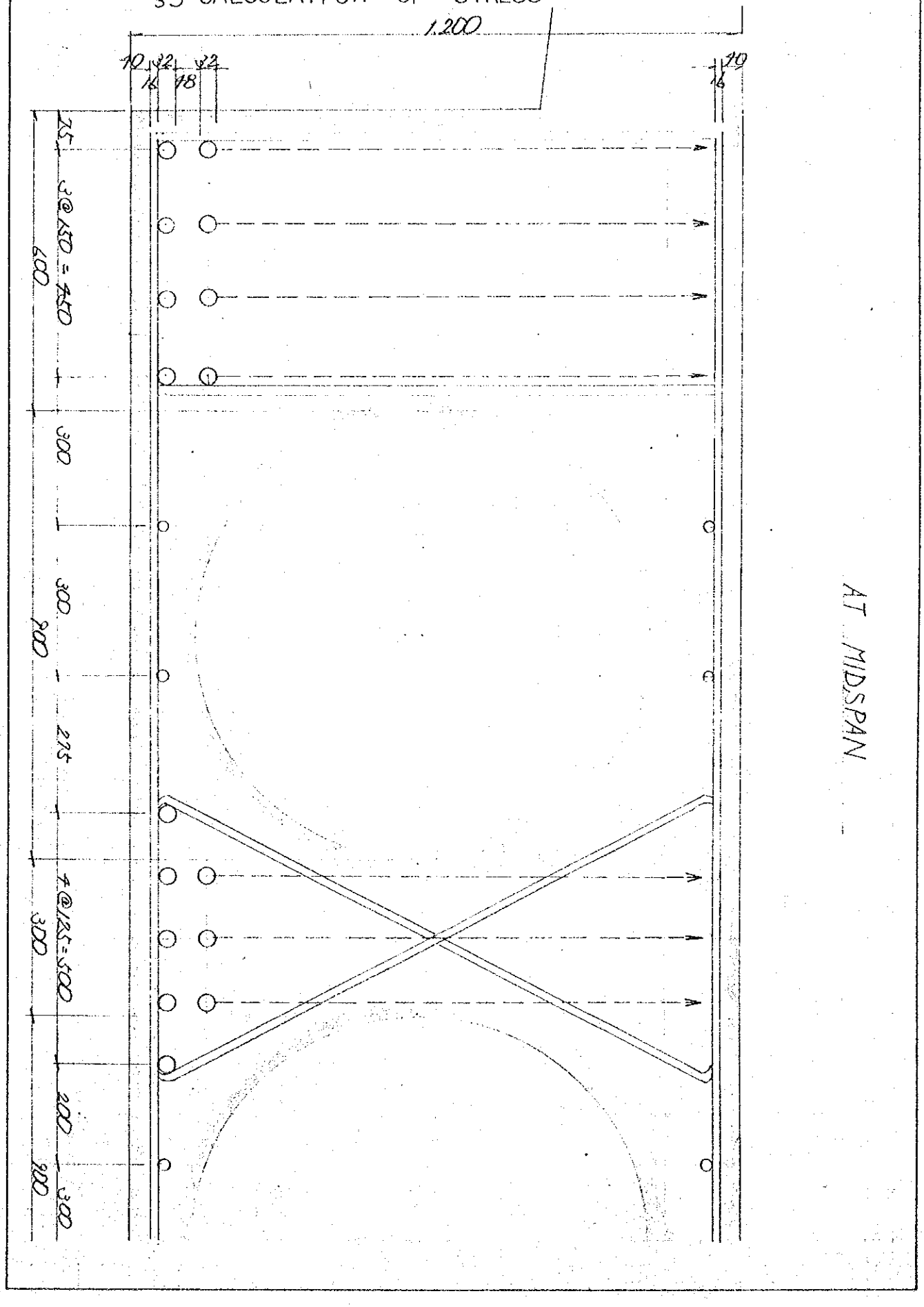
CROSS BEAM

MOMENT (t·m)



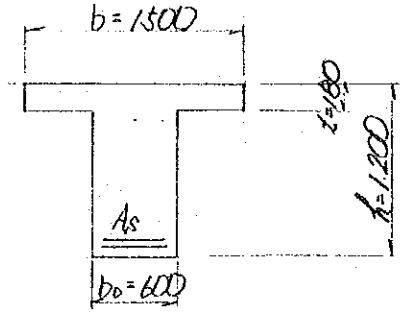


§3 CALCULATION OF STRESS



(1) EDGE GIRDER ① ~ ⑥ AND ㊲ ~ ㊷

1) AT MID SPAN



$M = 122.694\ t\cdot m$

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

$d = 120 - 11.2 = 108.8\ cm$

$A_s = 8 - \Phi 32 = 8\times 8.04 = 64.32\ cm^2$

$np = \frac{15\times 64.32}{150\times 108.8} = 0.0591$

$x = \frac{n\cdot d\cdot A_s + b t^2}{nA_s + bt} = 41.90\ cm$

NEUTRAL AXIS IS EXISTED AT WEB

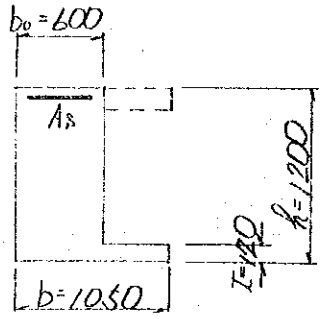
$k = \frac{np + \frac{1}{2}(t/d)^2}{np + t/d} = 0.324$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left[\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right] = 0.927$

$\sigma_s = \frac{M}{A_s\cdot j\cdot d} = \frac{122.694\times10^5}{64.32\times0.927\times108.8} = 1891\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$

$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.324}{15\times(1-0.324)}\times1891 = 60.4\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

2) AT SUPPORT



$M = 42.233$ t-m

$d' =$ $= 7.2$ cm

$d = 120 - 7.2$ $= 112.8$ cm

$As = 4 - \Phi 32 = 4 \times 8.04$ $= 32.16$ cm

$$np = \frac{15 \times 32.16}{105 \times 112.8} = 0.0407$$

$$x = \frac{ndAs + bt^2}{nAs + bt} = 27.9 \text{ cm}$$

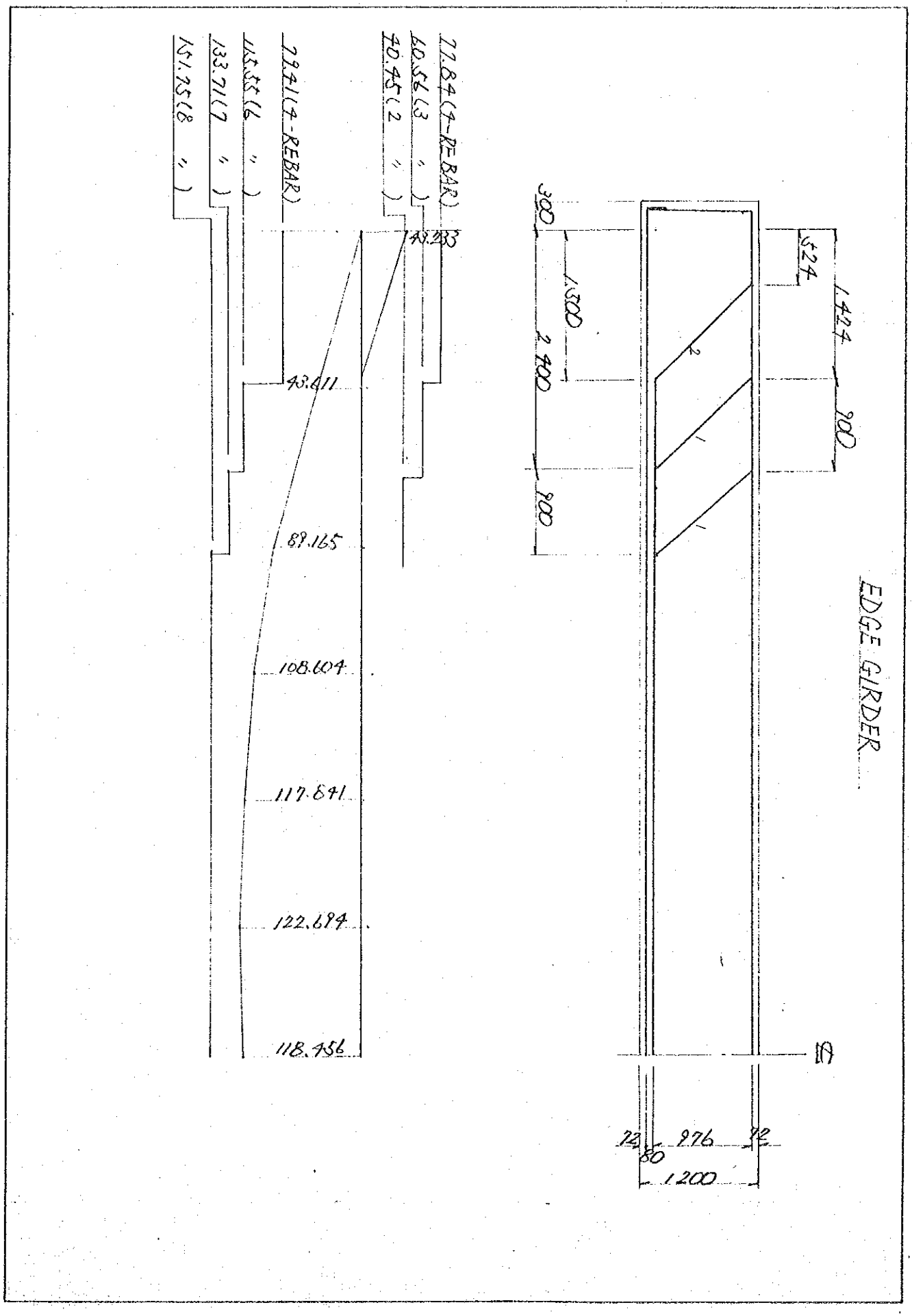
NEUTRAL AXIS IS EXISTED AT WEB

$$k = \frac{np + 1/2 \cdot (t/d)^2}{np + t/d} = 0.247$$

$$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.917$$

$$\sigma_s = \frac{M}{As \cdot j \cdot d} = \frac{42.233 \times 10^5}{32.16 \times 0.917 \times 112.8} = 1268 \text{ kg/cm}^2 < \sigma_{sa} = 2340 \text{ kg/cm}^2$$

$$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.247 \times 1268}{15 \times (1 - 0.247)} = 27 \text{ kg/cm}^2 < \sigma_{ca} = 101 \text{ kg/cm}^2$$


EDGE GIRDER
300
1300
2400
800
524
1424
900
2
1
1
43.411
89.165
108.604
117.841
122.694
118.756
77.84 (7-REBAR)
60.56 (3 〃)
20.45 (2 〃)
22.41 (7-REBAR)
45.55 (6 〃)
133.71 (7 〃)
151.25 (8 〃)
12
976
12
80
1200

1 POINT Ⓐ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

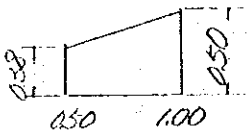
$\frac{100 A_{st}}{bd}$ $\quad A_{st} = 8-\phi 32 = 8 \times 8.04 = 64.32\ cm^2$

$b = 60\ cm$

$d' = \frac{7.2 \times 4 + 15.2 \times 4}{4+4} = 11.2\ cm$

$d = 120 - 11.2 = 108.8\ cm$

$\frac{100 A_{st}}{bd} = \frac{100 \times 64.32}{60 \times 108.8} = 0.985$



$\tau_a = \frac{0.12}{0.50} \times 0.985 + 0.38 = 0.496\ N/mm^2$

$= 4.96\ kg/cm^2$

$\therefore S_{r1} = \tau_a bd = 4.96 \times 60 \times 108.8 \times 10^{-3} = 32.38\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$S_{r2} = \frac{\sigma_{sa}(A_b + 0.707 A_v)}{0.707 v} d$

σ_{sa} $\quad 4180 \times 0.87 = 3.637\ kg/cm^2$

$A_b = 0\ cm^2$

$A_v = 2-\phi 16 = 2 \times 2.01 = 4.02\ cm^2$

$v = 33.92\ cm$

$d = 108.8\ cm$

$\therefore S_{r2} = \frac{3.637 \times (0 + 0.707 \times 4.02)}{0.707 \times 33.92} \times 108.8 \times 10^{-3} = 48.57\ t$

iii) TOTAL RESISTIBLE SHEARING FORCE

$S_r = S_{r1} + S_{r2} = 32.38 + 48.57 = 80.95\ t$

2 POINT Ⓑ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

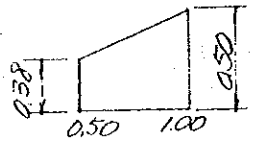
$\frac{100\,Ast}{bd}$ $\quad Ast = 7-\phi 32 = 7\times 8.04 = 56.28\ cm^2$

$b = 60\ cm$

$d' = \frac{7.2\times 4 + 15.2\times 3}{4+3} = 10.6\ cm$

$d = 120 - 10.6 = 109.4\ cm$

$\therefore \frac{100\,Ast}{bd} = \frac{100\times 56.28}{60\times 109.4} = 0.857$



$\tau a = \frac{0.12}{0.50}\times 0.357 + 0.38 = 0.466\ N/mm^2$

$= 4.66\ kg/cm^2$

$\therefore Sr_1 = \tau a\, b\, d = 4.66\times 60\times 109.4\times 10^{-3} = 30.57\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$Sr_2 = \frac{\sigma sa\,(Ab + 0.707\,Av)}{0.707\,V}\,d$

$\sigma sa = 3837\ kg/cm^2$

$Ab = 1-\phi 32 = 1\times 8.04 = 8.04\ cm^2$

$Av = 3\times 2\times 2.01 = 12.06\ cm^2$

$V = 90\ cm$

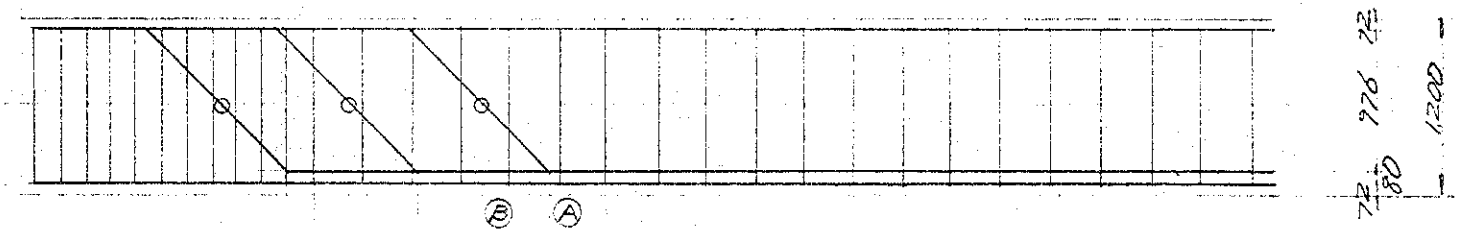
$d = 109.4\ cm$

$\therefore Sr_2 = \frac{3.837\times(8.04+0.707\times 12.06)}{0.707\times 90}\times 109.4\times 10^{-3} = 106.91\ t$

iii) TOTAL SHEARING FORCE

$Sr = Sr_1 + Sr_2 = 30.57 + 106.91 = 137.50\ t$

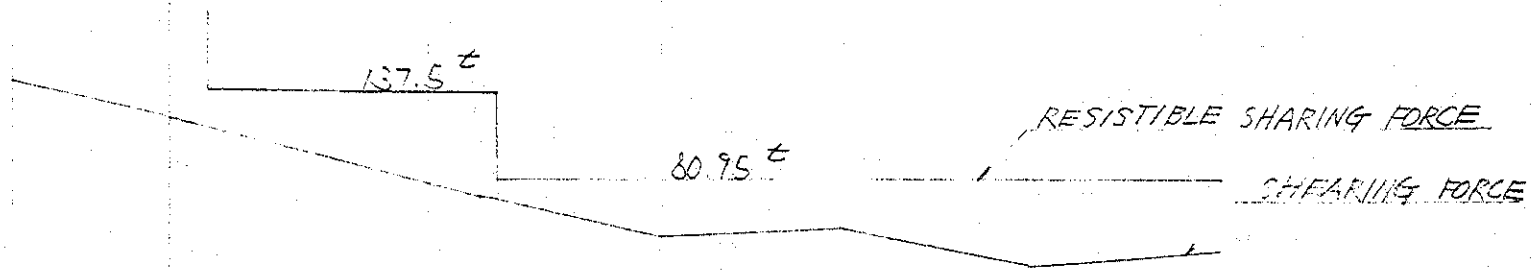
EDGE GIRDER ℄



1800 — 900 — 900 — 4996

115^2 11@169 = 1865^8 — 19.5@339 = 6615

8.596

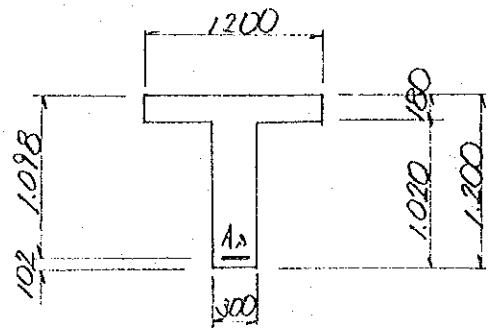


t	16.9700		133.2425		78.1200	50.8645	51.0578	34.0043	39.0652
300	1.071		2.125			4@1.275 = 5.100			

8.596

(2) INTERIOR GIRDER

1). AT MID.SPAN



$M = 121.334$ t-m

$d' = \frac{2.2\times3 + 15.2\times3}{5+3} = 10.2$ cm

$d = 120 - 10.2 = 109.8$ cm

$A_s = 8 - \phi 32 = 8 \times 8.04 = 64.32$ cm²

$np = \frac{15 \times 64.32}{120 \times 109.8} = 0.0732$

$x = \frac{n\cdot d\cdot A_s + b t^2}{n A_s + b t} = 46.34$ cm

NEUTRAL AXIS IS EXISTED AT WEB

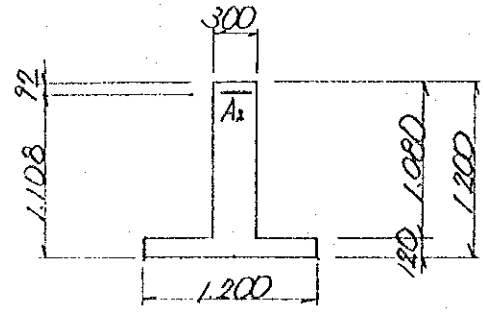
$k = \frac{np + \frac{1}{2}(t/d)^2}{np + t/d} = 0.365$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.926$

$\sigma_s = \frac{M}{A_s \cdot j \cdot d} = \frac{121.334\times10^5}{64.32\times0.926\times109.8} = 1855$ kg/cm² < $\sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \frac{k}{n(1-k)}\sigma_s = \frac{0.365}{15\times(1-0.365)}\times1855 = 71.1$ kg/cm² < $\sigma_{ca} = 101$ kg/cm²

2). AT SUPPORT



$M = 28.045^{t\text{-}m}$

$d' =$ $= 7.2\ cm$

$d = 120 - 7.2$ $= 112.8\ cm$

$A_s = 3 - \Phi 32 = 3 \times 8.04$ $= 24.12\ cm^2$

$np = \dfrac{15 \times 24.12}{100 \times 112.8} = 0.0321$

$x = \dfrac{n \cdot d \cdot A_s + b t^2}{n A_s + b t} = 35.4\ cm$

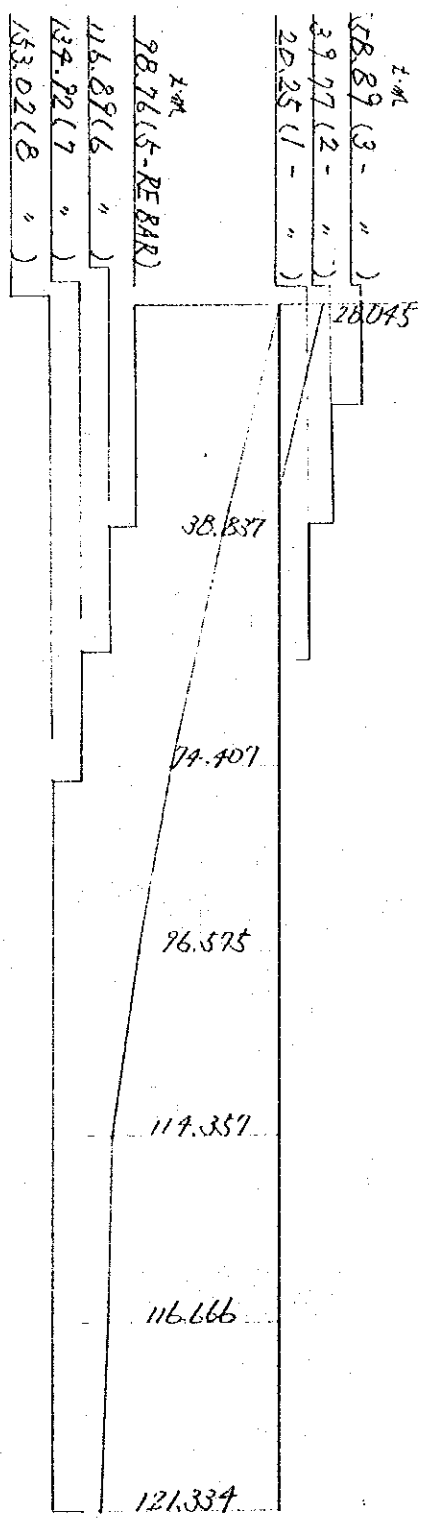
NEUTRAL AXIS IS EXISTED AT WEB

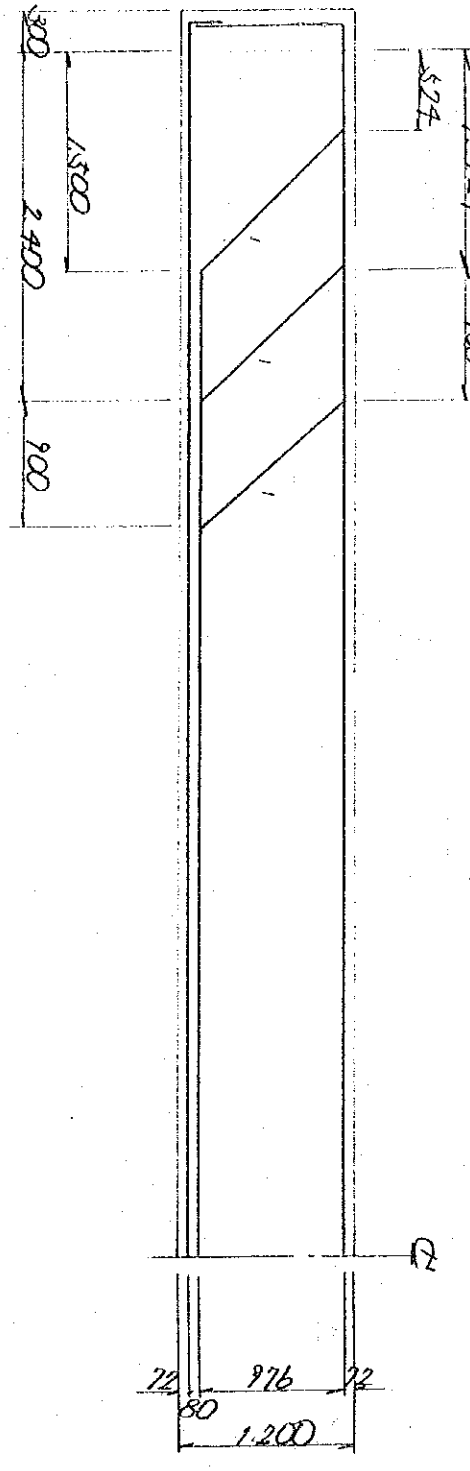
$k = \dfrac{np + \frac{1}{2}(t/d)^2}{np + t/d} = 0.223$

$j = 1 - \dfrac{1}{3}\left(\dfrac{t}{d}\right)\left[\dfrac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right] = 0.925$

$\sigma_s = \dfrac{M}{A_s \cdot j \cdot d} = \dfrac{28.045 \times 10^5}{24.12 \times 0.923 \times 112.8} = 1114\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$

$\sigma_c = \dfrac{k}{n(1-k)}\sigma_s = \dfrac{0.223 \times 1114}{15 \times (1 - 0.223)} = 21\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$





INTERIOR GIRDER

1 POINT Ⓐ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

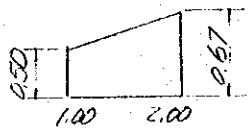
$\frac{100\,Ast}{bd}$ $\quad Ast = 8-\phi 32 = 8\times 8.04 = 64.32\ cm^2$

$b = 30\ cm$

$d' = \frac{7.2\times 5 + 15.2\times 3}{5+3} = 10.2\ cm$

$d = 120 - 10.2 = 109.8\ cm$

$\frac{100\,Ast}{bd} = \frac{100\times 64.32}{30\times 109.8} = 1.953$



$\tau a = \frac{0.17}{1.00}\times 0.953 + 0.50 = 0.662\ N/mm^2$

$= 6.62\ kg/cm^2$

$\therefore S_{r1} = \tau a\, bd = 6.62\times 30\times 109.8\times 10^{-3} = 21.81\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$S_{r2} = \frac{\overline{\sigma sa}\,(A_b + 0.707 A_v)}{0.707\,v}\,d$

$\overline{\sigma sa} = 3.837\ kg/cm^2$

$A_b = 0\ cm^2$

$A_v = 2-\phi 16 = 2\times 2.01 = 4.02\ cm^2$

$v = 33.92\ cm$

$d = 109.8\ cm$

$\therefore S_{r2} = \frac{3.837\times(0+0.707\times 4.02)}{0.707\times 33.92}\times 109.8\times 10^{-3} = 49.02\ t$

iii) TOTAL RESISTIBLE SHEARING FORCE

$S_r = S_{r1} + S_{r2} = 21.81 + 54.39 = 76.20\ t$

2 POINT Ⓑ

i) RESISTIBLE SHEARING FORCE BY CONCRETE

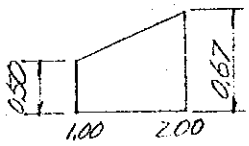
$\frac{100\,Ast}{bd}$ $\quad Ast = 7-\phi 32 = 7\times 8.04 = 56.28\ cm^2$

$b = 30\ cm$

$d' = \frac{2.2\times 5 + 15.2\times 2}{5+2} = 9.5\ cm$

$d = 120 - 9.5 = 110.5\ cm$

$\therefore \frac{100\,Ast}{bd} = \frac{100\times 56.28}{30\times 110.5} = 1.698$



$\tau_a = \frac{0.17}{1.00}\times 0.698 + 0.50 = 0.619\ N/mm^2$

$= 6.19\ kg/cm^2$

$\therefore S_{r1} = \tau_a b d = 6.19\times 30\times 110.5\times 10^{-3} = 20.52\ t$

ii) RESISTIBLE SHEARING FORCE BY SHEAR REINFORCEMENT

$S_{r2} = \frac{\sigma_{sa}(A_b + 0.707 A_v)}{0.707 V} d$

$\sigma_{sa} = 3.637\ kg/cm^2$

$A_b = 1-\phi 32 = 1\times 8.04 = 8.04\ cm^2$

$A_v = 3\times 2\times 2.01 = 12.06\ cm^2$

$V = 90\ cm$

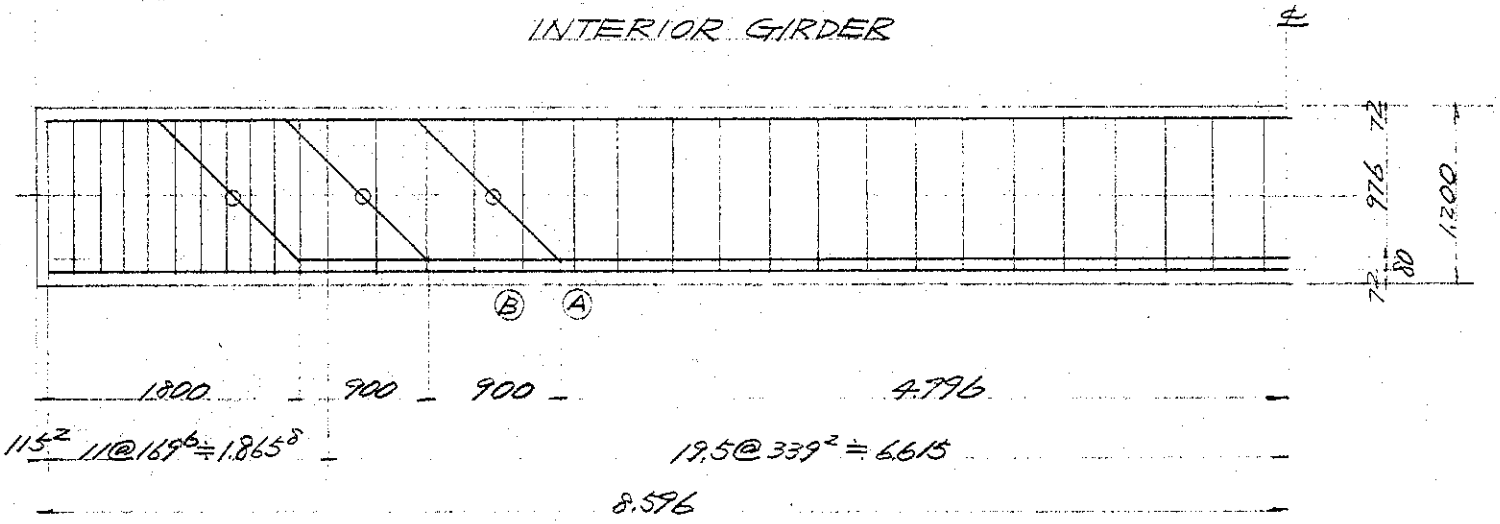
$d = 110.5\ cm$

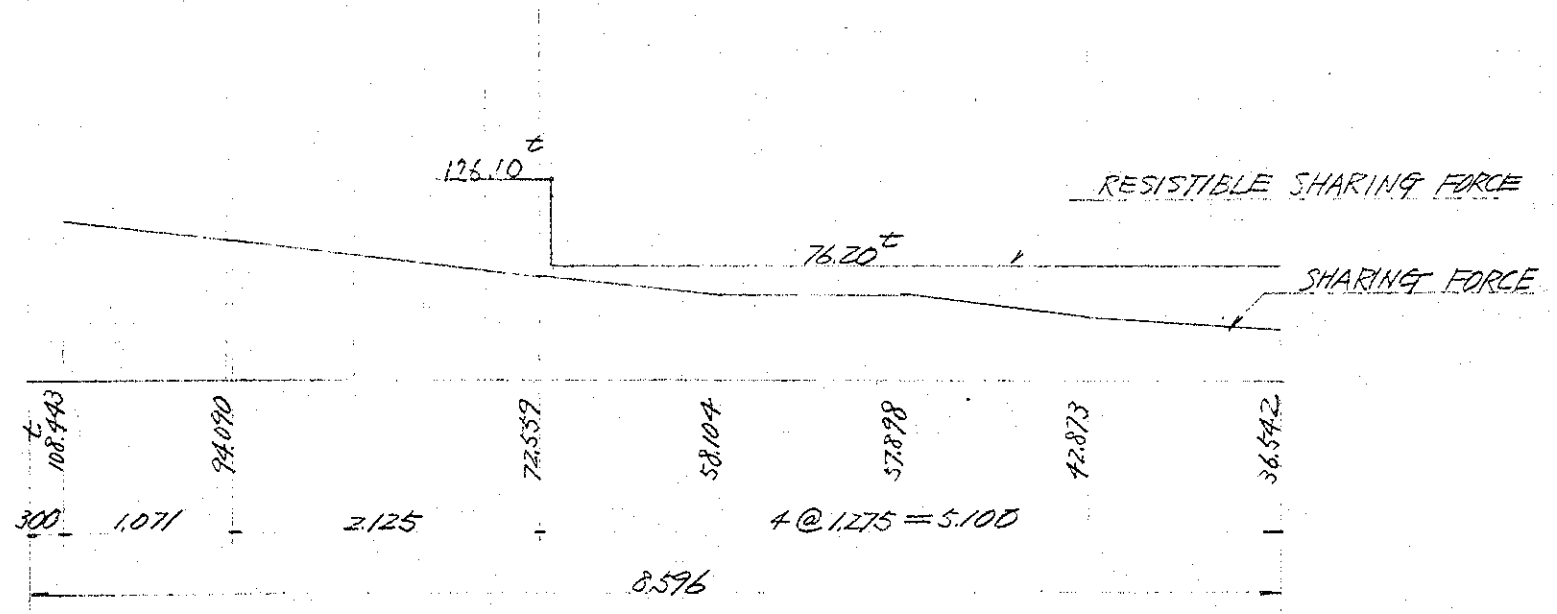
$\therefore S_{r2} = \frac{3.637\times(8.04+0.707\times 12.06)}{0.707\times 90}\times 110.5\times 10^{-3} = 105.58\ t$

iii) TOTAL SHEARING FORCE

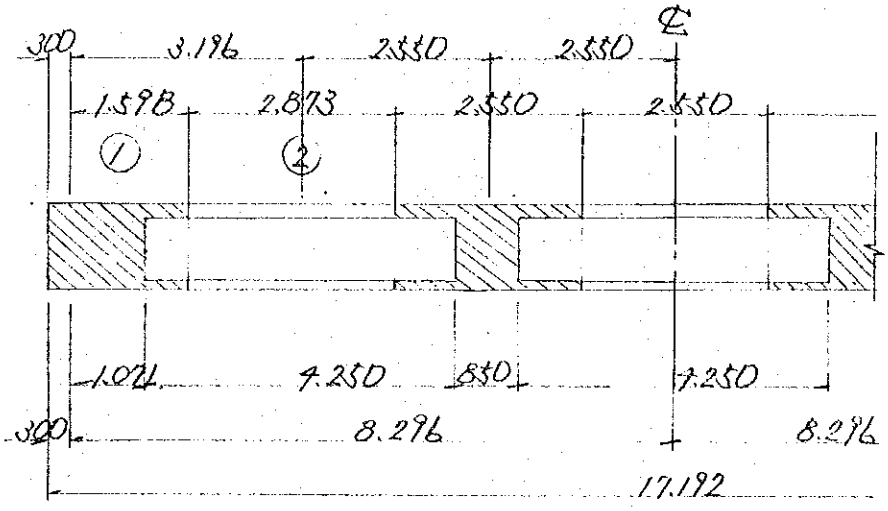
$S_r = S_{r1} + S_{r2} = 20.52 + 105.58 = 126.10\ t$

INTERIOR GIRDER

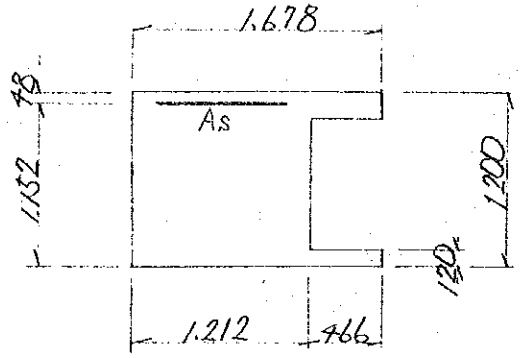




§§ 3 DESIGN OF CROSS BEAM



(1) ㉓ ~ ㊺



1.878 × 0.884 = 1.678

1.371 × 〃 = 1.212

RESISTIBLE WIDTH 167 cm

$M = 64.797$ t·m

$d' = 7.8$ cm

$d = 120 - 7.8 = 115.2$ cm

$A_s = 22 - \phi 16 = 44.22$ cm²

$np = \frac{15 \times 44.22}{167 \times 115.2} = 0.0345$

$x = \frac{n \cdot d \cdot A_s + b t^2}{n A_s + b t} = 37.66$ cm

NEUTRAL AXIS IS EXISTED AT WEB

$k = \frac{np + 1/2 \cdot (t/d)^2}{np + t/d} = 0.288$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.952$

$\sigma_s = \frac{M}{A_s \cdot j \cdot d} = \frac{64.797 \times 10^5}{44.22 \times 0.952 \times 115.2} = 1336$ kg/cm² < $\sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \frac{k}{n(1-k)} \sigma_s = \frac{0.288}{15 \times (1 - 0.288)} \times 1336 = 36$ kg/cm² < $\sigma_{ca} = 101$ kg/cm²

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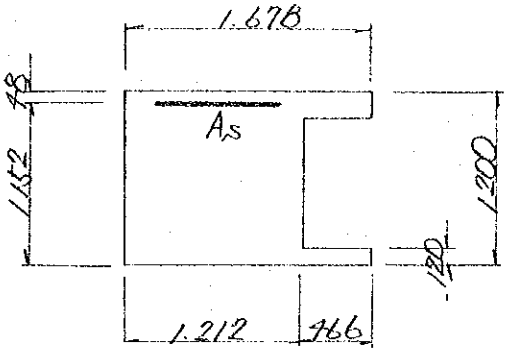


RESISTIBLE WIDTH 167 cm

$M = 26.116$ t·m

$d' =$ = 7.8 cm

$d = 120 - 7.8$ = 115.2 cm

$A_s = 11 - \phi 16$ = 22.11 cm²

$np = \dfrac{15 \times 22.11}{167 \times 115.2}$ = 0.0172

$x = \dfrac{n \cdot d \cdot A_s + b t^2}{n A_s + b t}$ = 26.65 cm

NEUTRAL AXIS IS EXISTED AT WEB

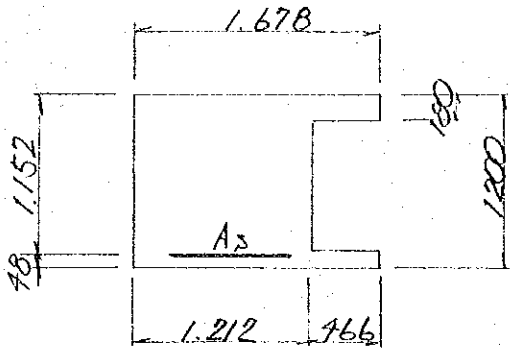
$k = \dfrac{np + 1/2 (t/d)^2}{np + t/d}$ = 0.186

$j = 1 - \dfrac{1}{3}\left(\dfrac{t}{d}\right)\left\{\dfrac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\}$ = 0.935

$\sigma_s = \dfrac{M}{A_s \cdot j \cdot d} = \dfrac{26.116 \times 10^5}{22.11 \times 0.935 \times 115.2} = 1074 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$

$\sigma_c = \dfrac{k}{n(1-k)} \sigma_s = \dfrac{0.186}{15 \times (1 - 0.186)} \times 1074 = 16.4 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$

㉝ ~ ㊻



RESISTIBLE WIDTH 167 cm

$M = 31.045\ t\cdot m$

$d' =$ $= 4.8\ cm$

$d = 120 - 4.8$ $= 115.2\ cm$

$As =$ $11 - \phi 16$ $= 22.11\ cm^2$

$np = \dfrac{15 \times 22.11}{167 \times 115.2} = 0.0172$

$x = \dfrac{nd\cdot As + b\,t^2}{n\,As + b\,t} = 27.66\ cm$

NEUTRAL AXIS IS EXISTED AT WEB

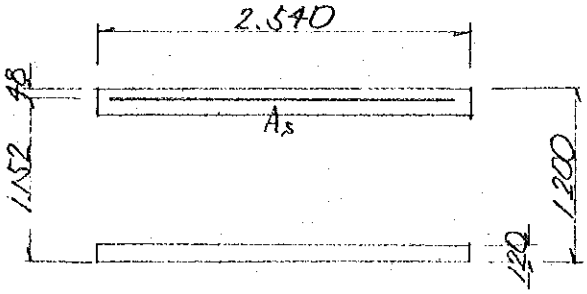
$k = \dfrac{np + \frac{1}{2}(t/d)^2}{np + t/d} = 0.170$

$j = 1 - \dfrac{1}{3}\left(\dfrac{t}{d}\right)\left\{\dfrac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.944$

$\sigma_s = \dfrac{M}{As\cdot j\cdot d} = \dfrac{31.045 \times 10^5}{22.11 \times 0.944 \times 115.2} = 1291\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$

$\sigma_c = \dfrac{k}{n(1-k)}\sigma_s = \dfrac{0.170}{15 \times (1 - 0.170)} \times 1291 = 17.6\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

(2) ④7 ~ ⑤7



$2.873 \times 0.884 = 2540$

RESISTIBLE WIDTH 254 cm

$M = 31.498$ t·m

$d' = 7.8$ cm

$d = 120 - 4.8 = 115.2$ cm

$A_s = 16 - \phi 16 = 32.16$ cm²

$np = \frac{15 \times 32.16}{254 \times 115.2} = 0.0165$

$x = \frac{n \cdot d \cdot A_s + b \cdot t^2}{n \cdot A_s + b \cdot t} = 26.10$ cm

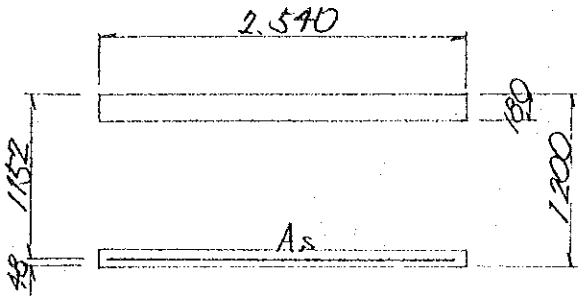
NEUTRAL AXIS IS EXISTED AT WEB

$k_2 = \frac{np + 1/2 \cdot (t/d)^2}{np + t/d} = 0.182$

$j = 1 - \frac{1}{3}\left(\frac{t}{d}\right)\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.955$

$\sigma_s = \frac{M}{A_s \cdot j \cdot d} = \frac{31.498 \times 10^5}{32.16 \times 0.955 \times 115.2} = 890$ kg/cm² $< \sigma_{sa} = 2340$ kg/cm²

$\sigma_c = \frac{k}{n(1-k)} \sigma_s = \frac{0.182}{15 \times (1 - 0.182)} \times 890 = 13.2$ kg/cm² $< \sigma_{ca} = 101$ kg/cm²



RESISTIBLE WIDTH 254 cm

$M = 26.355$ t·m

$d' =$ $= 4.8$ cm

$d = 120 - 4.8$ $= 115.2$ cm

$As = 16 - \phi 16$ $= 32.16$ cm²

$np = \frac{15 \times 32.16}{254 \times 115.2} = 0.0165$

$x = \frac{n \cdot d\, As + b t^2}{n \cdot As + b t} = 27.28$ cm

NEUTRAL AXIS IS EXISTED AT WEB

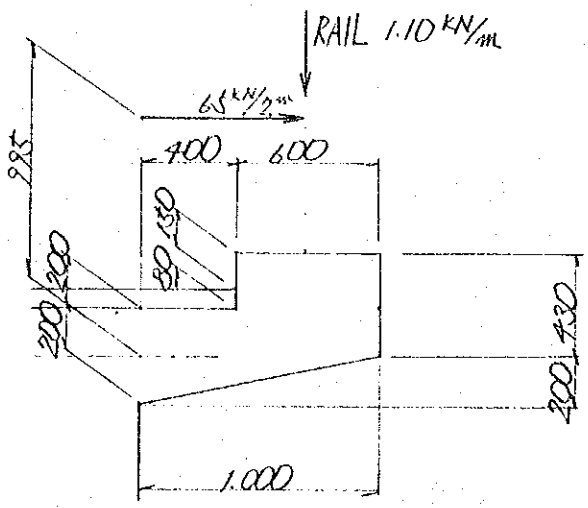
$k = \frac{np + 1/2 \cdot (t/d)^2}{np + t/d} = 0.166$

$j = 1 - \frac{1}{3}(\frac{t}{d})\left\{\frac{3k - 2\frac{t}{d}}{2k - \frac{t}{d}}\right\} = 0.945$

$\sigma_s = \frac{M}{As \cdot j \cdot d} = \frac{26.355 \times 10^5}{32.16 \times 0.945 \times 115.2} = 753\ kg/cm^2 < \sigma_{sa} = 2340\ kg/cm^2$

$\sigma_c = \frac{k}{n(1-k)} \sigma_s = \frac{0.166}{15 \times (1 - 0.166)} \times 753 = 10.0\ kg/cm^2 < \sigma_{ca} = 101\ kg/cm^2$

§§ 4 DESIGN OF CANTILEVER SLAB



(1) BENDING MOMENT DUE TO DEAD LOAD

		(P_i)	(X_m)	$(M\ KN\cdot m)$
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
		12.16 KN		6.341 (KN·m/m)

(2) BENDING MOMENT DUE TO COLLISION LOAD

COLLISION LOAD 65 KN

$$P = 65/3 = 21.667^{KN}$$

INTERVAL OF POST 2.0^{M}

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

$$= 21.667 \times (0.71 + 0.995 + 1.28) \times 1/2.0 = 32.338\ KN\cdot m/m$$

(3) BENDING MOMENT DUE TO LIVE LOAD

$$M_x = \frac{P}{\pi L} \cdot \frac{1}{1+\left(\frac{y}{L}\right)^2} \quad (y=0)$$

$$= \frac{P}{\pi L} = \frac{112.5}{\pi} = 35.81 \ KN\cdot m/m$$

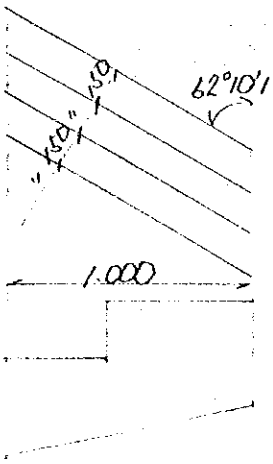
$$P = 112.5 \ KN$$

(4) TOTAL BENDING MOMENT AND SHEAR

$$\Sigma M = 6.341 + 32.338 + 35.810 = 74.489 \ KN\cdot m = 7.601 \ t\cdot m$$

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

(5) CALCULATION OF STRESS AND COMPRESION



$$A_s = (6.67 - \Phi 16) \times \sin(62°10'19") = 6.67 \times 20 \times 0.884 = 11.85 \ cm^2$$

$$np = \frac{15 \times 11.85}{100 \times 35.2} = 0.0305$$

$$k = \sqrt{2np + (np)^2} - np = 0.271$$

$$j = 1 - k/3 = 0.910$$

$$\sigma_c = \frac{2M}{k \cdot j \cdot b \cdot d^2} = \frac{2 \times 7.601 \times 10^5 / 1.25}{0.271 \times 0.910 \times 100 \times 35.2^2} = 39.8 \ kg/cm^2 < \sigma_{ca} = 101 \ kg/cm^2$$

$$\sigma_s = n \cdot \sigma_c \frac{1-k}{k} = 15 \times 39.8 \times \frac{1-0.271}{0.271} = 1606 \ kg/cm^2 < \sigma_{sa} = 2340 \ kg/cm^2$$

$$\tau = \frac{S}{b \cdot d} = \frac{12.720 \times 10^3}{100 \times 35.2 \times 1.25} = 2.89 \ kg/cm^2 < \tau_a = 3.0 \ kg/cm^2$$

5. R.C. Voided Slab Bridge (M.J. B-Ramp BR)

CONTENTS

§§ 1 DESIGN CONDITION

§ 1. DESIGN CONDITION

TYPE	2 SPANS CONTINUANCE RC VOIDED SLAB BRIDE
BRIDGE LENGTH	35 150
GIRDER LENGTH	35 100
SPAN	16000 + 18400
WIDTH	9 100
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. REINFORCEMENT

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)