JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

CALCULATIONS FOR

MADE BY ____ DATE ____ FILE NO ____
CHECKED BY ____ DATE ____ PAGE NO ____

昭和五年三月

福島縣新川橋設計々算書
及材料調書

増田淳氏関係資料（独立行政法人 土木研究所蔵）

CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima ken.

We have decided to adopt the following:—

Width of roadway 13.0 meters between curbs.

Width of arch ring 13.6 meters or 2 ribs @ 6.74 = 13.48 with a clearance of 12 cm.

Paving gravel 10 cm deep.

Span length 11.0 meter clear, 11.36 meter effective.

Rise 1.64 meters on neutral axis. Rise ratio = $1.64/11.36$ = $1/6.93$ = 0.144

Thickness of arch rib 26 cm at crown + 60 cm at springing; thickness ratio = $60/26$ = 2.31

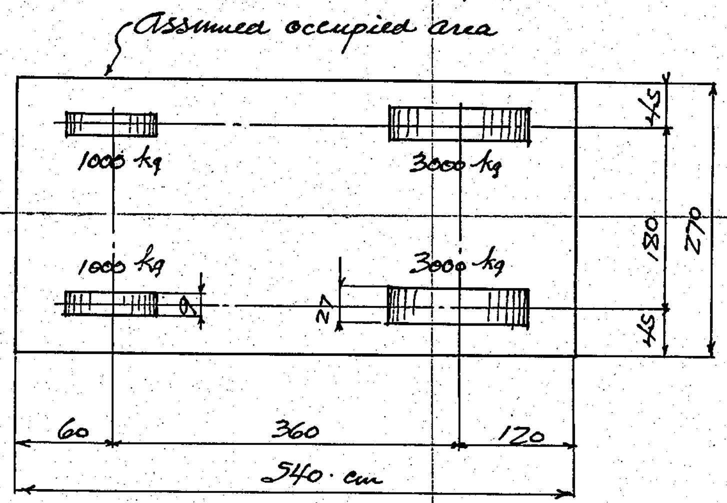
Assumed Loadings

Uniform load on Roadway $w = \dfrac{100000}{170+l} \leq 500$ kg/m²

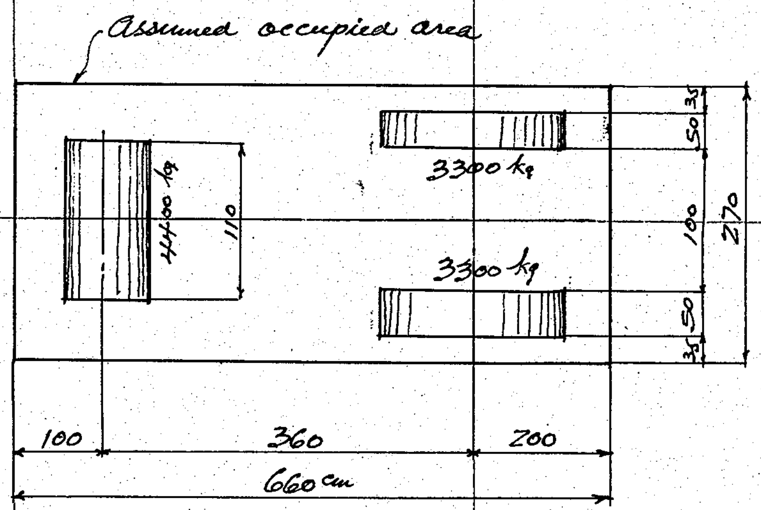
where w = uniform load in kg per square meter.

l = Span length in meter.

8 ton motor truck loading



11 ton Road Roller



4 rows of motor traffic on Roadway with occupied width of 270 cm each; unoccupied space around the motor truck shall be filled with uniform load specified above.

One road roller on one span.

Impact for motor truck loading Coefficient = $\dfrac{20}{60+l}$ where l = loaded length in meters

max. impact 30%.

No impact considered for road roller and uniform load.

Allowable working Strength

Concrete 1:2:4 mixture

Direct compression	35	kg/cm²
Fibre stress due to bending	45	"
Combined stress direct and bending compression member	35	"
arch ring	45	"
Punching shear of concrete	9	"
Shear of plain concrete	4	"
Bearing value	45	"
Bond stress for plain bars	6	"
" " deformed bars	9	"

Reinforcing Bars

Tension or Compression	1200	"
Shearing strength	900	"

Considering wind, temperature, or rib shortening stress in addition to dead live and impact load, the allowable working strength shall be increased 25%; in case of Earthquake, the allowable strength shall be increased 60%.

Seismic acceleration 2000 mm/sec² or say k = 0.200

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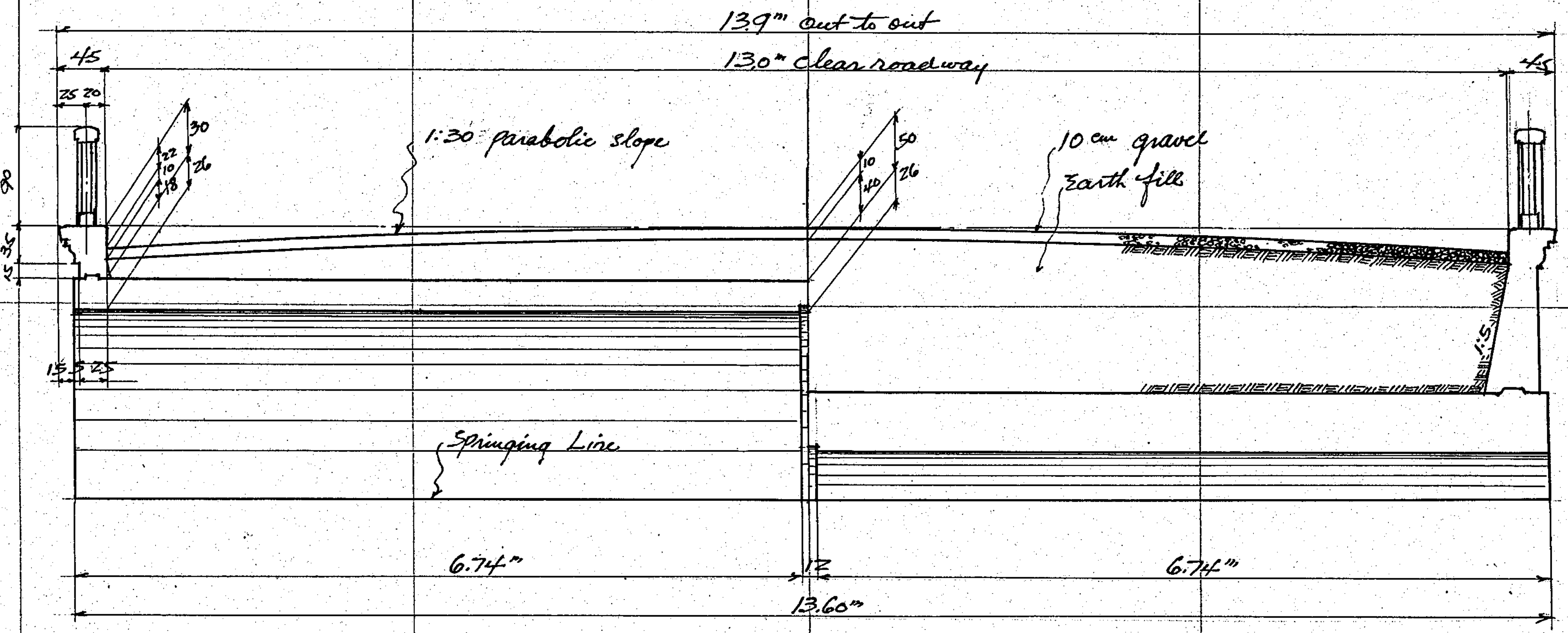
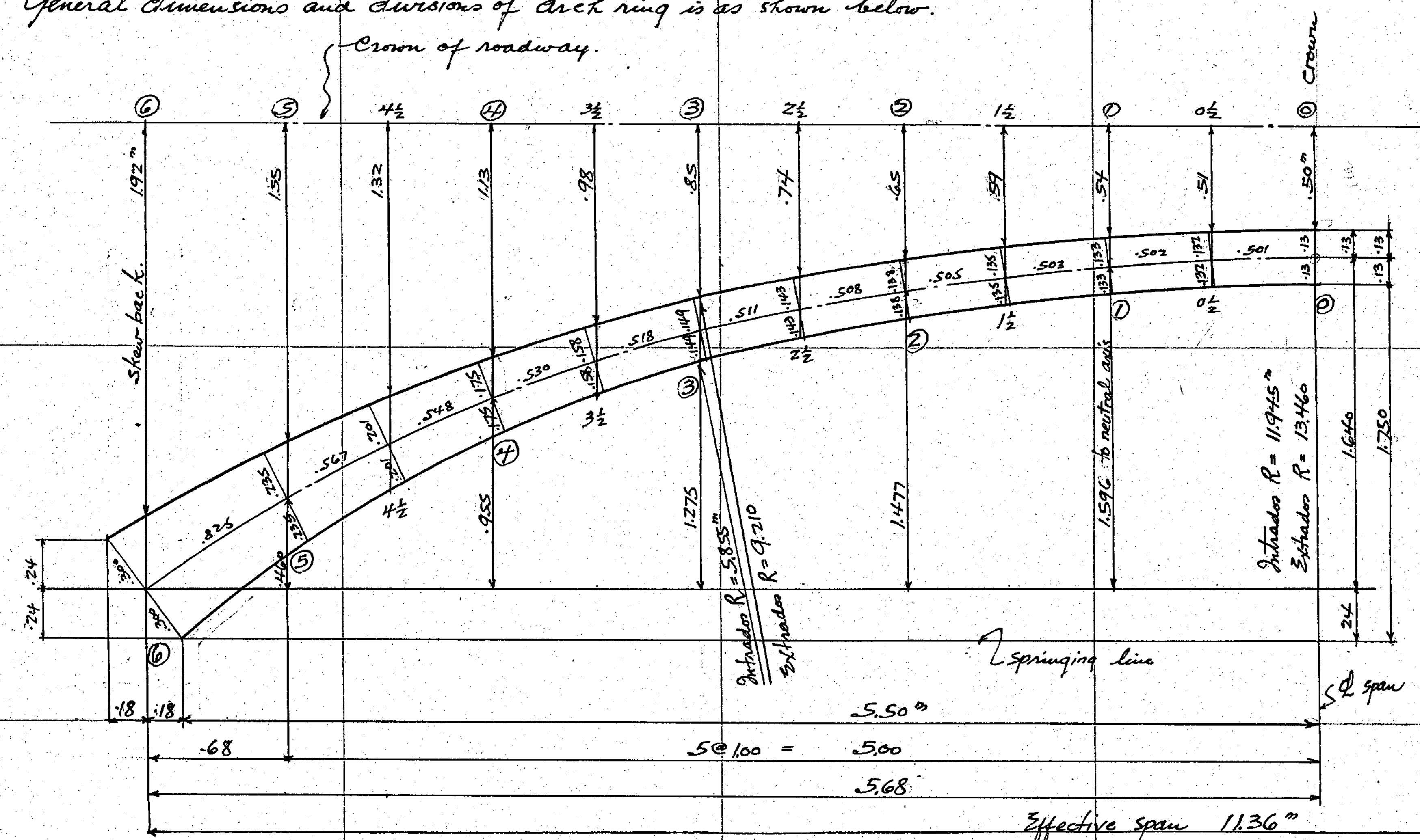
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

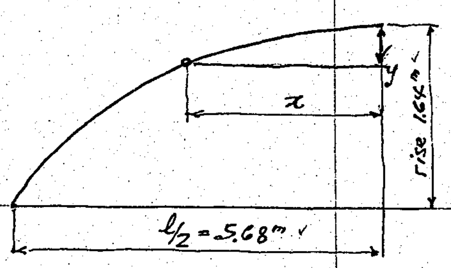
Cross section of Bridge assumed as shown on sketch below:



General dimensions and divisions of arch ring is as shown below.



Panel point		x	y	Thickness	ds.
0	crown	0.00m	0.000m	.260m	1.003m
1		1.00	.044	.266	1.008
2		2.00	.163	.276	1.019
3		3.00	.365	.298	1.048
4		4.00	.685	.350	1.115
5		5.00	1.180	.470	.826
6	spr.	5.68	1.640	.600	



$\frac{s}{2} = 6.018^m$

$s = 12.036^m$

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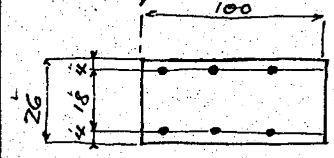
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Division of Arch ring for Constant $\frac{ds}{I}$. Length of arch axis = 6.018 meters between crown and skewback.

Moment of inertia at panel points.

Reinforcing bars assumed 22 mm φ bars at 30 cm c to c at all panel points. Steel area 3.801 × 6.67 = 25.4 cm²



panel point 0 or Crown

I_0 $\frac{100 \times 26^3}{12} = 146500$

$14 \times 25.4 \times 9^2 = 28800$

175300 cm⁴

d = 26.6 panel pt 1. I_1 $\frac{100 \times 26.6^3}{12} = 157000$

$14 \times 25.4 \times 9.3^2 = 30700$

187700

d = 27.6 Panel pt 2 I_2 $\frac{100 \times 27.6^3}{12} = 175250$

$14 \times 25.4 \times 9.8^2 = 34100$

209350

d = 29.8 panel pt 3. I_3 $\frac{100 \times 29.8^3}{12} = 220700$

$14 \times 25.4 \times 10.9^2 = 42200$

262900

d = 35.0 panel pt 4 I_4 $\frac{100 \times 35^3}{12} = 357700$

$14 \times 25.4 \times 13.5^2 = 64800$

422500

d = 47.0 Panel pt 5 I_5 $\frac{100 \times 47^3}{12} = 865500$

$14 \times 25.4 \times 19.5^2 = 135100$

1000600

d = 60.0 panel pt. 6. I_6 $\frac{100 \times 60^3}{12} = 1800000$

$14 \times 25.4 \times 26^2 = 240200$

2040200

d = 31.6 Panel pt. 3½ $I_{3\frac{1}{2}}$ $\frac{100 \times 31.6^3}{12} = 263000$

$14 \times 25.4 \times 11.8^2 = 49500$

312500

d = 40.2 panel pt. 4½ $I_{4\frac{1}{2}}$ $\frac{100 \times 40.2^3}{12} = 542000$

$14 \times 25.4 \times 16.1^2 = 92000$

634000

Values of $\frac{ds}{I}$ Division AB d = 26.1 cm $\frac{100 \times 26.1^3}{12} = 148200$, $14 \times 25.4 \times 9.1^2 = 29400$ } 177600 $\frac{60.2}{177600} = .000344$

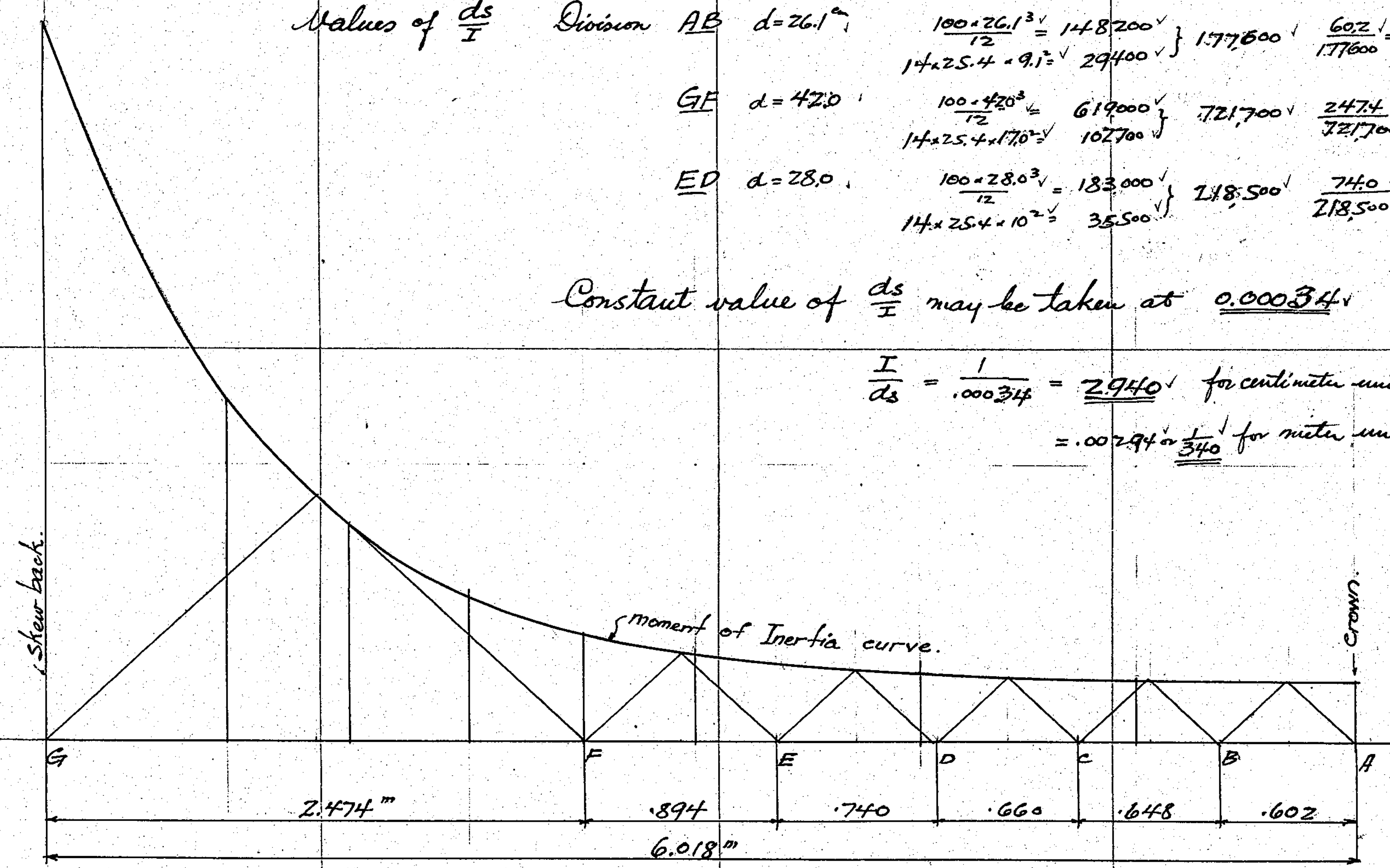
GF d = 42.0 $\frac{100 \times 42.0^3}{12} = 619000$, $14 \times 25.4 \times 17.0^2 = 102700$ } 721700 $\frac{247.4}{721700} = .000344$

ED d = 28.0 $\frac{100 \times 28.0^3}{12} = 183000$, $14 \times 25.4 \times 10^2 = 35500$ } 218500 $\frac{74.0}{218500} = .000340$

Constant value of $\frac{ds}{I}$ may be taken at 0.00034

$\frac{I}{ds} = \frac{1}{.00034} = 2940$ for centimeter unit

$= .00294$ or $\frac{1}{340}$ for meter unit



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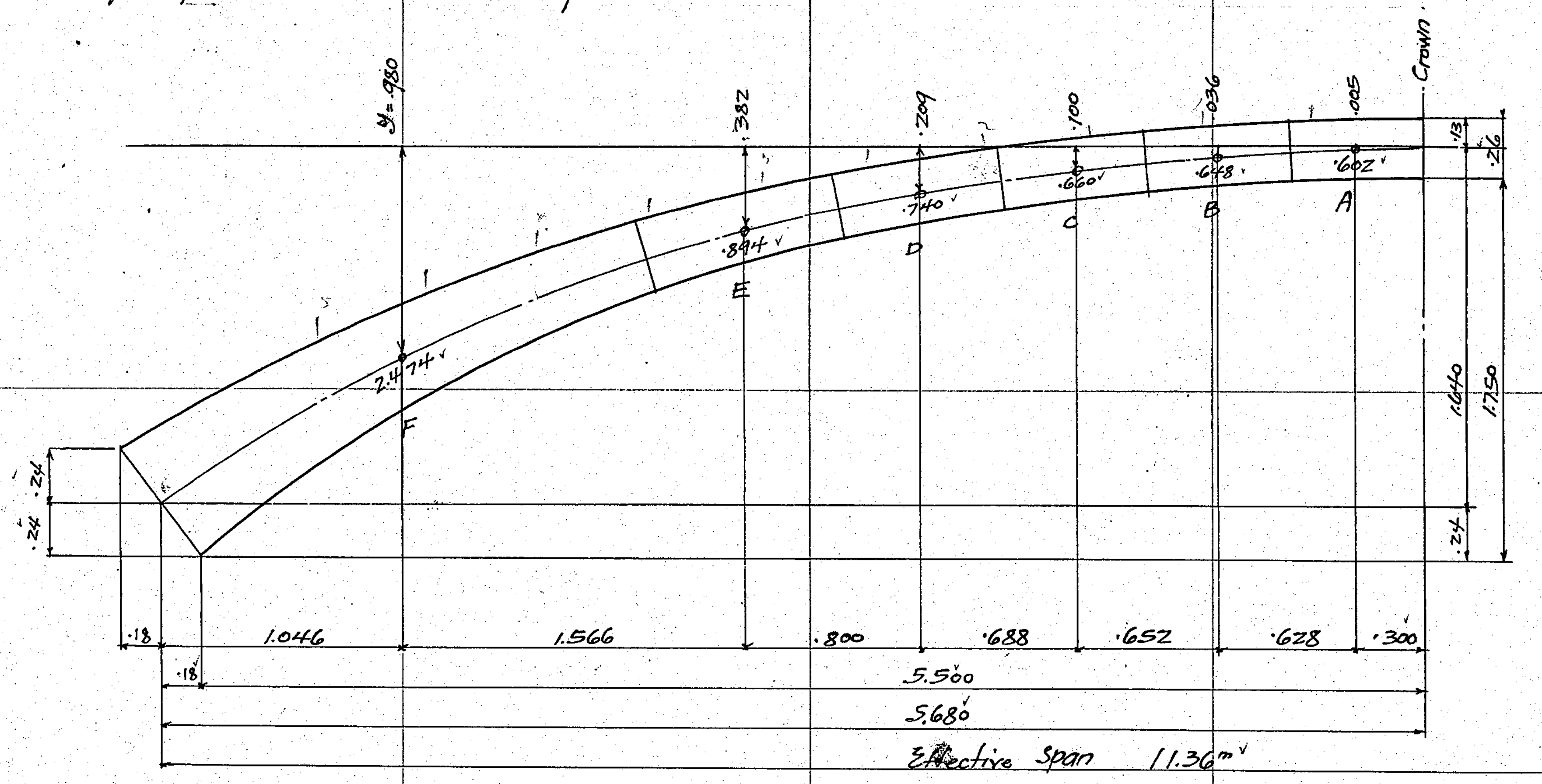
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima ken.



Let us determine the thrusts, moments, and shears at crown for unite loads at panel points A, B, C, D, E, and F respectively.

Unite load at the crown (moments about all division points).

Division points	x	y	x^2	y^2	xy
A	.300	.005	.090	.000	.002
B	.928	.036	.861	.001	.033
C	1.580	.100	2.496	.010	.158
D	2.268	.209	5.144	.044	.474
E	3.068	.382	9.413	.146	1.172
F	4.634	.980	21.474	.960	4.541
	12.778	1.712	39.478	1.161	6.380
	$=\Sigma x$	$=\Sigma y$	$=\Sigma x^2$	$=\Sigma y^2$	$=\Sigma xy$

$(\Sigma y)^2 = 2.931$

$M_L = x$, $\Sigma M_L = \Sigma x$.
$M_R = 0$.
$M_L y = xy$, $\Sigma M_L y = \Sigma xy$.
$\Sigma M_L x = \Sigma x^2$

$$H_c = \frac{6\Sigma M_L y - \Sigma M_L \Sigma y}{2[6\Sigma y^2 - (\Sigma y)^2]}$$

$$V_c = \frac{\Sigma M_L x}{2\Sigma x^2}$$

$$M_c = \frac{\Sigma M_L - 2H_c \Sigma y}{2 \cdot 6}$$

$$H_c = \frac{\overset{16.404}{6 \times 6.380} - 12.778 \times 1.712}{\underset{8.070}{2(6 \times 1.161 - 2.931)}} = 2.033, \quad V_c = 0.500, \quad M_c = \frac{12.778 - 2 \times 2.033 \times 1.712}{12} = +0.485$$

Equations for ΣM_L, $\Sigma M_L x$, and $\Sigma M_L y$ for load of unity at point d meters distant from crown

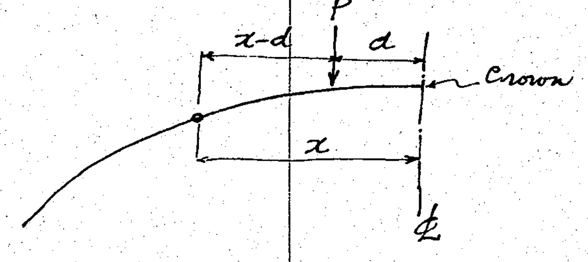
Let d = distance of load from crown.
n' = no. of division points to left of load.
$P = 1$.

Then if we donote by $\Sigma' x$, $\Sigma' y$, &c the summation ~~of~~ for n' points, we have:

$$\Sigma M_L = \Sigma'(x-d) = \Sigma' x - n'd$$

$$\Sigma M_L x = \Sigma' x(x-d) = \Sigma' x^2 - d\Sigma' x$$

$$\Sigma M_L y = \Sigma' y(x-d) = \Sigma' xy - d\Sigma' y$$



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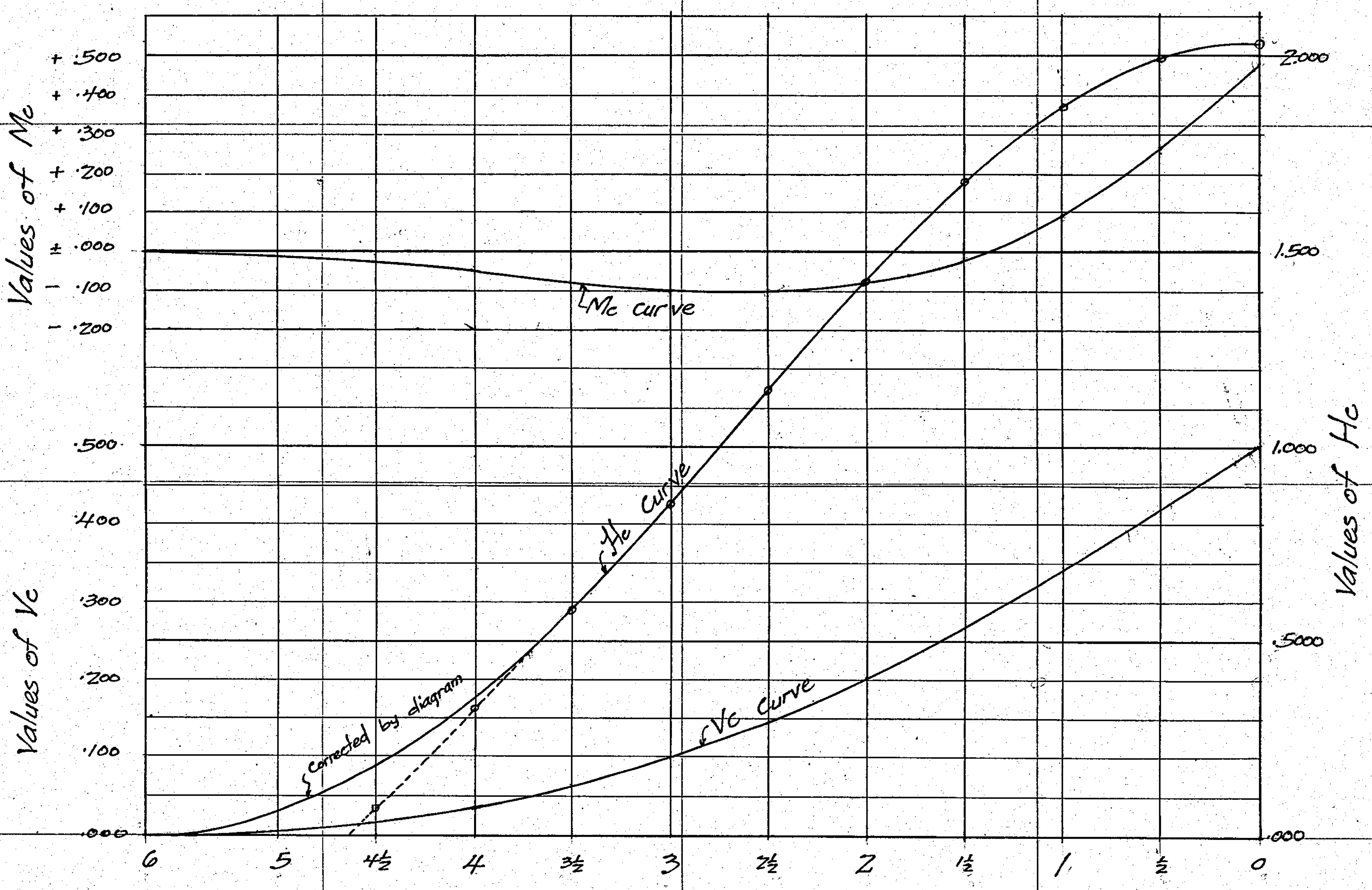
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Table of Values of ΣM_L, $\Sigma M_L x$, + $\Sigma M_L y$.

Load unity at Load point	n'	$\Sigma' x$	$\Sigma' y$	$\Sigma' x^2$	$\Sigma' xy$	d	$n'd$	$d\Sigma' x$	$d\Sigma' y$
0½	5	12.478	1.707	39.388	6.378	.500	2.500	6.239	.854
1	4	11.550	1.671	38.527	6.345	1.000	4.000	11.550	1.671
1½	4	11.550	1.671	38.527	6.345	1.500	6.000	17.325	2.507
2	3	9.970	1.571	36.031	6.187	2.000	6.000	19.940	3.142
2½	2	7.702	1.362	30.887	5.713	2.500	5.000	19.255	3.405
3	2	7.702	1.362	30.887	5.713	3.000	6.000	23.106	4.086
3½	1	4.634	.980	21.474	4.541	3.500	3.500	16.219	3.430
4	1	4.634	.980	21.474	4.541	4.000	4.000	18.536	3.920
4½	1	4.634	.980	21.474	4.541	4.500	4.500	20.853	4.410

Load at Point	ΣM_L	$\Sigma M_L x$	$\Sigma M_L y$	$\Sigma M_L \Sigma y$	H_c	V_c	M_c
½	9.978	33.149	5.524	17.082	1.990	.420	+ .264
1	7.550	26.977	4.674	12.926	1.873	.342	+ .095
1½	5.550	21.202	3.838	9.502	1.676	.269	− .016
2	3.970	16.091	3.045	6.797	1.422	.204	− .075
2½	2.702	11.632	2.308	4.626	1.143	.147	− .101
3	1.702	7.781	1.627	2.914	0.849	.099	− .100
3½	1.134	5.255	1.111	1.941	0.586	.067	− .073
4	.634	2.938	.621	1.085	0.327	.037	− .039
4½	.134	.621	.131	.229	0.069	.008	− .008



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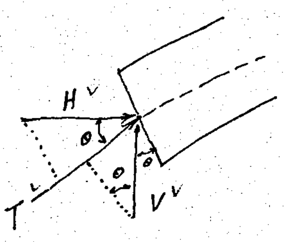
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima ken.

Summary of Hc, Vc, & Mc. (Corrected by the diagram near springing).

Load at point	Hc	Vc	Mc
0 crown	2.033	.500	+.485
½	1.990	.420	+.264
1	1.873	.342	+.095
1½	1.676	.269	−.016
2	1.422	.204	−.075
2½	1.143	.147	−.101
3	.849	.099	−.100
3½	.586	.067	−.073
4	.358	.038	−.055
4½	.180	.018	−.023
5	.060	.005	−.010
6	.000	.000	.000

Formula for computing normal thrust.



H = Horizontal thrust.
V = Vertical shear
= Vc or 1-Vc
T = thrust.
θ = angle between plane of section and vertical plane

Then $T = H\cos\theta + V\sin\theta$

Values of $\cos\theta$ & $\sin\theta$.

Section	$\cos\theta$	$\sin\theta$
0	1.000	.000
1	.995	.076
2	.988	.159
3	.969	.248
4	.930	.378
5	.857	.510
6	.802	.600

Table of Thrust due to unit load.

Load at	Term	S6	S5	S4	S3	S2	S1	S0	S1′	S2′	S3′	S4′	S5′	S6′
0	$H\cos\theta$	1.630	1.742	1.890	1.970	2.009	2.022	2.033	2.022	2.009	1.970	1.890	1.742	1.630
	$V\sin\theta$	.300	.255	.189	.124	.079	.038	0	.038	.079	.124	.189	.255	.300
	T	1.930	1.997	2.079	2.094	2.088	2.060	2.033	2.060	2.088	2.094	2.079	1.997	1.930
½		1.596	1.705	1.850	1.928	1.965	1.980	1.990	1.980	1.965	1.928	1.850	1.705	1.596
	"	.348	.296	.219	.144	.092	.044	0	.032	.067	.104	.159	.214	.252
		1.944	2.001	2.069	2.072	2.057	2.024	1.990	2.012	2.032	2.032	2.009	1.919	1.848
1		1.503	1.605	1.743	1.815	1.851	1.865	1.873	1.865	1.850	1.815	1.743	1.605	1.503
	"	.395	.336	.249	.163	.105	−.050	0	.026	.054	.085	~~1.293~~ .129	.174	.205
		1.898	1.941	1.992	1.978	1.956	1.815	1.873	1.891	1.905	1.900	1.872	1.779	1.708
1½		1.344	1.436	1.559	1.624	1.655	1.669	1.676	1.668	1.655	1.624	1.559	1.436	1.344
	"	.439	.373	.277	.182	.116	−.056	0	.020	.043	.067	.102	.137	.162
		1.783	1.809	1.836	1.806	1.771	1.613	1.676	1.688	1.698	1.691	1.661	1.573	1.506
2		1.140	1.218	1.322	1.377	1.404	1.414	1.422	1.414	1.404	1.377	1.322	1.218	1.140
	"	.478	.406	.301	.198	.127	−.016	0	.016	.032	.051	.077	.104	.122
		1.618	1.624	1.623	1.575	1.531	1.398	1.422	1.430	1.436	1.428	1.399	1.322	1.262
2½		.917	.979	1.064	1.097	1.130	1.138	1.143	1.138	1.130	1.097	1.064	.979	.917
	"	.512	.435	.322	.212	−.023	−.011	0	.011	.023	.036	.056	.075	.088
		1.429	1.414	1.386	1.309	1.107	1.127	1.143	1.149	1.153	1.133	1.120	1.054	1.005
3		.681	.727	.789	.823	.839	.845	.849	.845	.839	.823	.789	.727	.681
	"	.541	.459	.340	.224	−.016	−.008	0	.008	.016	.025	.037	.051	.059
		1.222	1.186	1.129	1.047	.823	.837	.849	.853	.855	.848	.826	.778	.740
3½		.470	.502	.545	.568	.579	.583	.586	.583	.579	.568	.545	.502	.470
	"	.560	.475	.352	−.017	−.011	−.005	0	.005	.011	.017	.025	.034	.040
		1.030	.977	.897	.551	.568	.578	.586	.588	.590	.585	.570	.536	.510
4		.287	.307	.333	.347	.354	.356	.358	.356	.354	.347	.333	.307	.287
	"	.577	.491	.364	−.009	−.006	−.003	0	.003	.006	.009	.014	.019	.023
		.864	.798	.697	.338	.348	.353	.358	.359	.360	.356	.347	.326	.310
4½		.144	.154	.168	.174	.177	.179	.180	.179	.177	.174	.168	.154	.144
	"	.589	.501	−.007	−.004	−.003	−.001	0	.001	.003	.004	.007	.009	.011
		.733	.655	.161	.170	.174	.178	.180	.180	.180	.178	.175	.163	.155
5		.048	.051	.056	.058	.059	.060	.060	.060	.059	.058	.056	.051	.048
	"	.597	.507	−.002	−.001	−.001	−.000	0	.000	.001	.001	.002	.003	.003
		.645	.558	.054	.057	.058	.060	.060	.060	.060	.059	.058	.054	.510

Design of Shinkawa Bashi for Fukushima Ken

Average Stress in Arch Rib.

We can determine the average stress throughout rib by the following method.
Let f_a = average stress throughout arch rib due to a load at any point.
The stresses at the various sections due to this load be designated by
$f_0, f_0', f_1, f_1', f_2, f_2'$ .... f_6, f_6'.

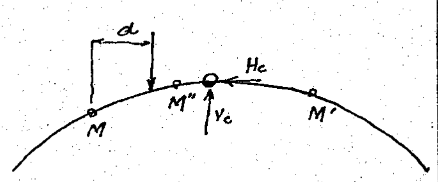
Then $f_a = \dfrac{f_0 ds_0 + f_0' ds_0 + f_1 ds_1 + f_1' ds_1 \text{ ---------- } + f_6 ds_6 + f_6' ds_6}{S}$

Table of Average Stress due to Unit load.

Stress	Area of Section A	Length of Rib ds	ds/A	Stresses due to a load of unity at (ds/A multiplied) 0	½	1	1½	2	2½	3	3½	4	4½	5	6
f_0	.260	1.002	3.854	7.835	7.669	7.219	6.459	5.480	4.405	3.272	2.258	1.380	.694	.231	
f_1	.266	1.005	3.778	7.783	7.647	6.857	6.094	5.282	4.258	3.162	2.184	1.334	.672	.227	
f_1'				7.783	7.601	7.144	6.377	5.403	4.341	3.223	2.221	1.356	.680	.227	
f_2	.276	1.013	3.670	7.663	7.549	7.179	6.500	5.619	4.063	3.020	2.085	1.277	.639	.213	
f_2'				7.663	7.457	6.991	6.232	5.270	4.232	3.138	2.165	1.321	.661	.220	
f_3	.298	1.029	3.453	7.231	7.155	6.830	6.236	5.438	4.520	3.615	1.903	1.167	.587	.197	
f_3'				7.231	7.016	6.561	5.839	4.931	3.912	2.928	2.020	1.229	.615	.204	
f_4	.350	1.078	3.080	6.403	6.373	6.135	5.655	4.999	4.269	3.477	2.763	2.147	.496	.166	
f_4'				6.403	6.188	5.766	5.116	4.309	3.450	2.544	1.756	1.069	1.539	.179	
f_5	.470	.980	2.085	4.164	4.172	4.047	3.772	3.386	2.948	2.473	2.037	1.664	1.366	1.163	
f_5'				4.164	4.001	3.709	3.303	2.756	2.198	1.622	1.118	.680	.340	.113	
f_6	.534	.412	.772	1.490	1.501	1.461	1.376	1.249	1.103	.943	.795	.667	.566	.498	
f_6'				1.490	1.427	1.319	1.163	.974	.776	.571	.394	.239	.120	.039	
	$S = 12.036^m$			77.303	75.756	71.218	64.122	55.096	44.475	33.988	23.699	15.530	7.975	3.677	
	f_a kg/m² =			6.423 kg/m²	6.294	5.917	5.328	4.578	3.695	2.824	1.969	1.290	.663	.305	

Moments due to unit load.

Let $x + y$ = Co-ordinates of center of section.
d = lever arm of unit load about center of section.
$M_c, M_1, M_1', M_2, M_2'$ designate moments
Then
for left hand sections $M = M_c + H_c y + V_c x - d$ (1)
" right hand " $M' = M_c + H_c y - V_c x.$ (2)
between load and crown $M'' = M_c + H_c y + V_c x.$ (2)



Load at	① $x=1.00, y=.042$ HcY	Vcx	d	④ $x=4.00, y=.685$ HcY	Vcx	d	⑤ $x=5.00, y=1.183$ HcY	Vcx	d	⑥ $x=5.68, y=1.64$ HcY	Vcx	d
0	.085	.500	1.000	1.393	2.000	4.000	2.405	2.500	5.00	3.334	2.840	5.680
½	.084	.420	.500	1.363	1.680	3.500	2.354	2.100	4.500	3.264	2.386	5.180
1	.079	.342		1.283	1.368	3.000	2.216	1.710	4.000	3.072	1.943	4.680
1½	.070	.269		1.148	1.076	2.500	1.983	1.350	3.500	2.749	1.528	4.180
2	.060	.204		.974	.816	2.000	1.682	1.020	3.000	2.332	1.159	3.680
2½	.048	.147		.783	.588	1.500	1.352	.735	2.500	1.875	.835	3.180
3	.036	.099		.582	.396	1.000	1.004	.495	2.000	1.392	.562	2.680
3½	.026	.067		.401	.268	0.500	.693	.335	1.500	.961	.381	2.180
4	.016	.038		.245	.152		.424	.190	1.000	.587	.216	1.680
4½	.009	.018		.123	.072		.213	.098	.500	.295	.102	1.180
5	.004	.005		.041	.020		.071	.025		.098	.028	.680

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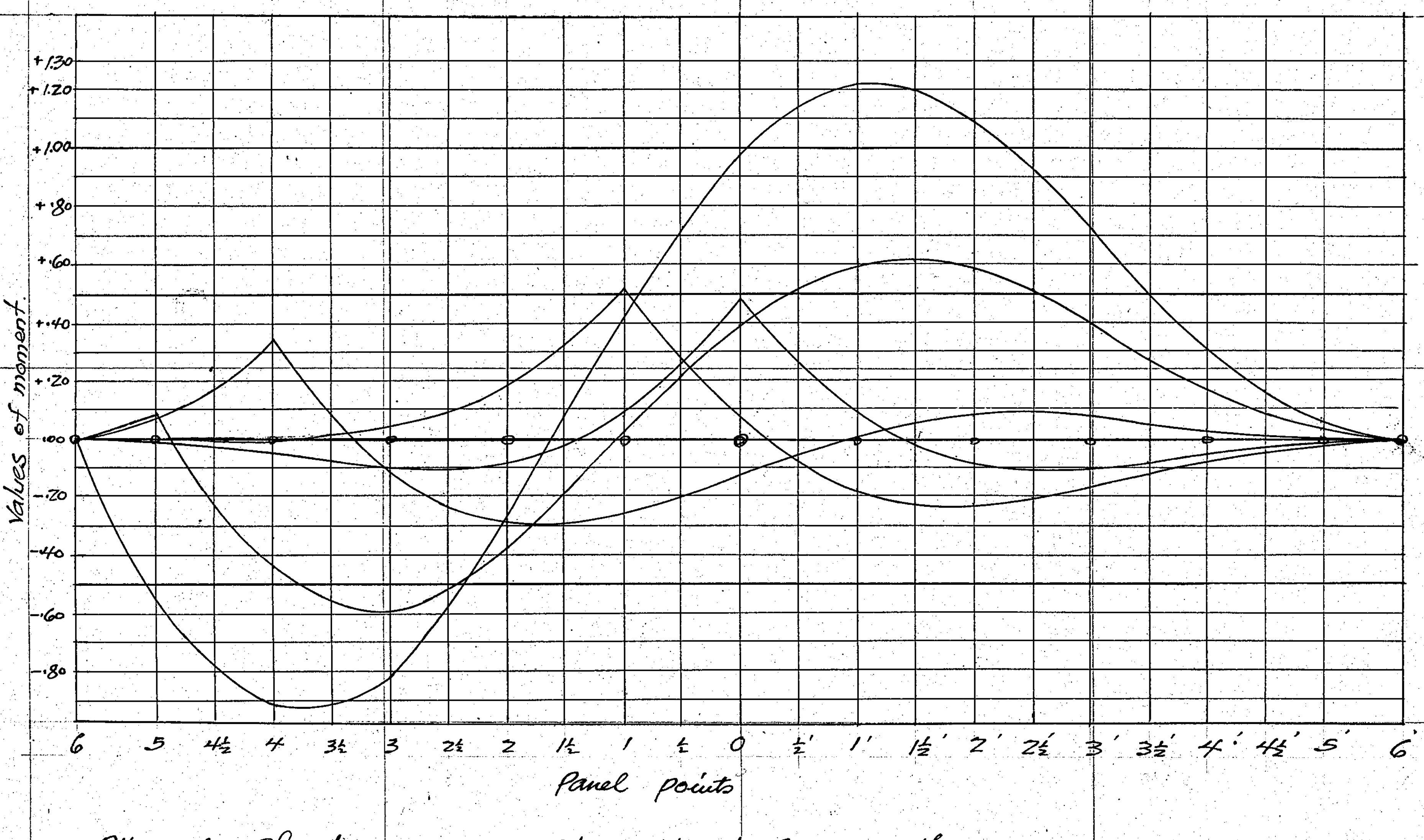
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Table of Moments for Unit Loads.

Load at	Moments at Section								
	0	1	1'	4	4'	5	5'	6	6'
0	+.485	+.070	+.070	−.122	−.122	+.390	+.390	+.979	+.979
½	+.264	+.268	−.072	−.193	−.053	+.218	+.518	+.734	+1.142
1	+.095	+.516	−.168	−.254	+.010	+.021	+.601	+.430	+1.224
1½	−.016	+.323	−.215	−.292	+.056	−.183	+.617	+.081	+1.205
2	−.075	+.189	−.219	−.285	+.083	−.373	+.587	−.264	+1.098
2½	−.101	+.094	−.200	−.230	+.094	−.514	+.516	−.571	+.939
3	−.100	+.035	−.163	−.122	+.086	−.601	+.409	−.826	+.730
3½	−.073	+.020	−.114	+.096	+.060	−.545	+.285	−.911	+.507
4	−.055	−.001	−.079	+.342	+.038	−.441	+.179	−.932	+.316
4½	−.023	−.001	−.032	+.172	+.028	−.220	+.100	−.806	+.170
5	−.010	−.001	−.011	+.051	+.011	+.086	+.036	−.564	+.060

Influence diagram of moments.



Moments, Thrusts and Average Stresses due to Balanced Loads of unity.

Load at	Average stress fa	0		1		4		5		6	
		M	T	M	T	M	T	M	T	M	T
0	6.423 kg/cm²	+.485 kg-m	2.033 kg	+.070	2.060	−.122	2.079	+.390	1.997	+.979	1.930
½+½'	12.588	+.528	3.980	+.196	4.036	−.246	4.078	+.736	3.920	+1.876	3.792
1+1'	11.834	+.190	3.740	+.348	3.706	−.244	3.864	+.622	3.720	+1.654	3.606
1½+1½'	10.656	−.032	3.352	+.108	3.301	−.236	3.497	+.434	3.382	+1.286	3.289
2+2'	9.156	−.150	2.844	−.030	2.828	−.202	3.022	+.214	2.946	+.834	2.880
2½+2½'	7.390	−.202	2.286	−.106	2.276	−.136	2.506	+.002	2.468	+.368	2.434
3+3'	5.648	−.200	1.698	−.128	1.690	−.036	1.955	−.192	1.964	−.096	1.962
3½+3½'	3.938	−.146	1.172	−.094	1.166	+.156	1.467	−.260	1.513	−.404	1.540
4+4'	2.580	−.110	.716	−.078	.712	+.380	1.044	−.262	1.124	−.616	1.174
4½+4½'	1.326	−.046	.360	−.033	.358	+.200	.336	−.120	.818	−.630	.888
5+5'	.610	−.020	.120	−.012	.120	+.068	.112	+.122	.612	−.504	.696

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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Stresses of Arch Ring.
Let us design the arch ring of one meter strip along center line of Bridge.
Dead Load:-

panel point 0.	Gravel paving	0.1 @ 1700 × .5 = 85		
	Earth filling	0.4 @ 1600 × .5 = 320		
	arch ring	0.26 @ 2400 × .5 = 312	717 kg	call this 720 kg
panel point 1/2	Gravel paving	85		
	Earth filling	0.41 @ 1600 × .5 = 328		
	arch ring	0.264 @ 2400 × .502 = 318	731 kg	" 730
panel point 1.	Gravel paving	85		
	Earth filling	0.44 @ 1600 × .5 = 352		
	arch ring	0.266 @ 2400 × .503 = 321	758 kg	" 760
panel point 1½	gravel pav.	85		
	Earth fill.	0.49 @ 1600 × .5 = 392		
	arch ring	0.27 @ 2400 × .504 = 327	804 kg	" 800
panel point 2	gravel pav.	85		
	Earth fill	0.55 @ 1600 × .5 = 440		
	arch ring	0.276 @ 2400 × .507 = 337	862 kg	" 860
panel point 2½	gravel pav	85		
	Earth fill	0.64 @ 1600 × .5 = 512		
	arch ring	0.286 @ 2400 × .51 = 350	947 kg	" 950
panel point 3	gravel pav.	85		
	Earth fill	0.75 @ 1600 × .5 = 600		
	arch ring	0.298 @ 2400 × .515 = 368	1,053 kg	" 1,050
panel point 3½	gravel pav.	85		
	Earth fill	0.88 @ 1600 × .5 = 704		
	arch ring	0.316 @ 2400 × .524 = 398	1,187 kg	" 1,190
panel point 4	gravel pav.	85		
	Earth fill	1.03 @ 1600 × .5 = 824		
	arch ring	0.35 @ 2400 × .539 = 453	1,362 kg	" 1,360
panel point 4½	gravel pav.	85		
	Earth fill	1.22 @ 1600 × .5 = 975		
	arch ring	0.402 @ 2400 × .558 = 538	1,598 kg	" 1,600
panel point 5	gravel pav.	0.1 @ 1700 × .59 = 100		
	Earth fill	1.45 @ 1600 × .59 = 1,370		
	arch ring	0.470 @ 2400 × .696 = 785	2,255 kg	" 2,260
panel point 6	gravel pav.	0.1 @ 1700 × .34 = 58		
	Earth fill	1.82 @ 1600 × .34 = 989		
	arch ring	0.568 @ 2400 × .413 = 563	1,610 kg	" 1,610

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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Dead Load Moments, Thrusts and Average Stresses of arch ring.

Load at	Load	Average Stress f_a kg/m²	Panel pt. 0		Panel pt. 1		Panel pt. 4		Panel pt. 5		Panel pt. 6	
			M	T	M	T	M	T	M	T	M	T
0	720 kg	4627	+ 349	1464	+ 50	1483	− 88	1496	+ 281	1437	+ 708	1390
½ + ½′	730	9190	+ 386	2905	+ 143	2946	− 180	2977	+ 537	2862	+ 1370	2770
1 + 1′	760	8990	+ 145	2842	+ 265	2817	− 185	2937	+ 473	2827	+ 1257	2740
1½ + 1½′	800	8530	− 26	2682	+ 86	2641	− 189	2797	+ 347	2715	+ 1028	2630
2 + 2′	860	7870	− 129	2445	− 26	2430	− 174	2600	+ 184	2532	+ 717	2475
2½ + 2½′	950	7020	− 192	2172	− 101	2162	− 129	2380	+ 2	2345	+ 350	2312
3 + 3′	1050	5930	− 210	1783	− 135	1775	− 38	2054	− 202	2062	− 101	2060
3½ + 3½′	1190	4675	− 174	1392	− 112	1388	+ 186	1745	− 310	1800	− 481	1833
4 + 4′	1360	3510	− 150	974	− 106	968	+ 517	1420	− 357	1528	− 838	1597
4½ + 4½′	1600	2123	− 74	576	− 53	573	+ 320	538	− 192	1308	− 1020	1420
5 + 5′	2260	1380	− 45	271	− 27	271	+ 154	253	+ 276	1383	− 1140	1573
	23840 kg on one span	63845 kg/m² or 6.385 kg/cm²	+ 880 − 1000 − 120 kgm	19510 kg	+ 544 − 560 − 16 kgm	19450 kg	− 983 + 1177 + 194	21200	+ 2100 − 1061 + 1039	22800	+ 5430 − 3580 + 1850	22800

Panel Loads for Approximate Max. Live Load Moments.

By plotting location of wheel load on a strip of paper to same scale as diagram on p 8, we can determine, by inspection, the approximate position of wheels for max. moments. Live Load distribution on arch ring assumed as follows.

Uniform Load $= \frac{100000}{170 + 11.36} = 550$ use 500 kg/m²

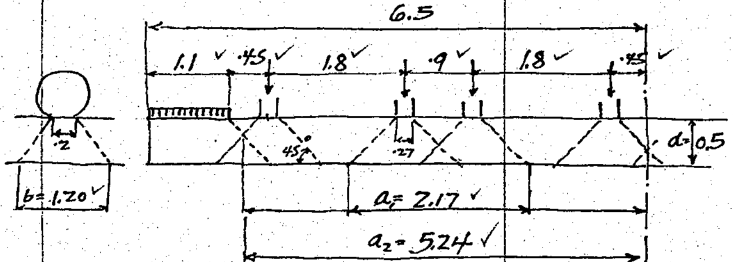
motor truck rear wheel concentration $= 3000$ kg

Impact $= \frac{20}{60 + 113.6} = 28\%$ $= 840$

3840 kg

Front wheel concentration with impact say $\frac{3840}{3} = 1280$ kg

Distribution at crown or pt. 0.



Rear wheels of motor truck

Load per meter strip $\frac{3840 \times 2}{2.17} = 3540$ kg

" $\frac{3840 \times 4}{5.24}$ 2930 kg front wheel say $\frac{2950}{3} = 985$

Load per lin. meter of span $= \frac{3540}{1.20} = 2950$ kg

Distribution at panel pt. 1. $d = .54$

$a_1 = 2.25$, $a_2 = 5.24$

$b = 1.28$

Load per meter strip $= \frac{3840 \times 2}{2.25} = 3410$ kg

Load per lin. meter $= \frac{3410}{1.28} = 2670$ kg

front wheel say $\frac{2670}{3} = 890$ kg

Distribution at panel pt. 2. $d = .65$

$a_1 = 2.47$, $a_2 = 5.24$

$b = 1.50$

Load per meter strip $= \frac{3840 \times 2}{2.47} = 3110$ kg

Load per lin meter $= \frac{3110}{1.50} = 2070$ kg

front wheel say $\frac{2070}{3} = 690$ kg

Distribution at panel pt 3. $d = .85$

$a_1 = 2.87$, $a_2 = 5.24$

$b = 1.90$

Load per meter strip $= \frac{3840 \times 2}{2.87} = 2680$ kg

" " $\frac{3840 \times 4}{5.24} = 2930$

Load per lin m $= \frac{2930}{1.9} = 1540$ kg

front wheel $= \frac{1540}{3} = 515$ kg

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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Distribution at panel point 4. $d = 1.13$ ✓ Load per meter strip $= \frac{3840 \cdot 4}{5.24}$ ✓ $= 2930$ ✓ kg

$a_2 = 5.24$ ✓, $b = 2.46$ ✓

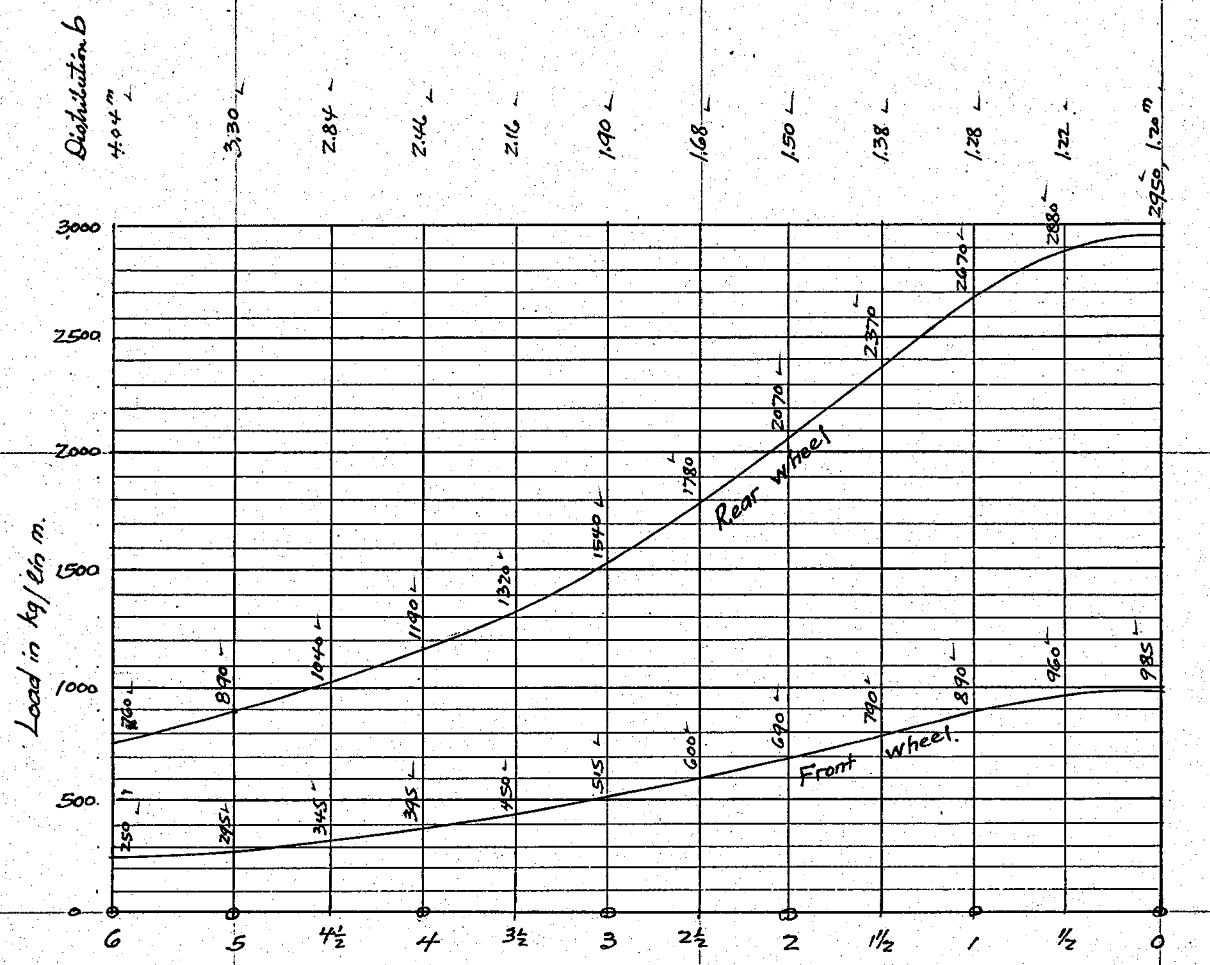
Load per lin m. of span $= \frac{2930}{2.46}$ ✓ $=$ 1190 ✓ kg

front wheel say $\frac{1190}{3}$ ✓ $=$ 395 ✓ kg.

Distribution at panel point 5 $d = 1.55$ ✓

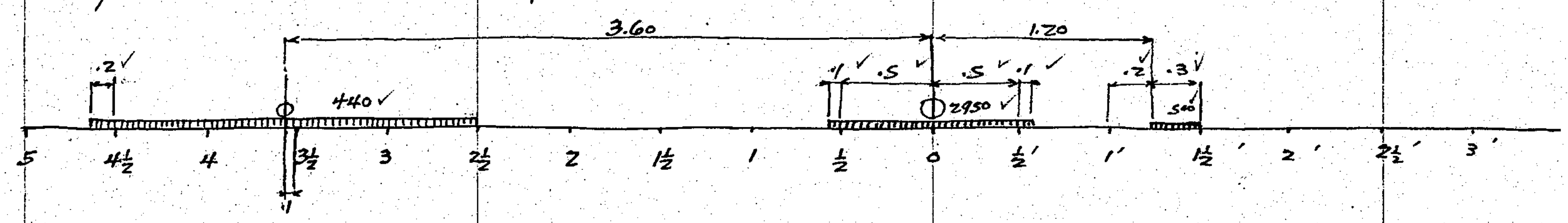
$a_2 = 5.24$ ✓, $b = 3.30$ ✓ Load per lin meter $= \frac{2930}{3.3}$ ✓ $=$ 890 ✓ kg

front wheel say $\frac{890}{3}$ ✓ $=$ 295 ✓ kg



Live Load moments and thrusts

Pos. moment at crown or point 0. Rear wheel at 0.



18 ✓ 70 ✓ 740 ✓ 1475 ✓ 740 ✓ 45 ✓ 105 ✓

110 ✓ 220 ✓ 220 ✓ 220 ✓ 110 ✓ 30 ✓ 265 ✓ 265 ✓ 30 ✓ ~~10~~

18 ✓ 180 ✓ 220 ✓ 220 ✓ 220 ✓ 110 ✓ 30 ✓ 1005 ✓ 1475 ✓ 1005 ✓ 75 ✓ 105 ✓

Load at	Load	M unit load.	moment.	T unit load.	Thrust (normal)	Unif. load.	moment	Thrust.
1½'	105 ✓	− .016 ✓	− 2 ✓	1.676 ✓	176. ✓			
1'	75 ✓	+ .095 ✓	+ 7 ✓	1.873 ✓	141 ✓	250 ✓	+ 24 ✓	471 ✓
½'	1005 ✓	+ .264 ✓	+ 265 ✓	1.990 ✓	2,000 ✓	250 ✓	+ 66 ✓	497 ✓
0	1475 ✓	+ .485 ✓	+ 715 ✓	2.033 ✓	2998 ✓	250 ✓	+ 121 ✓	508 ✓
½	1005 ✓	+ .264 ✓	+ 265 ✓	1.990 ✓	2,000 ✓	250 ✓	+ 66 ✓	497 ✓
1	30 ✓	+ .095 ✓	+ 3 ✓	1.873 ✓	56 ✓	250 ✓	+ 24 ✓	471 ✓
2½	110 ✓	− .101 (~~.016~~) ✓	− 11 ✓	1.143 ✓	126 ✓		+ 301 ✓	2,444 ✓
3	220 ✓	− .100 ✓	− 22 ✓	.849 ✓	187 ✓			
3½	220 ✓	− .073 ✓	− 16 ✓	.586 ✓	129 ✓			
4	220 ✓	− .055 ✓	− 12 ✓	.358 ✓	79 ✓			
4½	180 ✓	− .023 ✓	− 4 ✓	.180 ✓	32 ✓			
5	18 ✓	− .010 ✓	− 0 ✓	.060 ✓	1 ✓			
			+ 1188 kg-m		7925 kg.			

Moment and thrust for Unif. load only.

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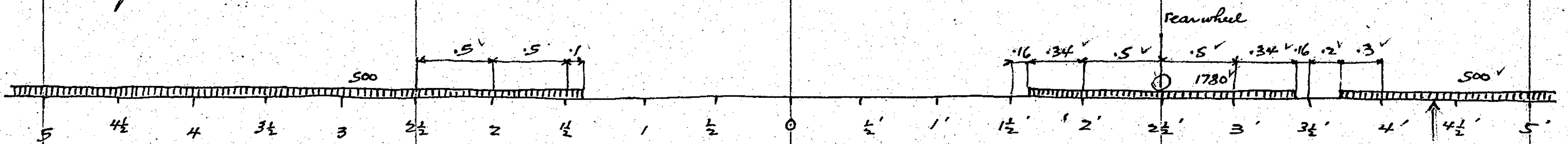
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken

Negative moment at crown



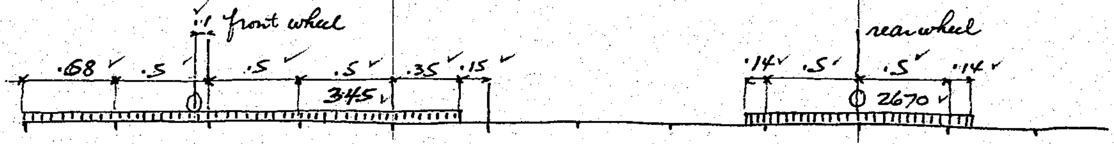
5	4½	4	3½	3	2½	2	1½	1	½	0	½'	1'	1½'	2'	2½'	3'	3½'	4'	4½'	5'
170							45	5					#	445	890	445	45	105		170
125	250	250	250	250	250	250	125						205	400		400	205	125	250	125
295	250	250	250	250	250	250	170	5					205	845	890	845	250	230	250	295

此 uniform load ハ載荷セザルヲ至当トス 但シ誤差僅少ニシテ且ツ safe side ナル故訂正セズ
(5-4-11)

Loads at	Loads	M unity	Moment	T unity	Thrust
5	295	−.010	3	.060	18
4½	250	−.023	6	.180	45
4	250	−.055	14	.358	90
3½	250	−.073	18	.586	147
3	250	−.100	25	.849	212
2½	250	−.101	25	1.143	286
2	250	−.075	19	1.422	356
1½	170	−.016	3	1.676	285
1	5	+.095	0	1.873	9
1½'	205	−.016	3	1.676	343
2'	845	−.075	63	1.422	1,202
2½'	890	−.101	90	1.143	1,018
3'	845	−.100	85	.849	717
3½'	250	−.073	18	.586	147
4'	230	−.055	14	.358	82
4½'	250	−.023	6	.180	45
5'	295	−.010	3	.060	18
			−395 kgm		5,020 kg

moment for unif load only
113 × 2 = −226 kgm
Thrust "
1448 × 2 = 2896 kg

Positive moment at point 1. Rear wheel at point 1.



6	5	4½	4	3½	3	2½	2	1½	1	½	0
	117			79	41		52	321		321	52
	86	173	173	86				668	1335	668	
	203	173	173	165	41		52	989	1335	989	52

Loads at	Loads	M unity	Moment	T unity	Thrust
5	203	−.001	0	.060	12
4½	173	−.001	0	.178	31
4	173	−.001	0	.353	61
3½	165	+.020	+3	.578	95
3	41	+.035	+1	.837	34
2½					
2	52	+.189	+10	1.398	73
1½	989	+.323	+319	1.613	1,595
1	1335	+.516	+689	1.815	2421
½	989	+.268	+265	2.024	2002
0	52	+.070	+4	2.060	107
			+1291 kgm		6,431 kg

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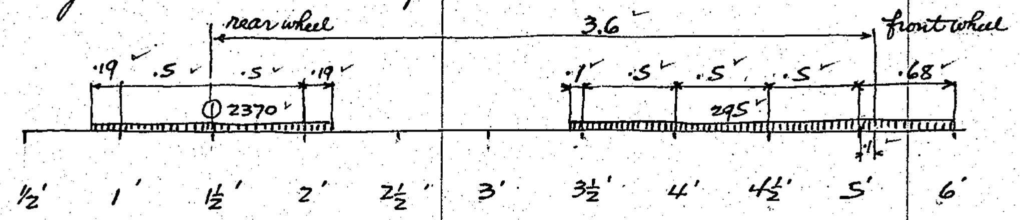
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken

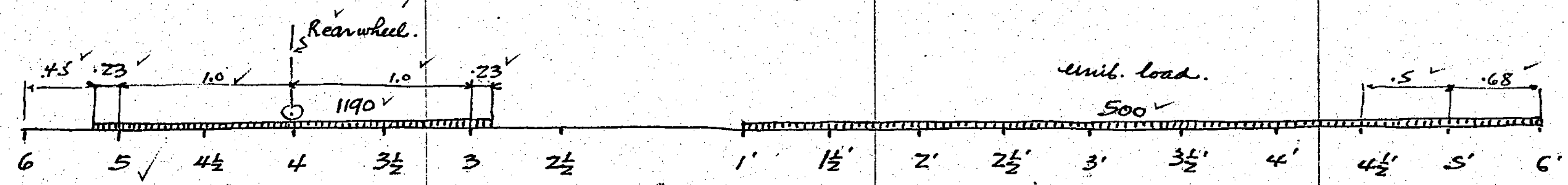
Negative moment at point 1. Rear wheel at 1½'



85	365		365	85	3	27			100	100
	593	1185	593			74	148	148	74	
85	958	1185	958	85	3	101	148	148	174	

Load at	Loads	M unity	Moment	T unity	Thrust
½'	85	-.072	- 6	2.012	171
1'	958	-.168	- 161	1.891	1812
1½'	1,185	-.215	- 255	1.688	2,000
2'	958	-.219	- 210	1.430	1370
2½'	85	-.200	- 17	1.149	98
3'	3	-.163	- 0	.853	3
3½'	101	-.114	- 12	.588	59
4'	148	-.077	- 11	.359	53
4½'	148	-.032	- 5	.180	27
5'	174	-.011	- 2	.060	10
			- 679 kgm		5603 kg

Positive moment at point 4. Rear wheel at 4.



227				211	63									170
298	595	595	595	298										125
525	595	595	595	509	63	125	250	250					250	295

Loads at	Loads	M unity	Moment	T unity	Thrust
5	525	+ .051	+ 30	.054	28
4½	595	+ .172	+ 102	.161	96
4	595	+ .342	+ 204	.697	415
3½	595	+ .096	+ 57	.897	534
3	509	- .122	- 62	1.129	574
2½	63	- .230	- 15	1.386	87
1'	125	+ .010	+ 1	1.872	234
1½'~4½'	250	+ .445	+ 111	6.098	1525
5'	295	+ .011	+ 3	.058	17
			+ 431 kgm		3,510 kg

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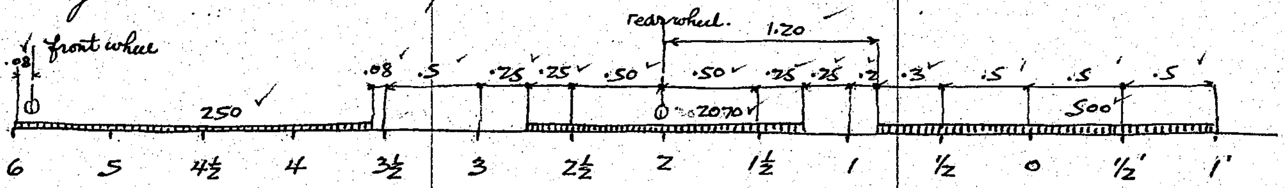
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

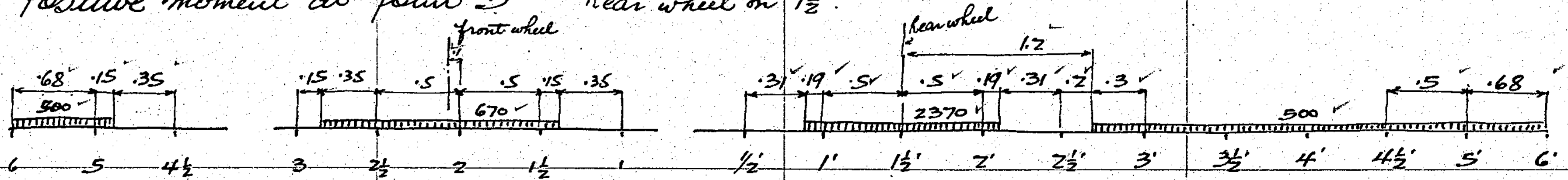
Negative moment at point 4. Rear wheel at 2.



5	4½	4	3½	3	2½	2	1½	1	½	0	½'	1'
85		61	44	130	388		388	130	125	250	250	125
63	125	63			518	1035	518	45	105			
148	125	124	44	130	906	1035	906	175	230	250	250	125

Loads at	Loads	M unity	Moment	T unity	Thrust.
5	148	+ .051	+ 8	.054	8
4½	125	+ .172	+ 22	.161	20
4	124	+ .342	+ 42	.697	86
3½	44	+ .096	+ 4	.897	40
3	130	− .122	− 16	1.129	147
2½	906	− .230	− 209	1.386	1256
2	1035	− .285	− 295	1.623	1680
1½	906	− .292	− 265	1.836	1664
1	175	− .254	− 44	1.992	348
0½	230	− .193	− 44	2.069	475
0	250	− .122	− 31	2.079	519
½'	250	− .053	− 13	2.009	502
1'	125	+ .010	+ 1	1.872	234
			− 840 kgm		6979 kg

Positive moment at point 5 Rear wheel on 1½'.



5	4½	3	2½	2	1½	1	½'	1'	1½'	2'	2½'	3'	3½'	4'	4½'	5'
170		82	153		153	82	86	365		365	86	125	250	250	250	125
64	11		168	335	168			593	1185	593	45	105				170
234	11	82	321	335	321	82	86	958	1185	958	131	230	250	250	250	295

Loads at	Loads	M unity	Moment	T unity	Thrust.
5	234	+ .086	+ 20	.558	131
4½	11	− .220	− 2	.655	7
3	82	− .601	− 49	1.186	97
2½	321	− .514	− 165	1.414	459
2	335	− .373	− 125	1.624	544
1½	321	− .183	− 59	1.809	580
1	82	+ .021	+ 2	1.941	159
½'	86	+ .518	+ 45	1.919	165
1'	958	+ .601	+ 576	1.779	1705
1½'	1185	+ .617	+ 731	1.573	1877
2'	958	+ .587	+ 572	1.322	1266
2½'	131	+ .516	+ 68	1.054	138
3'	230	+ .409	+ 94	.778	179
3½'	250	+ .285	+ 71	.536	134
4'	250	+ .179	+ 45	.326	82
4½'	250	+ .100	+ 25	.163	41
5'	295	+ .036	+ 11	.054	16
			+ 1860 kgm		7580 kg

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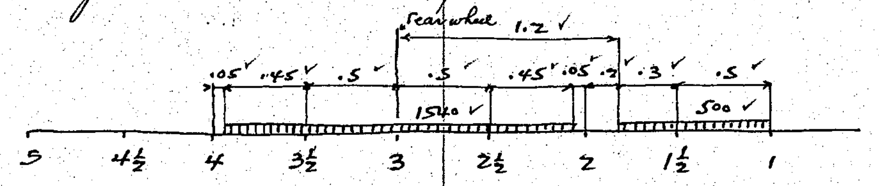
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

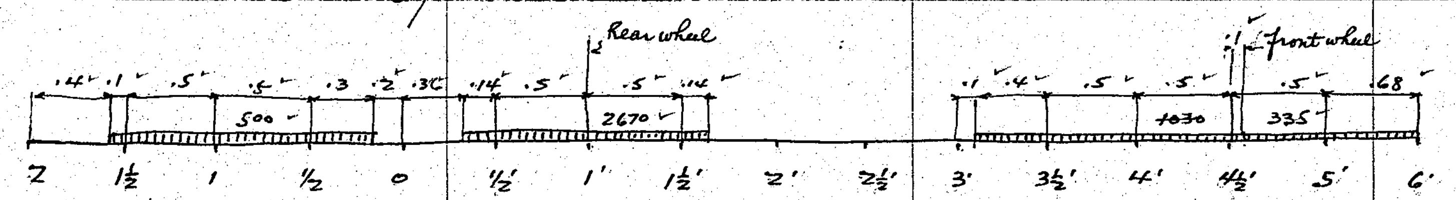
Negative moment at point 5 Rear wheel on point 3.



312 381 381 312 175 175
385 770 385 45 105
312 766 770 766 357 230 175

Loads at	Loads	M unity	Moments	T unity	Thrust
4	312	− .441	− 138	.798	249
3½	766	− .545	− 418	.977	748
3	770	− .601	− 463	1.186	913
2½	766	− .514	− 394	1.414	1083
2	357	− .373	− 133	1.624	580
1½	230	− .183	− 42	1.809	416
1	175	+ .021	+ 3	1.941	243
			− 1585 kgm		4232 kg

Positive moment at point 6. Rear wheel on 1'



5 45 668 1335 668 54 81 114
175 250 175 52 322 322 52 84 168 168 84
5 170 250 230 97 990 1335 990 52 54 165 168 168 198

Loads at	Loads	M unity	Moment	T unity	Thrust
2	5	− .264	− 1	1.618	8
1½	170	+ .081	+ 14	1.783	303
1	250	+ .430	+ 108	1.898	475
½	230	+ .734	+ 169	1.944	447
0	97	+ .979	+ 95	1.930	187
½'	990	+ 1.142	+ 1129	1.848	1828
1'	1335	+ 1.224	+ 1634	1.708	2280
1½'	990	+ 1.205	+ 1192	1.506	1490
2'	52	+ 1.098	+ 57	1.262	66
2½'	—	+ .939	+ —	1.005	—
3'	54	+ .730	+ 39	.740	40
3½'	165	+ .507	+ 84	.510	84
4'	168	+ .316	+ 53	.310	52
4½'	168	+ .170	+ 29	.155	26
5'	198	+ .060	+ 12	.051	10
			+ 4614		7296 kg

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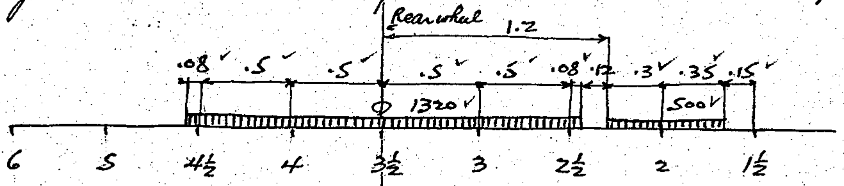
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Negative moments at point 6. Rear wheel at point $3\frac{1}{2}$.



8	97				97	8	
	330	660	660	660	330	114	61
					45	105	
8	427	660	660	660	472	227	61

Load at	Load	M unit load	moment	T unity	Thrust
5	8	− .504	− 4	.645	5
$4\frac{1}{2}$	427	− .806	− 344	.733	313
4	660	− .932	− 615	.864	570
$3\frac{1}{2}$	660	− .911	− 601	1.030	680
3	660	− .826	− 545	1.220	806
$2\frac{1}{2}$	472	− .571	− 270	1.429	675
2	227	− .264	− 60	1.618	367
$1\frac{1}{2}$	61	+ .081	+ 5	1.783	109
			−2434 kgm		3525 kg

Temperature Stress:-

Crown Thrust $H_c = \dfrac{E.w.t.\ l.\ n}{2[n\Sigma y^2-(\Sigma y)^2]}\cdot\dfrac{I}{ds}$

$= \dfrac{252000\times 12.036\times 6}{8.070\times 340}$

$= \pm\ 6640$ kg (for one meter strip)

for $t = \pm\ 15°C$

where E = 1,400,000,000 kg/m²
coef. of exp. w = 0.000012 for 1°C
variation of temperature ± 15°C
l = length of span on arch axis = 12.036 m
$E.w.t$ = 252000 kg
n = no. of division for ½ span = 6
I/ds = 1/340
$2[n\Sigma y^2-(\Sigma y)^2]$ = 8.070 page 4.

Crown moment $M_c = \pm\ \dfrac{H_c\ \Sigma y}{n}$

$= \pm\ \dfrac{6640\times 1.712}{6}$

$= \mp\ 1890$ kgm for $t = \pm\ 15°C$

$\dfrac{M_c}{H_c} = \dfrac{1890}{6640} = .285$ m below crown for fall

Temperature stresses at various points for fall of temperature of 15°C.

panel point	moment: Mo − Hc · y = Moment				Thrust: Hc · Cos θ = Thrust			× ds/A (Page 7)	
	Mo	Hc	y	Moment (kgm)	Hc	Cos θ	Thrust (kg)	ds/A	
0	+ 1890	− 6640	0	= + 1890	− 6640	1.000	= − 6640	1.928	= − 12800
1	+ 1890	− 6640	.044	= + 1600	− 6640	.995	= − 6610	3.778	= − 24950
2	+ 1890	− 6640	.163	= + 810	− 6640	.988	= − 6560	3.670	= − 24050
3	+ 1890	− 6640	.365	= − 530	− 6640	.969	= − 6430	3.453	= − 22200
4	+ 1890	− 6640	.685	= − 2610	− 6640	.930	= − 6170	3.080	= − 19000
5	+ 1890	− 6640	1.180	= − 5940	− 6640	.857	= − 5690	2.085	= − 11850
6	+ 1890	− 6640	1.640	= − 8990	− 6640	.802	= − 5320	.772	= − 4100
									− 118950

Average stress = $\dfrac{-118950}{6.018}$ = − 19700 kg/m²
or − 1.97 kg/cm²

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CHECKED BY M. Jinda DATE 5-14-13 PAGE NO 17

CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken

Average stresses in arch ring

Dead Load stress	average stress	= 63,845 kg/m²	page 10
Temperature stress	" "	= −19,700 " for fall	" 16

Live Load average stresses in arch ring for the entire span are only approximate. average stresses are founds by the prepared diagrams. (If more presice values are desired they will be found by the table on page 7 for each loading condition).

Concrete area at crown $1.0 \times .26 = .2600$
Equivalent steel area $14 \times 25.4 \div 10000 = .0355$
$.2955$ square meter

Thickness ratio $= \frac{60}{26} = 2.31$, Rise ratio $= \frac{1.64}{11.36} = .144$

Live Load stresses

		T kg				Coef. for average stress		Average stress
Crown	+ moment	7925	÷ .2955	=	26,800 kg	× .870	=	23,300 kg/m²
panel pt. 1	+ moment	6431	÷ .2955	=	21,800	× .870	=	18,950
panel pt. 4	+ moment	3510	÷ .2955	=	11,900	× .870	=	10,350
	− moment	6979	÷ .2955	=	23,650	× .905	=	21,400
panel pt. 5	+ moment	7580	÷ .2955	=	25,700	× .870	=	22,350
	− moment	4232	÷ .2955	=	14,330	× .905	=	12,970
Springing	+ moment	7296	÷ .2955	=	24,700	× .870	=	21,500
	− moment	3525	÷ .2955	=	11,950	× .905	=	10,810

$R = \frac{Temp}{E.w.t + Temp} \times C = \frac{19700}{252000 + 19700} C = \frac{19700}{271700} C = .0725 C$

Fibre stress in arch ring.

Crown section. : positive moment. compression in the upper fibre.

	Thrust	moment	average stress
Dead Load	+ 19,510	−120	63,845
Live Load	+ 7,925	+ 1,188	23,300
Temperature	− 6,640	+ 1,890	− 19,700
Rib shortening	− 1,060	+ 470	− 4,880 R
	19,135 kg	+ 3,428 kgm	62,505 kg/m²

E.w.t. = 252,000 for temp.

$62,565 \div 252000 = .25$ $e_{cc} = \frac{3428}{19135} = .179$ $e/h = \frac{.179}{.26} = .688$

$d'/h = 4/26 = .154$; $P_0 = 2p = \frac{25.4}{2600} = .0097$ $h = 26$ cm

$k = .408$, $L = .118$

$f_c = \frac{M}{Lbh^2} = \frac{3428 \times 100}{.118 \times 100 \times 26^2} = 43.0$ kg/cm² $< 45 \times 1.25 = 56$ kg/cm² ok

$f_s = nf_c\left(\frac{d}{kh} - 1\right) = 15 \times 43.0\left(\frac{22}{.408 \times 26} - 1\right) = 700$ kg/cm² $< 1200 \times 1.25 = 1500$ ok

	Thrust	moment	average stress
Dead Load	+ 19,510	− 120	63,845
Live Load	+ 7,925	+ 1,188	23,300
Rib shortening	− 2,130	+ 607	− 6,310 R
	+ 25,305	+ 1,675	80,835

$80835 \div 252000 = .321$ $e_{cc} = .066$ $e/h = .254$

$k = .80$, $L = .116$

$f_c = \frac{1,675 \times 100}{.116 \times 100 \times 26^2} = 21.4$ kg/cm² < 45 ok.

$f_s = 15 \times 21.4\left(\frac{22}{.80 \times 26} - 1\right) = 18.6$ kg/cm² < 1200 ok.

Panel point 1. positive moment.

	Thrust	moment	average stress
Dead Load	19,450	− 16	63,845
Live Load	6,431	+ 1,291	18,950
Temperature	− 6,610	+ 1,600	− 19,700
Rib shortening	− 1,533	+ 371	− 4,575
	17,738	+ 3,246	58,520

$58520 \div 252000 = .232$ $e_{cc} = .183$ $e/h = \frac{.183}{.266} = .688$

$d'/h = 4/26.6 = .15$ $P_0 = \frac{25.4}{2660} = .0095$ $h = 26.6$ cm

$k = .405$ $L = .117$

$f_c = \frac{324600}{.117 \times 100 \times 26.6^2} = 39.2$ kg/cm² ok.

$f_s = 15 \times 39.2 \times \left(\frac{22.6}{.405 \times 26.6} - 1\right) = 655$ kg/cm²

Design of Shinkawa Bashi for Fukushima Ken.

Panel point 1. positive moment

	Thrust	moment	average stress
Dead Load	19450	− 16	63845
Live Load	6431	+ 1291	18950
Rib shortening	− 2015	+ 487	− 6000
	23,866	+ 1762	76,795

$76795 \div 252000 = .305$ $\xi_{cc} = .074$ $\xi/h = \frac{.074}{.266} = .278$

$k = .75$ $L = .117$

$f_c = \frac{176200}{.117 \times 100 \times 26.6^2} = 22.3$ kg/cm² ok.

$f_s = 15 \times 22.3 \left(\frac{22.6}{.75 \times 26.6} - 1\right) = 444$ kg/cm² ok.

Panel point 4. positive moment

Dead Load	+ 21,200	+ 194	+ 63845
Live Load	+ 3510	+ 431	+ 10350
Temperature	+ 6170	+ 2610	+ 19,700
Rib shortening	− 2140	− 905	− 6820
	+ 28740	+ 2313	+ 87075

$87075 \div 252{,}000 = .347$ $\xi_{cc} = .081$ $\xi/h = \frac{.081}{.35} = .23$

$d'/h = 4/35 = .114$, $p_0 = \frac{25.4}{3500} = .0073$ $h = 35$ cm

$k = .87$ $L = .112$

$f_c = \frac{231300}{.112 \times 100 \times 35^2} = 17.2$ kg/cm² ok.

$f_s = 15 \times 17.2 \left(\frac{31}{.87 \times 35} - 1\right) = 5$ 〃

Dead Load	+ 21,200	+ 194	+ 63,845
Live Load	+ 3,510	+ 431	+ 10,350
Rib shortening	− 1685	− 713	− 5370
	+ 23,025	− 188	+ 68825

$68825 \div 252000 = .273$ $\xi_{cc} = .0038$ $\xi/h = \frac{.0038}{.35} = .011$

Panel point 4. Negative moment

Dead Load	+ 21,200	+ 194	+ 63845
Live Load	+ 6979	− 840	+ 21400
Temperature	− 6170	− 2610	− 19,700
Rib shortening	− 1490	− 642	− 4,750
	+ 20,519	− 3898	+ 60,795

$60{,}795 \div 252{,}000 = .2415$, $\xi_{cc} = .190$, $\xi/h = .190/.35 = .543$

$k = .440$; $L = .114$

$f_c = \frac{389{,}800}{.114 \times 100 \times 35^2} = 27.9$ kg/cm² ok.

$f_s = 15 \times 27.9 \left(\frac{31}{.44 \times 35} - 1\right) = 423$ kg/cm² ok.

Dead Load	+ 21,200	+ 194	+ 63,845
Live Load	+ 6,979	− 840	+ 21,400
Rib shortening	− 1,937	− 820	− 6180
	26,242	− 1466	+ 79,065

$79065 \div 252{,}000 = .314$ $\xi_{cc} = .0558$ $\xi/h = .0558/.35 = .160$

Panel point 5 positive moment

Dead Load	+ 22,800	+ 1039	+ 63845
Live Load	+ 7,580	+ 1,860	+ 22,350
Temperature	+ 5690	+ 5940	+ 19,700
Rib shortening	− 2220	− 2315	− 7,680
	+ 33,850	+ 6524	+ 98,215

$98215 \div 252000 = .390$ $\xi_{cc} = .193$ $.193/.47 = .411$

$d'/h = 4/47 = .085$, $p_0 = \frac{25.4}{4700} = .0054$, $h = 47$ cm

$k = .54$, $L = .112$

$f_c = \frac{652400}{.112 \times 100 \times 47^2} = 26.4$ kg/cm² ok

$f_s = 15 \times 26.4 \left(\frac{43}{.54 \times 47} - 1\right) = 275$ 〃 ok.

Dead Load	22800	1039	63845
Live Load	7,580	1,860	22,350
Rib Shortening	− 1803	− 1885	− 6240
	28577	1,014	79,955

$79{,}955 \div 252000 = .317$ $\xi_{cc} = .0355$ $.0355/.47 = .0755$

Panel point 5 Negative moment

Dead Load	+ 22800	+ 1039	+ 63845
Live Load	+ 4232	− 1585	+ 12,970
Temperature	− 5690	− 5940	− 19,700
Rib shortening	− 1195	− 1,247	− 4140
	+ 20,147	− 7,733	+ 52,975

$52{,}975 \div 252{,}000 = .210$ $\xi_{cc} = .384$ $\xi/h = .384/.47 = .818$

$k = .338$, $L = .107$

$f_c = \frac{773300}{.107 \times 100 \times 47^2} = 32.7$ kg/cm² ok

$f_s = 15 \times 32.7 \left(\frac{43}{.338 \times 47} - 1\right) = 838$ kg/cm² ok

Dead Load	+ 22800	+ 1039	+ 63845
Live Load	+ 4232	− 1585	+ 12,970
Rib shortening	− 1610	− 1682	− 5570
	+ 25422	− 2228	+ 71,245

$71245 \div 252000 = .283$ $\xi_{cc} = .088$ $\xi/h = .088/.47 = .187$

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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken

Springing ″ 6. positive moment.

	Thrust	moment	average stress
Dead Load	+ 22,800	+ 1,850	+ 63,845
Live Load	+ 7,296	+ 4,614	+ 21,500 ~~7,296~~
Temperature	+ 5,320	+ 8,990	+ 19,700
Rib shortening	− 2,060	− 3,480	− 7,620
	+ 33,356	+ 11,974	+ 97,426

97,425 ÷ 252,000 = .387, e_{cc} = .359, $e/h = .359/.6 = .600$

$d'/h = 4/60 = .0667$, $p_0 = \frac{25.4}{6000} = .00423$, $h = 6.0$ cm

$k = .377$, $L = .102$

$f_c = \frac{1197400}{.102 \times 100 \times 60^2} = 32.6$ kg/cm² ok

$f_s = 15 \times 32.6 \left(\frac{56}{60 \times .377} - 1\right) = 726$ kg/cm² ok.

Dead Load	+ 22,800	+ 1,850	+ 63,845
Live Load	+ 7,296	+ 4,614	+ 21,500
Rib shortening	− 1,670	− 2,820	− 6,190
	+ 28,426	+ 3,644	+ 79,155

79,155 ÷ 252,000 = .314, e_{cc} = .127, $e/h = .127/.60 = .214$

$k = .89$, $L = .103$

$f_c = \frac{364400}{.103 \times 100 \times 60^2} = 10.0$ kg/cm² ok

$f_s = 15 \times 10 \left(\frac{56}{60 \times .89} - 1\right) = 1$

Springing, Negative moment.

Dead Load	+ 22,800	+ 1,850	+ 63,845
Live Load	+ 3,525	− 2,434	+ 10,810
Temperature	− 5,320	− 8,990	− 19,700
Rib shortening	− 1,063	− 1,800	− 3,980
	+ 19,942	− 11,374	+ 50,975

50,975 ÷ 252,000 = .200, e_{cc} = .572, $e/h = \frac{.572}{.60} = .955$

$k = .290$, $L = .096$

$f_c = \frac{1137400}{.096 \times 100 \times 60^2} = 38.$ kg/cm² ok.

$f_s = 15 \times 38 \left(\frac{56.0}{.29 \times 60.0} - 1\right) = 1265$ kg/cm² < 1200 × 1.25 = 1500 ok

Dead Load	+ 22,800	+ 1,850	+ 63,845
Live Load	+ 3,525	− 2,434	+ 10,810
Rib shortening	− 1,463	− 2,472	− 5,410
	+ 24,862	− 3,056	+ 69,245

69,245 ÷ 252,000 = .275, e_{cc} = .12, $e/h = \frac{.12}{.60} = .20$

$k = .93$, $L = .100$

$f_c = \frac{305600}{.10 \times 100 \times 60^2} = 8.3$ kg/cm² ok

$f_s = 15 \times 8.3 \left(\frac{56}{.94 \times 60} - 1\right) = 0$

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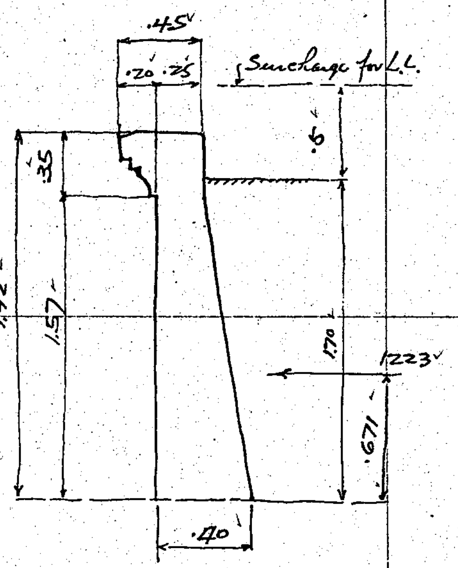
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Design of Spandrel wall. max height 1.92 metres from extrados of arch ring to top of coping.

Stability of wall

Stability at normal state.



Earth pressure $\frac{1}{3} \times 1600 \times .5 = 267$

$\frac{1}{3} \times 1600 \times 2.2 = 1173$

$1440 \div 2 = 720$ kg/m² average.

Earth pressure on wall $= 720 \times 1.7 = 1223$ kg/meter strip.

∴ moment $= 1223 \times .671 = 820$ kgm.

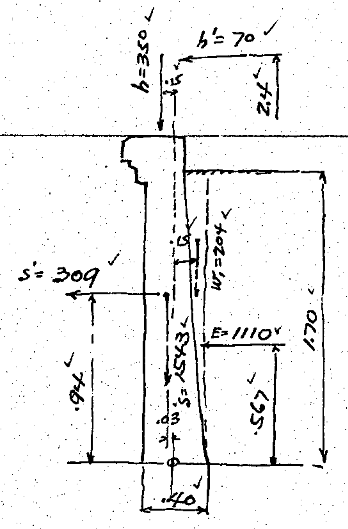
Effective depth required for moment $= \sqrt{\frac{820 \times 100}{100 \times 7.18}} = 10.7$ cm

use 40 cm depth over all with 3cm insulation, Eff. depth 37cm.

Steel area required for moment $= \frac{82000}{1200 \times \frac{7}{8} \times 37} = 2.11$ cm²

use 13mmφ bars 30cm ctoc $= 4.42$ cm²

Stability during Earthquake. $k = .20$ assumed.



Weight and center of gravity.

coping	$.35 \times .38$ @	$2400 =$	319	$\times 1.77 =$	564
wall	$.325 \times 1.57$ @	$=$	1224	$\times .72 =$	881
			1543 kg	.94	1445

Seismic force $1543 \times .2 = 309$ kg.

Earth pressure during earthquake $= .48 \times 1600 \times \frac{1.7^2}{2} = 1110$ kg

Earth on rear. $.15 \times \frac{1.7}{2} \times 1600 = 204$ kg.

Handrail assumed 350 kg/m. seismic force $= 70$ kg.

Taking moment about center of bottom section

Loads	Hor. forces	Vert. forces	Lev arm	Moment
S		1543	.03	46
S'	309		.94	290
w,		204	−.15	−31
E	1110		.567	630
h	~~1419~~	350	.15	53
h'	70		2.40	168
	1489	2097		1156 kgm.

Steel area required for moment $= \frac{1156 \times 100}{1200 \times 1.0 \times \frac{7}{8} \times 37} = 1.06$ cm² ok.

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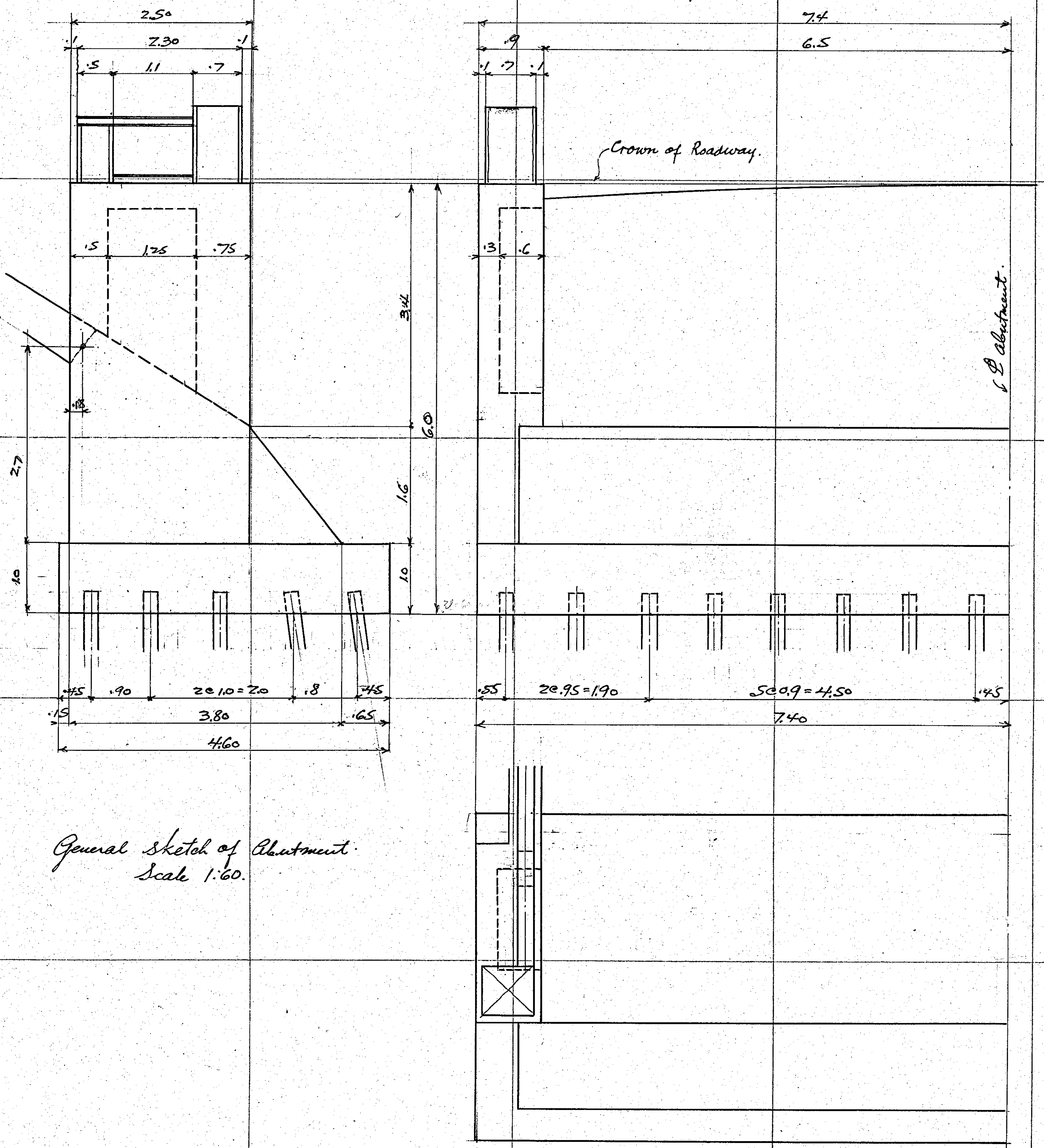
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken

Design of Abutment.

General dimensions are as shown on sketch below.



General sketch of Abutment
Scale 1:60.

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MADE BY K. Inaba DATE 5-3-22 FILE NO
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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Design of wing wall. panel wall.

span length 1.5^m assumed depth of earth filling $= 2.3^m$
Earth pressure at bottom $= \frac{1}{3} \times 1600 \times 2.3 = 1225$ kg/m²
moment at bottom $= \frac{1}{10} \times 1225 \times 1.5^2 = 275$ kgm
Steel area req'd $= \dfrac{27500}{1200 \times \frac{7}{8} \times 27} = .97$ cm² per m strip.

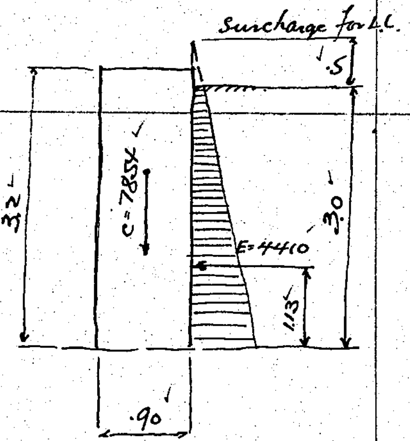
Use $13^{mm\phi}$ bars at 50^{cm} c to c on both sides.

Columns. Rear column.

Handrail post.	.7 × .7 × 1.1 =	.539 @ 2400 =	1294 ×	3.65	=	4725
〃 panel.	.15 × .9 × .55 =	.075	〃	180 ×	3.60	= 648
Column	.75 × .9 × 3.1 =	2.092	〃	5020 ×	1.60	= 8030
Coping	.35 × .6 × .61 =	.128	〃	307 ×	3.00	= 921
wall.	.30 × .61 × 2.4 =	.439	〃	1053 ×	1.70	= 1790
		3273		7854^{kg}	2.05^m	16114

Stability at normal state.

Earth pressure $\frac{1}{3} \times 1600 \times .5 = 267$
$\frac{1}{3} \times 1600 \times 3.5 = 1865$
$2132 \div 2 = 1066$ kg/m² average.



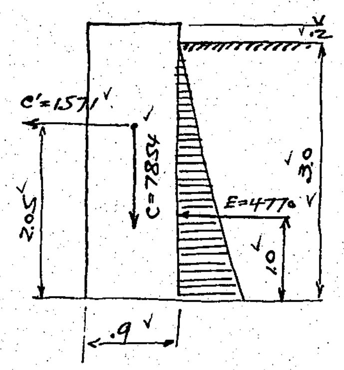
pressure on column $= 1066 \times 3 \times 1.38 = 4410$ kg
moment 〃 $= 4410 \times 1.13 = 4990$ kgm
effective depth required for moment $= \sqrt{\dfrac{4990 \times 100}{75 \times 7.18}} = 30.4$ cm

Use 85^{cm} eff. depth with 5^{cm} insulation.
Steel area required $= \dfrac{4990 \times 100}{1200 \times \frac{7}{8} \times 85} = 5.6$ cm²

Use $4 - 19^{\phi}$ bars $= 11.34$ cm²

Stability during Earthquake. $k = 0.20$. Earth pressure $= .480 \times 1600 \times \frac{3^2}{2} \times 1.38 = 4770$

moment on column E $4770 \times 1.00 = 4770$
C' $1571 \times 2.05 = 3220$
6341 7990 kgm.



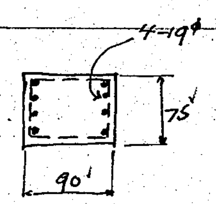
Eccentricity $e = \dfrac{7990}{7854} = 1.02^m$ $e/h = \dfrac{1.02}{.9} = 1.13$

$d'/h = 5/90 = .0556$, $p_0 = 2p = \dfrac{11.34 \times 2}{75 \times 90} = .00336$

$k = .255$ $L = .0935$

$f_c = \dfrac{799000}{.0935 \times 75 \times 90^2} = 14.1$ kg/cm² ok.

$f_s = 15 \times 14.1 \left(\dfrac{85}{.255 \times 90} - 1\right) = 590$ kg/cm² ok.



Unit shear $= \dfrac{6341}{75 \times \frac{7}{8} \times 85} = 1.14$ kg/cm² ok.

Unit bond $= \dfrac{6341}{4 \times 5.97 \times \frac{7}{8} \times 85} = 3.57$ kg/cm² ok.

Column on front. 50×90^{cm} section.
Reinforcements $3 - 19^{\phi}$ bars on both sides.

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CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima ken.

Abutment body.

Max. Horizontal Thrust. (For loading, refer to page 11) due to Live Load.

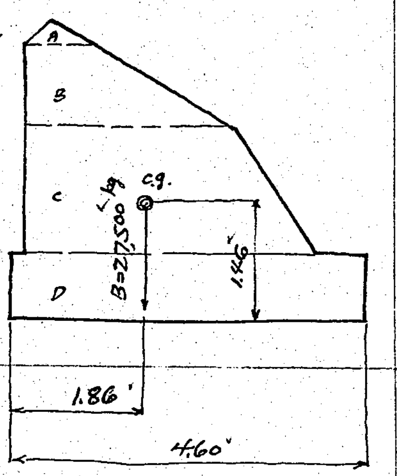
Load at	Load	H unity	H	V unity	V.	moment unity	moment at springing
5'	295	.060	18	1-.005	293	- .564	- 163
4½'	250	.180	45	1-.018	245	- .806	- 195
4'	250	.358	90	1-.038	241	- .932	- 233
3½'	250	.586	147	1-.067	234	- .911	- 228
3'	250	.849	212	1-.099	225	- .826	- 207
2½'	250	1.143	286	1-.147	213	- .571	- 143
2'	250	1.422	355	1-.204	199	- .264	- 66
1½'	230	1.676	385	1-.269	168	+ .081	+ - 19
1'	75	1.873	140	1-.342	49	+ .430	+ 32
½'	1005	1.990	2000	1-.420	583	+ .734	+ 738
0	1475	2.033	3000	.500	738	+ .979	+ 1,445
½	1005	1.990	2000	.420	422	+ 1.142	+ 1,148
1	30	1.873	56	.342	10	+ 1.224	+ 37
2½	110	1.143	126	.147	16	+ .939	+ 103
3	220	.849	187	.099	22	+ .730	+ 161
3½	220	.586	129	.067	15	+ .507	+ 112
4	220	.358	79	.038	8	+ .316	+ 70
4½	180	.180	32	.018	3	+ .170	+ 31
5	18	.060	1	.005	0	+ .060	+ 1
			9288 kg.		3684 kg		+ 2662 kgm.

Superimposed Loads on abutment.

	Horizontal Thrust H	Vertical Load V	Moment M.
Dead Load	+ 22,800	11,920	+ 1,850
Rib shortening	- 1,250	—	- 2,110
	+ 21,550 kg	11920 kg	- 260 kgm.
	panel load on 6	1,606	
		13,530	
Dead Load	+ 22,800	11,920	+ 1,850
Live Load	+ 9,288	3,684	+ 2662
Rib shortening	- 1,590	—	- 2,690
	+ 30,498 kg	15,604 kg	+ 1,807 kgm
		1,606	
		17,210	

Weight and center of gravity of abutment body for one meter strip.

			Hor. arm	Hor. moment	Vert. arm	Vert. moment
A	1.1×.24 = .264 × 2400 =	630	.64	400	3.63	2,290
B	1.8×.87 = 1.565 × " =	3750	1.08	4050	3.01	11,290
C	3.15×1.60 = 5.040 × " =	12,100	1.77	21,400	1.74	21,050
D	1.0×4.6 = 4.600 × " =	11,020	2.30	25,350	.50	5,510
		27,500 kg	1.86 m	51,200	1.46 m	40,140



CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Center of gravity of Superstructure.

All figures in the following calculation are for one meter strip along center line of Bridge.

	Gravel paving			Earth filling			Arch ring		
	weight	arm	moment	weight	arm	moment	weight	arm	moment
Crown one-half	43	.05	2	160	.30	48	156	.63	98
panel pt. ½	85	"	4	328	.31	102	318	.64	204
" 1	85	"	4	352	.32	113	321	.67	215
" 1½	85	"	4	392	.35	137	327	.72	235
" 2	85	"	4	440	.38	167	337	.79	266
" 2½	85	"	4	512	.42	220	350	.88	308
" 3	85	"	4	600	.48	288	368	.99	364
" 3½	85	"	4	704	.54	380	398	1.15	458
" 4	85	"	4	824	.62	511	453	1.32	598
" 4½	85	"	4	975	.71	692	538	1.54	829
" 5	100	"	5	1370	.83	1137	785	1.82	1428
" 6	58	"	3	989	1.01	999	563	2.27	1278
	966		46	7646		4794	4914		6281

Summary for moments and weights.

	moments	weights
Gravel paving	46	966
Earth filling	4794	7646
Arch ring	6281	4914
	11121 kgm	13526 kg

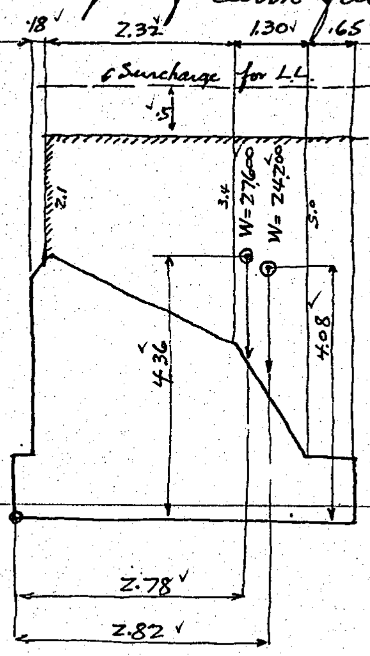
call this 13530 kg

Lever arm from crown $= \dfrac{11121}{13526} = 0.82^m$

$6.0 - .82 = 5.18^m$ above bottom

Seismic force $= 13526 \times .2 = 2700$ kg

Weight of Earth filling on abutment body.



		hor. arm	hor. m	vert arm	vert m
$.65 \times 5.0$ @ 1600 =	5200	4.28	22250	3.50	18200
4.20×1.30 @ " =	8750	3.34	29200	3.85	33780
2.75×2.32 @ " =	10,250	1.65	16900	4.58	46,920
	24200 kg	2.82 m	68,350	4.08 m	98,900
Surcharge $4.27 \times .5$ @ 1600 =	3400	2.46	8370	6.25	21,250
	27600	2.78 m	76,720	4.36 m	120,150

Earth pressure at normal state $\frac{1}{3} \times 1600 \times .5 = 267$

$\frac{1}{3} \times 1600 \times 6.5 = 3460$

$3727 \div 2 = 1864$ kg/m² average.

Earth pressure $= 1860 \times 6.0 = 11,150$ kg. $= E$

arm $= 2.15$ meters from bottom of base.

Earth pressure during earthquake.

Earth pressure $E = .480 \times 1600 \times \frac{6.0^2}{2} = 13830$ kg.

arm $= 2.0^m$

Earth pressure on front side neglected at normal state.

Earth pressure on front side during earthquake.

$E' = .48 \times 1600 \times \frac{2^2}{2} = 1,540$ kg

arm $= .67^m$

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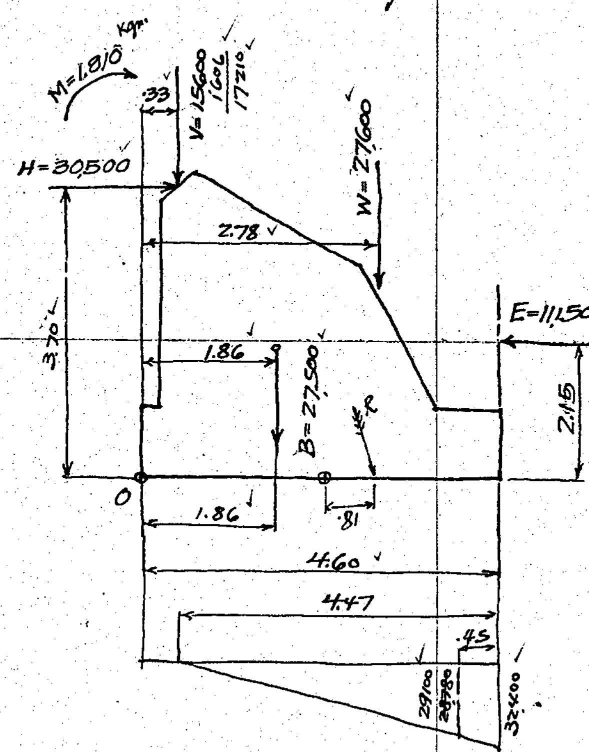
CALCULATIONS FOR

Design of Shinkawa Bashi for Fukushima Ken.

Stability of Abutment.

Case 1. Stability at normal state.



Taking moment about point O.

Loads	Horizontal forces	Vertical forces	Lever arms	Moments.
H	30500		3.70 =	115,000
V		17,210	.33 =	5680
M			=	1,810
B		27,500	1.86 =	51,190
W		27,600	2.78 =	76,700
E	11,150		(−) 2.15 =	(−) 24,000
	41,650 (.575V)	72,310	3.11m =	+ 226,380

Eccentricity $\Sigma = 3.11 - 2.3 = 0.81$ m

Resultant force outside of middle third, neglecting tension,

Pressure area $= 3 \times (4.60 - 3.11) = 1.49 \times 3 = 4.47$ m

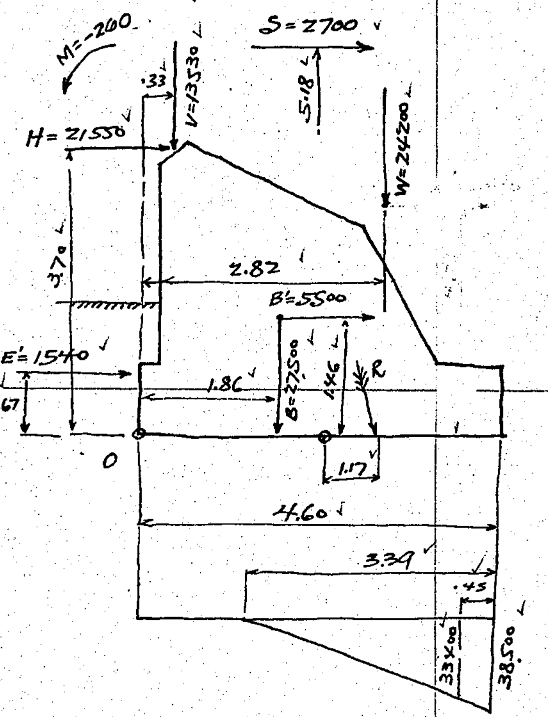
max. bearing pressure at toe $= \frac{2 \times 72310}{4.47} = 32400$ kg/m² or (2.96 tons/□')

max. load on one pile $= 29100 \times .85 \times .9 = 22.2$ kg tons

If 11.0 kg tons/m (1.0 tons/□') be allowed to be carried by foundation bed.

Load on pile $= (29100 - 11000) \times .85 \times .9 = \underline{13.8}$ kg tons/pile.

Case 2. Stability during Earthquake. Seismic forces forward. k assumed 0.20.



Loads	Hor. forces	Vert. forces	Lev. arm	moments.
H	21,550		3.70 =	79700
V		13,530	.33 =	4470
S	2,700		5.18 =	14,000
M			= −	260
B		27,500	1.86 =	51,100
B'	5,500		1.46 =	8030
W		24,200	2.82 =	68,200
E'	1,540		.67 =	1,030
	31,290 (.48V)	65,230	3.47 =	226,270

Eccentricity $= 3.47 - 2.30 = 1.17$ meters

Resultant force outside of middle third. $4.60 - 3.47 = 1.13$

Pressure area $= 3 \times 1.13 = 3.39$ sq. meters

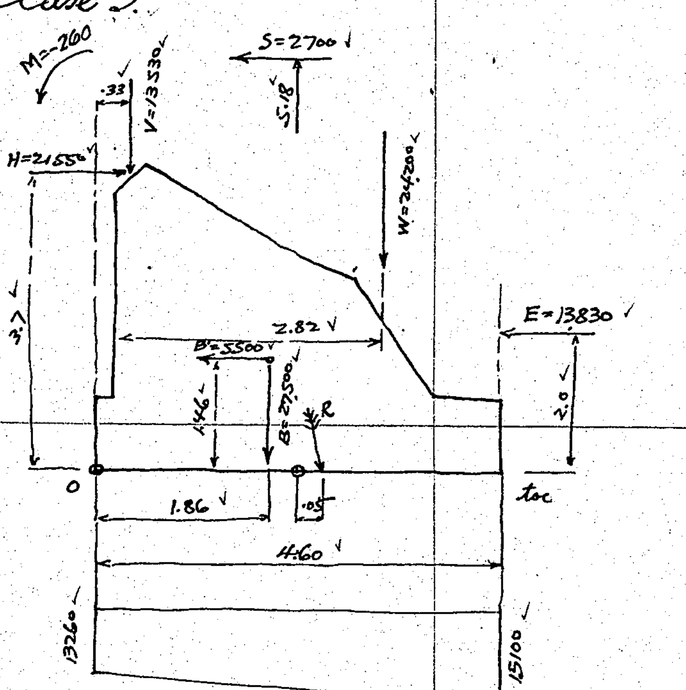
Max. bearing pressure at toe $= \frac{65230 \times 2}{3.39} = \underline{38500}$ kg/m² or (3.52 tons/□')

max. load on one pile $= 33400 \times .85 \times .9 = 25.6$ kg tons.

If 11.0 kg tons/m be allowable to be carried by foundation bed directly

max. load on one pile $= 22.4 \times .85 \times .9 = \underline{17.1}$ kg tons.

Case 3.



Loads	Hor. forces	Vert. forces	Lev. arm	moments.
H	21550		3.70 =	+ 79,700
V		13,530	.33 =	+ 4,470
S	− 2,700		5.18 =	− 14,000
M			=	− 260
B		27,500	1.86 =	+ 51,100
B'	− 5,500		1.46 =	− 8,030
W		24,200	2.82 =	+ 68,200
E	− 13,830		2.00 =	− 27,660
	− 480	65,230	2.35m	+ 153,520

Eccentricity $\Sigma = 2.35 - 2.30 = .05$

Resultant force within middle third.

Bearing pressure $= \frac{65230}{10 \times 4.6}\left(1 \pm \frac{6 \times .05}{4.6}\right) = 15100$ kg/m² on toe

or $= 13260$ on heel.

Load on pile at heel $= 13.26 \times .9 \times .9 = 10.8$ kg tons.

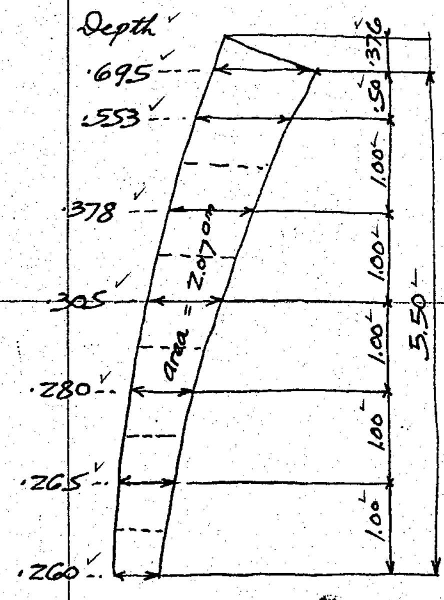
Note :- A proper inclination shall be given to the extreme row of piles.

Materials of Shinkawa Bashi for Fukushima Ken.

Materials of Arch Ring.

Concrete 1:2:4 mixture.

Average thickness		Length		Area
.695 × ½	×	.375	=	.13
.624	×	.50	=	.31
.466	×	1.00	=	.47
.342	×	1.00	=	.34
.293	×	1.00	=	.29
.273	×	1.00	=	.27
.263	×	1.00	=	.26



2 × Longitudinal Sectional area of Rib 2.07 × 4 = 8.28 m²

volume of Rib =	8.28 × 6.75 =	55.89
fillets	2 × .30 × .05 × 6.75 =	.20
filling between 2 Ribs.	2.07 × .1 × 2 = .41	
less	2 × .1 × .13 = − .03	
	.1 × .02 × 11.796 = − .02	
		.36

Total concrete for arch rings = 56.45 cub. meters.

Forms.

Faces of arch rings	2.07 × 8	=	16.56 (See area for concrete)
fillets	4 × 3 × .05	=	.06
less	4 × ½ × .695 × .375	=	− .52
			16.10 sq. meters.

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Both faces of Ribs (See area for concrete)		=	8.280
Extrados edges	2 × .05 × 11.432	=	1.143
Intrados edges	2 × .25 × 11.796	=	5.900
less	4 × .13	=	− .520
			14.803 sq. meters.

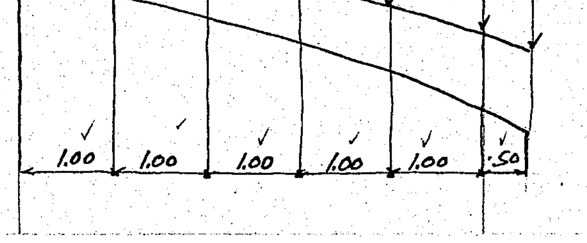
Reinforcing Bars. Plain Bar. (See drawing) 4.6943 kg tons.

Materials of Spandrel walls.

Concrete 1:2:4 mixture

Average depth	Length	area	Average thickness	volume	Remarks on thickness. Top	Bottom.
1.39	.50	.70	.32	.22	.25	.39
1.05	1.00	1.05	.31	.33	〃	.36
.698	1.00	.70	.29	.21	〃	.32
.458	1.00	.46	.28	.13	〃	.30
.305	1.00	.31	.27	.08	〃	.28
.230	1.00	.23	.26	.06	〃	.27
Coping		.29 × .39 × 5.50		.62		
				1.65		

Total volume of spandrel walls. 1.65 × 4 = 6.60 cub. meters.



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CALCULATIONS FOR

Materials of Shinobu Bashi for Fukushima ken

Forms for Spandrel walls.

wall area same as for concrete	8 × 3.45	=	27.60
Coping	4 × .78 × 5.50	=	17.16
			44.76 sq. meters.

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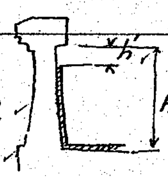
Area of finish on wall.	4 × 3.45	=	13.80
Coping	4 × 1.08 × 5.50	=	23.76
			37.56 sq. meters.

Water proofing of arch rib extrados (2cm 1:2 cement mortar).

Extrados of rib	13.00 × 12.80	=	166.40
Spandrel walls inside	4 × 3.45	=	13.80 area for height h
less	2 × .03 × 11.00	=	− 0.66 " " " h'
			179.54 sq. meters.



Reinforcing Bars, plain Bars. (see drawing.) = 0.4774 kg tons.

Materials of Entrance pedestal. (男柱). (一基分)

Granite	1 − .70 × .20 × .70	=	.098
	4 − .35 × .15 × .43	=	.090
	2 − .40 × .15 × .43	=	.051
	4 − .35 × .15 × .44	=	.092
	2 − .40 × .15 × .44	=	.053
			0.384 cub. meter

Bronze name plate. see drawing — 1.0 plate.

Concrete 1:2:4 mixture
.40 × .40 × .85 = 0.14 cub meter

Handrail (One side of Bridge).

Concrete 1:2:4 mixture.

Top rail	.25 × .13 × 13.90	=	.45
bottom rail	.18 × .11 × 13.10	=	.26
intermediate post.	2 × .40 × .22 × .72	=	.13
notches less	8 × .075 × .02 × .72	=	− .01
Side posts.	2 × .50 × .25 × .85	=	.21
projection	6 × .18 × .075 × .63	=	.05
wall	.61 × .12 × 11.04	=	.81
			1.90 cub. meters

Concrete for handrails on both sides = 1.90 × 2 = 3.80.

Forms.

Both sides	2 × .85 × 14.39	=	24.46
Side posts	2 × .60 × .85	=	1.02
posts corners	20 × .05 × .68	=	.68
Int. side posts	2 × .12 × .61	=	.15
bottom of top rail	.13 × 11.04	=	1.44
" center "	.25 × 1.60	=	.40
grate area, less	2 × .61 × 1.60	=	− 1.95
			26.20 sq. meters

Forms for handrails on both sides 2 × 26.20 = 52.40.

Cast iron grate H1. 2 grates @ 130 kg = 260 kg for both sides

Reinforcements, plain bars see drawings 2 @ .2566 = .5132 kg ton.

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CALCULATIONS FOR

Materials of Shinkawa Bashi for Fukushima Ken.

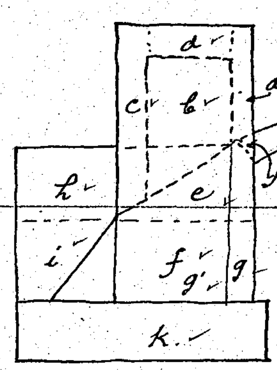
人造洗出仕上

Both sides	2 × .85 × 14.39	=	24.463
Side posts	2 × .60 × .85	=	1.020
grate area less	2 × .61 × 1.60	−	1.952
top of bottom rail	.1 × 11.04	=	1.104
Sides of posts (corners)	20 × .05 × .68	=	.680
bottom of top rail	.13 × 11.04	=	1.435
Side of int. posts	2 × .08 × .61	=	.098
bott. of top rail at center	.21 × 1.60	=	.336
top of top rail	.26 × 13.90	=	3.614
top of side posts	2 × .25 × .50	=	.250
top of bott. rail	.08 × 1.60	=	.128
			31.176 sq. meters

Total area of finish for handrails on both sides 2 × 31.176 = 62.352 sq. meters.

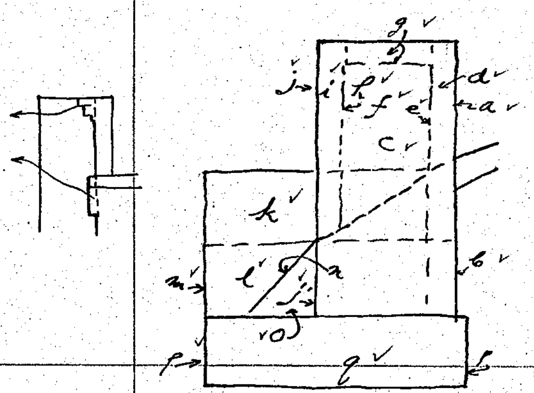
Materials of South abutment SA. (South Abutment)

Concrete 1:2:4 mixture.



Front columns	a.	2 × .50 × .983 × 1.95	=	1.92
wing walls	b	2 × 1.25 × .30 × 2.53	=	1.90
Rear columns	c	2 × .75 × .90 × 3.19	=	4.31
Top strut	d	2 × .35 × .60 × 1.25	=	.53
Body	e	1.439 × 1.491 × 13.60	=	29.18
〃	f	1.45 × 3.15 × 13.60	=	62.12
Front col. bottom	G	2 × .50 × .60 × 3.01	=	1.81
wing walls	G'	2 × .60 × 2.00 × 2.20	=	5.28
Retaining wall at center	h	.27 × 1.73 × 3.20	=	1.49
〃	i	.58 × 1.30 × 1.45	=	1.09
Skew back less.	j	½ × .376 × .468 × 13.6	= −	1.20
Base	k	1.00 × 4.60 × 14.80	=	68.08
				176.51 cub meters.

Forms.



Front columns front	a	2 × .65 × 4.985	=	6.48
Body	b	2.473 × 13.50	=	33.39
Coping less		2 × .11 × .29	= −	.06
Arch ring		2 × .05 × .70	= −	.07
wing wall outside	c	2 × 2.50 × 4.985	=	24.93
Front columns inside	d	2 × .50 × 1.95	=	1.95
〃 rear	e	2 × .68 × 1.70	=	2.31
wing wall inside	f	2 × 1.25 × 2.13	=	5.33
Top strut side + bott.	g	2 × .95 × 1.25	=	2.38
Rear wall front	h	2 × .60 × 2.54	=	3.05
〃 inside	i	2 × .75 × 3.19	=	4.79
〃 rear	j	2 × .90 × 3.45	=	6.21
〃 bott.	j'	2 × .60 × 1.45	=	1.74
Retaining wall at center	k	2 × 1.73 × 3.20	=	11.07
〃	l	2 × 1.30 × 1.45	=	3.77
〃 rear	m	.45 × 3.18	=	1.43
Body rear	n	1.95 × 13.60	=	26.52
〃 sides	o	2 × ½ × 1.3 × 1.45	=	1.89
〃 less		.58 × 1.95	= −	1.13
Base front and rear	p	2 × 1.0 × 14.80	=	29.60
〃 both side	q	2 × 1.0 × 4.60	=	9.20
				174.78 sq. meters.

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CALCULATIONS FOR

Materials of Shinkawa Bashi for Fukushima Ken.

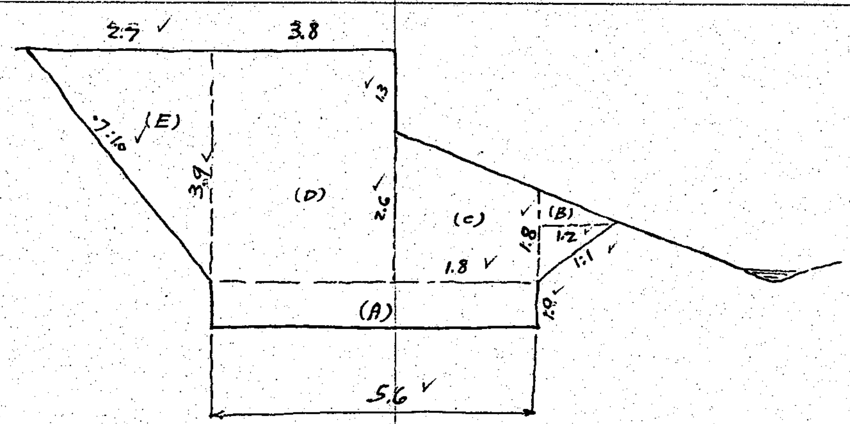
Reinforcements ✓, Plain bars ✓ see drawings ✓ 2.7203✓ kg tons.

人造洗去仕上 ✓

Front columns, front ✓	2 × .85 × 4.985 ✓	=	8.475 ✓
Coping , less ✓	2 × .11 × .29 ✓	=	− .064 ✓
Arch ring , ✓	2 × .05 × .70 ✓	=	− .070 ✓
Spandrel wall , ✓	2 × .20 × 2.512 ✓	=	− 1.005 ✓
Wing wall outside ✓	2 × 2.743 × 2.50 ✓	=	13.715 ✓
〃 rear ✓	2 × .50 × .90 ✓	=	.900 ✓
Top and outside ✓	2 × 1.22 × 2.50 ✓	=	6.100 ✓
Entrance posts less ✓	2 × .70 × .70 ✓	=	− .980 ✓
Handrail area , ✓	2 × .18 × 1.45 ✓	=	− .522 ✓
Post area , ✓	2 × .25 × .50 ✓	=	− .250 ✓
			26.299 ✓ sq. meters.

Foundation piles ✓ 内地産赤松末口18cm長3.50m ✓ - - - 80 piles.

Excavation (Rough approximation)



A ✓	5.6 × 1.0 × 15.8 ✓ =	88.5 ✓	
B	1.8 × .6 =	1.08 ✓	
C	2.2 × 1.8 =	3.96 ✓	
D	3.9 × 3.8 =	14.82 ✓	
E	3.9 × 1.35 =	5.26 ✓	
		25.12 ✓ × 18.8 =	472.5 ✓
			561.0 ✓ cub. meters.

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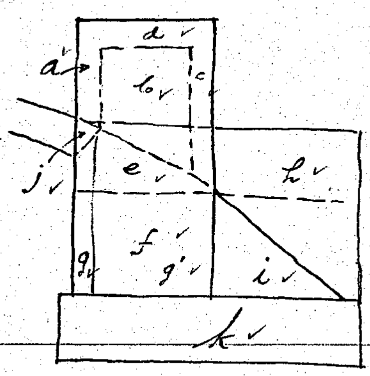
Materials of abutment SB ✓ (North abutment ✓)

Concrete 1:2:4 mixture ✓



Front columns ✓	a	2 × .50 × .983 × 1.97 ✓	=	1.94 ✓
Wing wall ✓	b	2 × 1.25 × .30 × 2.55 ✓	=	1.91 ✓
Rear columns ✓	c	2 × .75 × .90 × 3.19 ✓	=	4.31 ✓
Top strut ✓	d	2 × .35 × .60 × 1.25 ✓	=	.53 ✓
Body ✓	e	1.42 × 1.319 × 13.60 ✓	=	25.47 ✓
〃 ✓	f	1.60 × 3.15 × 13.60 ✓	=	68.54 ✓
Front column bott. ✓	g	2 × .50 × .60 × 2.98 ✓	=	1.79 ✓
Wing wall 〃 ✓	g'	2 × .60 × 2.00 × 2.20 ✓	=	5.28 ✓
Retaining wall at center ✓	h	.27 × 1.53 × 3.20 ✓	=	1.32 ✓
〃 ✓	i	.58 × 1.30 × 1.60 ✓	=	1.21 ✓
Skew back less ✓	j	.344 × .48 × 13.60 ✓	=	− 1.12 ✓
Base ✓	k	1.00 × 4.66 × 14.80 ✓	=	68.08 ✓
				179.26 ✓ cub. meters.

Reinforcements ✓ Plain Bars ✓ (see drawings) 2.7903 ✓ kg tons.

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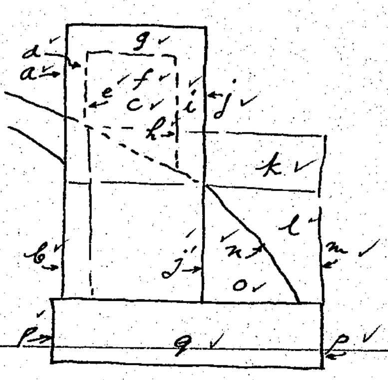
CALCULATIONS FOR

Materials of Shinkawa Bashi for Fukushima Ken.

Forms.

Front columns	front	a.	2 × .65 × 4.951	=	6.64
Body front		b	2.439 × 13.50	=	32.93
Coping less			2 × .11 × .29	= −	.06
Skew back less			2 × .05 × .70	= −	.07
wing wall outside		c	2 × 2.50 × 4.95	=	24.75
Front column inside		d	2 × .58 × 1.97	=	1.97
〃 〃	rear	e	2 × .68 × 1.76	=	2.39
wing wall inside		f	2 × 1.25 × 2.20	=	5.50
Top strut inside + bott.		g	2 × .95 × 1.25	=	2.38
Rear wall front		h	2 × .60 × 2.60	=	3.12
〃 〃	inside	i	2 × .75 × 3.19	=	4.79
〃 〃	rear	j'	2 × .90 × 3.43	=	6.17
〃 〃	bottom	j''	2 × .60 × 1.60	=	1.92
Retaining wall at center		k	2 × 1.53 × 3.20	=	9.79
〃 〃		l	2 × 1.30 × 1.60	=	4.16
〃 〃	rear	m	.45 × 3.13	=	1.41
Body	rear	n	2.03 × 13.60	=	27.61
〃	side	o	2 × ½ × 1.30 × 1.60	= +	2.08
	less		.58 × 2.03	= −	1.18
Base front + rear		p	2 × 1.0 × 14.8	=	29.60
〃 both sides		q	2 × 1.0 × 4.60	=	9.20
					174.90 sq. meters.

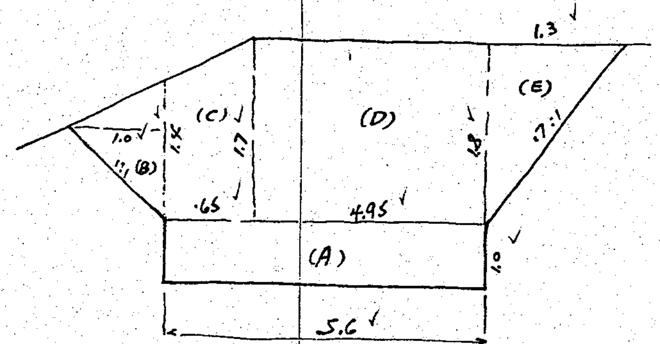


人造洗出仕上

Front column	front face	2 × .85 × 4.951	=	8.417
Coping	less	2 × .11 × .29	= −	.064
Arch ring	less	2 × .05 × .70	= −	.070
Spandrel wall	〃	2 × .20 × 2.512	= −	1.005
wing wall	outside	2 × 2.726 × 2.50	=	13.630
〃	rear	2 × .50 × .90	=	.900
Top + inside		2 × 1.22 × 2.50	=	6.100
Entrance post	bott. area, less	2 × .7 × .7	= −	.980
Handrail	〃 〃	2 × .18 × 1.45	= −	.522
Posts	〃 〃	2 × .25 × .5	= −	.250
				26.156 sq. meters.

Foundation piles 内地産赤松 末口 18cm 長 3.50m --- 80 piles required.

Excavation. (approximate)



A.	5.6 × 1.0 × 15.8		= 88.5
~~B~~	~~1.4~~		
B	1.4 × .5 ÷	.70	
C	1.55 × .65 ÷	1.01	
D	1.75 × 4.95 ÷	8.66	
E	1.80 × .65 ÷	1.17	
		11.54 × 17.6 ÷	203.5
			292.0 cub. meters.

底幅・周囲各五十糎宛・余裕ヲ見込ム

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CALCULATIONS FOR

materials of shinkawa-bashi for Fukushima-ken

新川橋盛土

	高	幅	長		
拱橋上盛土	1.52 ×	12.70 ×	.50	=	9.6
	1.17 ×	12.77 ×	1.00	=	14.9
	.82 ×	12.84 ×	1.00	=	10.5
	.58 ×	12.88 ×	1.00	=	7.5
	.43 ×	12.91 ×	1.00	=	5.6
	.35 ×	12.94 ×	1.00	=	4.5
					52.6
					× 2
					105.2
橋台A盛土	4.45 ×	4.92 ×	14.80	=	324.0
(-)路面下混凝土量				=	(-) 108.1
橋台B盛土	4.45 ×	4.88 ×	14.80	=	321.4
(-)路面下混凝土量				=	(-) 110.9
					426.4
					531.6 cub. meters

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CALCULATIONS FOR

Materials of Shinkawa-Bashi for Fukushima-Ken

Materials of Centering 一回分

		cm	cm	cm	unit Volume m^3	Total Volume m^3	Remarks
6	Plank 箱	10 ×	6 ×	285	0.017	0.102	米松
6	〃	〃	〃	455	0.027	0.162	〃
6	〃	〃	〃	325	0.020	0.120	〃
6	〃	〃	〃	415	0.025	0.150	〃
6	〃	20 ×	6 ×	285	0.034	0.204	〃
6	〃	〃	〃	455	0.055	0.330	〃
4	〃	〃	〃	325	0.039	0.156	〃
4	〃	〃	〃	415	0.050	0.200	〃
15	〃	〃	〃	285	0.034	0.510	〃
15	〃	〃	〃	455	0.055	0.825	〃
15	〃	〃	〃	325	0.039	0.585	〃
15	〃	〃	〃	415	0.050	0.750	〃
15	〃	〃	〃	400	0.048	0.720	〃
15	〃	〃	〃	340	0.041	0.615	〃
15	〃	〃	〃	470	0.056	0.840	〃
15	〃	〃	〃	270	0.032	0.480	〃
						6.749 cub. meters	
12	上弦材	30 ×	15 ×	250	0.113	1.356	米松
12	〃	〃	〃	340	0.153	1.836	〃
2	〃	〃	10	250	0.075	0.150	〃
2	〃	〃	〃	340	0.102	0.204	〃
1	梁	23 ×	20	325	0.150	0.150	〃
1	〃	〃	〃	415	0.191	0.191	〃
1	〃	〃	〃	340	0.156	0.156	〃
1	〃	〃	〃	400	0.184	0.184	〃
2	〃	20 ×	18 ×	340	0.122	0.244	〃
2	〃	〃	〃	400	0.144	0.288	〃
1	〃	〃	〃	325	0.117	0.117	〃
1	〃	〃	〃	415	0.149	0.149	〃
12	垂直材	20 ×	20 ×	55	0.022	0.264	〃
18	〃	〃	〃	130	0.052	0.936	〃
12	〃	〃	〃	90	0.036	0.432	〃
12	斜材	15 ×	15 ×	150	0.034	0.408	〃
24	〃	〃	〃	180	0.041	0.984	〃
12	下弦材	25 ×	20 ×	240	0.120	1.440	〃
12	〃	〃	〃	595	0.298	3.576	〃
36	猫木	15 ×	10 ×	20	0.003	0.108	〃
20	筋違	15 ×	9 ×	170	0.023	0.460	〃
12	塡材	20 ×	6 ×	25	0.003	0.036	〃
						13.669 cub. meters	
9	梁	20 ×	15 ×	690	0.207	1.863	米松
12	縦木	25 ×	20 ×	395	0.198	2.376	〃
6	〃	〃	〃 ×	595	0.298	1.788	〃
12	肘木	25 ×	15 ×	40	0.015	0.180	〃
18	〃	〃	〃	60	0.023	0.414	〃
8	挟樌及樌	15 ×	9 ×	690	0.093	0.744	〃
10	筋違	〃	〃	170	0.023	0.230	〃
12	〃	〃	〃	280	0.038	0.456	〃
6	〃	〃	〃	165	0.022	0.132	〃
						8.183	

米松材料合計 28.601 cub. meters

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CALCULATIONS FOR

Materials of Shinkawa-Bashi for Fukushima-Ken

108	楔	20 × 11 × 40	@ 0.009	0.972		樫	
杭（内地産赤松）							
6	支柱	和18φ × 135					
15	杭	〃 × 400					
3	〃	〃 × 450					
6	支柱	〃 × 130					
Sand box（木材部）一箇分 6 Reqd.							
1		25φ × 25	@ 0.012	0.012		米松	
2		30φ × 25	@ 0.002	0.004		〃	
2		35φ × 5	@ 0.00005	0.0001		〃	
				0.016 cub. meter			
Sand box（金物部）一箇分 6 Reqd.							
1	P/s (Sand box)	400mm × 6mm × 990mm	@ 18.6517	18.6517			
4	釘	五寸釘 sand box 取付用	@ 0.0235	0.0940			
1	亜鉛鍍金鈑	90cmφ no. 30 B.W.G.	@ 1.9408	1.9408			
				20.6865 kgs			
ボールト.及鋲等				（ボールト及座金）	（鋲）	（平鋼）	（釘）
18	上弦材締付用	22mmφ × 350mm	@ 1.3020	23.4360 kgs			
3	〃	〃 × 250	@ 1.0050	3.0150			
72	上弦材ト斜材締付用	〃 × 280	@ 1.0944	78.7968			
36	下弦材ト 〃	〃 × 450	@ 1.6010	57.6360			
24	垂直材締付用	〃 × 500	@ 1.7500	42.0000			
96	垂直材ト下弦材金物ト締付用	22φ × 320	@ 1.2136	116.5056			
48	継手金物 L	100 × 9 × 400	@ 2.8260			135.648 kgs	
24	筋違ト垂直材締付用	19φ × 340	@ 0.9348	22.4352			
8	〃 〃 〃	〃 × 430	@ 1.1346	9.0768			
44	杭ト筋違締付用	〃 × 390	@ 1.0458	46.0152			
36	〃 〃 〃	〃 × 470	@ 1.2234	44.0424			
6	砂箱上部締付用	〃 × 375	@ 1.0125	6.0750			
542	ボールト座金（22φ、19φ用）	50mmφ × 3	@ 0.0462	25.0404			
196	手違鋲（長サ5寸）				196 挺		
384	正 鋲				384		
	五寸釘		@ 0.0235				30 kgs
				474.0744 kgs	580 挺	135.648 kgs	30 kgs

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

weight of Handrail.

~~Top~~ Top rail	.13 × .23	=	0.0299
Bottom rail	.17 × .27	=	0.0459
panel	.13 × .55	=	0.0715
			0,1473 @ 2400 = 353 kg per lin. meter.

2 @ 353 = 706.

weight of coping

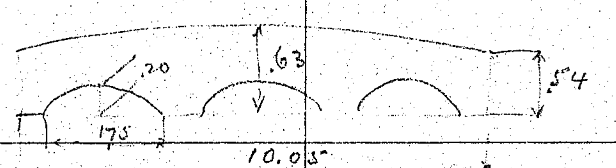
.35 × .365 = 0.1280
less .050 × 0.215 = 0.0107 ; .08 × 0.15 = 0.0120 ; 0.0227 → − 0.0227
0,1053
15
0,1068 @ 2400 = 256 × 2 = 512
.10 × 0.015

Pavement concrete .07 × 1.50 @ 2400 = 252.0 × 2 = 504

Pavement Asphalt 5 cm Asphalt @ 21 = 105
2 cm mortar @ 17 = 34
139 × 8.0 = 1110
1614 kg
Slab ,165 × 11,0 @ 2400 = 4350 — 4350
5964

Handrail	2 @ 353	=	706
coping	2 @ 256	=	512
pavement.			1614
Slab			4350
			7182 kg per lin meter.

Transverse cross beam



over 10.05 × .61 = 6.12
3 × .236 − .71
5,41 × .30 = 1,62
1,62 @ 2400 = 3890 kg

col. 4.8 × .30 @ 2400 = 3460 kg per meter.

Diameter

$r = \frac{4 \times .20^2 + 1.75^2}{8 \times .20}$

rise to dia = $\frac{.20}{4.03}$ = .0496

Area = $4.03^2 \times 0.145$ = .336

.16
3,06
3,22 = 2.015
1.6
d = 4.03

one opening 6.12
− .24
5.88 @ .30 × 2400 = 4220 kg.

wall. 8.30 × .30 @ 2400 = 5980 kg per meter of Height

Center cross beam. .63 × 1.75 = 1,10
less .24
.86 × .30 × 2400 = 620 kg.

wall on arch ring. 5980 kg per lin. meter of Height.

Longitudinal Fascia Girder

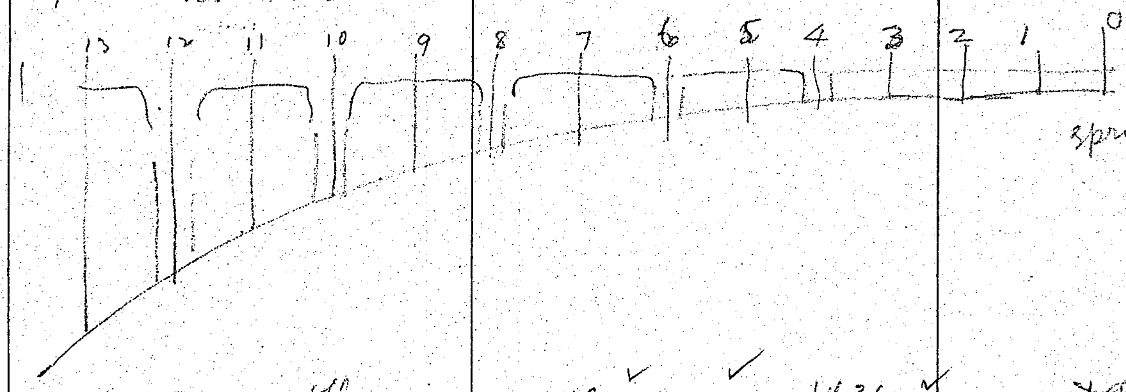
2.0 × .30 = .60 ; 1.70 ; .20 × 1.70 = .340 sq meter.
2 @ .019 = .38
.090
.078
.19
.378 × .25 = .0943 @ 2400 = 227 kg.
2 × 227 = 454 kg.

Longitudinal wall. 4 × .25 = 1.00 @ 2400 = 2400 kg per lin meter of per lin meter of Height

CALCULATIONS FOR

Shinobu bashi for Fukushima-ken

span no 4.



at (12) flooring 7182 × 2.0 = 14364
cross beam 3890
col. 3460 × ~~1.43~~ 1.68 = 5810 kg
Fascia girder 454
24518
Arch ring .71/.74 × 8.5 × 2400 — ~~14500~~ 39018

at (11) Arch ring .64/.65 × 8.5 × 2400 = ~~13260~~ 13050

at (10) flooring 7182 × 2.0 = 14364
cross beam 3890
Fascia girder 454
col. 3460 × 1.0 = 3460
21168
Arch ring .58/.60 × 8.5 × 2400 = 11820
32988

at (9) Arch ring .55 × 8.5 × 2400 = 11200

at 8 flooring 7182 × 2.0 = 14364
cross beam 4220
fascia girder 454
col. 5980 × .46 = 2750
21788
Arch ring .51/.52 × 8.5 × 2400 = ~~10600~~ 10400
32188

at (7) Arch ring .48/.49 × 8.5 × 2400 = ~~10000~~ 9800

at (6) flooring 7182 × 2.0 = 14364
cross beam 4220
fascia girder 1/2 — 227
longitudinal wall .35 × .55 @1200 231
Trans. wall 5980 × (.25) .05 300
19342
Arch ring .46 × 8.5 × 2400 = 9370
28712

at (5)
Arch ring .44 × 8.5 × 2400 = ~~9180~~ 8980
long wall 1.0 × .42 @1200 = 505
~~9710~~ 9485

spring - Arch ring
.38 × .86 × 8.5 × 2400 = 6650

at (13) Arch ring .44/2 + 0.5 = .72
.72 × .82 × 8.5 × 2400 = 12000
assumed.

at 4.
flooring 7182 × 1.5 = 10780
cross beam. entr. 620
cross wall - aver. .35 × 5980 = 2060
outside long .28 .30 × 400 @ 1200 = 336
inside .35 × .35 @ 1200 = 147
Sand fill .35 × .35 × 7.30 × 1800 = 1680
~~15987~~ 15553
Arch ring .42 × 8.5 × 2400 = 8760 8560
~~24747~~ 24113

at (3)
flooring 7182 × 1.0 = 7182
outside long wall .19 × 1.00 × 1200 = 230
inside .26 × 1.00 × 1200 = 310
filling 1.00 × .25 × 7.30 × 1800 = 3280
11002
Arch ring .42 × 8.5 × 2400 = 8550
19552

at (2)
floor 7182 × 1.0 = 7182
outside wall 1.00 × .11 × 1200 = 132
inside wall 1.0 × .17 × 1200 = 204
Sand fill 1.00 × .15 × 7.3 × 1800 = 2100
9618
Arch ring .41 × 8.5 × 2400 = 8350
17968

at (1)
floor 7182 × 1.0 = 7182
outside wall 1.00 × .06 × 1200 = 70
inside " 1.00 × .12 × 1200 = 144
Sand fill 1.00 × .10 × 7.3 × 1800 = 1315
8711
Arch ring .40 × 8.5 × 2400 = 8150
16861

1/2 at (0) 7182 × .565 = 4050
outside .565 × .05 × 1200 = 34
inside wall .565 × .11 × 1200 = 75
fill 1.0 × 0.05 × 7.3 × 1800 = 668 667
4827
Arch ring .40 × .565 × 8.5 × 2400 = 4610
9437

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CALCULATIONS FOR

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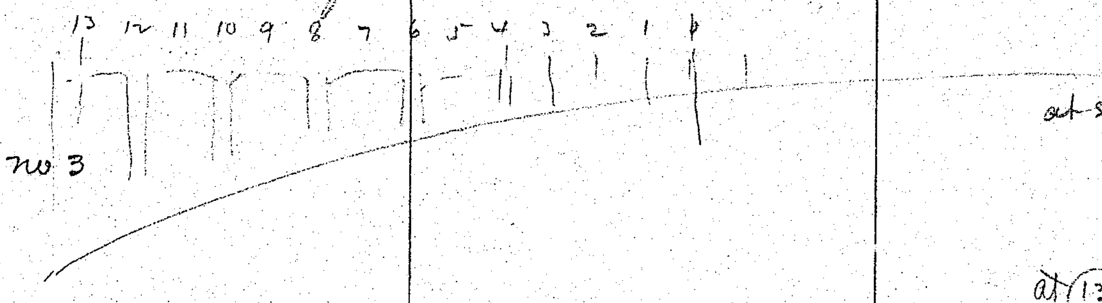

span no 3

at (12) flooring 7182 × 2.0 = 14364
cross beam 3890
Fascia g 454
col. 3460 × 1.60 = 5530
24238
Arch ring .73 × 8.5 × 2400 = 14900
39138

at 11 Arch ring ~~flooring~~ .65 ~~.70~~ × 8.5 × 2400 = 13250 ~~14300~~

at 10 floor 7182 × 2.0 = 14364
cross beam 3890
Fascia 454
col. 3460 × .93 ~~1.5~~ = 3220
21928
Arch ring .59 ~~.60~~ × 8.5 × 2400 = 12050
33978

at 9 Arch ring .55 ~~.58~~ × 8.5 × 2400 = 11200 ~~11800~~

at 8 flooring 7182 × 2.0 = 14364
cross beam 4220
fasia g 454
col. 5980 × ~~.48~~ .40 = 2400
21438
Arch ring .52 ~~.54~~ × 8.5 × 2400 = 10600
32038

at 7 Arch ring .485 ~~.51~~ 8.5 × 2400 = 9900 ~~10400~~

at 6 flooring 7182 × 2.0 = 14364
cross beam 4220
fascia 1/2 227
long'l wall .35 × .48 × 1200 = 202
~~Trans. wall 5980 × .21 1255~~
19013
Arch ring .46 ~~.48~~ × 8.5 × 2400 = 9400
28413

at 5 wall .38 × 1.00 × 1200 455
.44 × 8.5 × 2400 = 8980
9435

at 4 floor 7182 × 1.5 = 10780
cross beam inter. 600
cross wall 5980 × .32 1920
long'l outside .25 × 1.00 × 1200 300
inside .35 × .30 × 1200 1/2 126
sand fill .35 × .28 × 7.3 × 1800 = 1290
15036
Arch ring .42 × 8.5 × 2400 8560
~~23876~~
23596

at springing .78 × .86 × 8.5 × 2400 = 6650

at (13) Arch ring 1.44/2 × 0.5 = .72
.72 × .82 × 8.5 × 2400 = 12030
Assumed

at 3 floor 7182 × 1.0 = 7182
long'l outside .17 × 1.00 × 1200 = 204
inside .23 × 1.00 × 1200 = 390
fill .20 × 1.00 × 7.3 × 1800 = 2630
10406
Arch ring .415 ~~.42~~ 8.5 × 2400 8450
~~18966~~
18856

at 2 floor 7182 × 1.0 = 7182
outside .10 × 1.00 × 1200 = 120
inside .16 " 192
fill 1.0 × .14 × 7.3 × 1800 = 1840
9334
Arch ring .41 × 8.5 × 2400 = 8350
17684

at 1 floor 7182 × 1.0 = 7182
wall outside .06 × 1.00 × 1200 = 70
" inside .12 = 144
Sand fill 1.00 × .10 × 7.3 × 1800 = 1315
8711
Arch ring .40 × 8.5 × 2400 = 8150
16861

at 0 7182 × .265 = 1900
.265 × 0.05 × 1200 = 16
.265 × 0.11 × 1200 = 35
fill .265 × 0.08 × 7.3 × 1800 = 278
2229
Arch ring .40 × .265 × 8.5 × 2400 = 2165
4394

増田淳氏関係資料（独立行政法人 土木研究所蔵）

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JIJI BLDG, TOKYO

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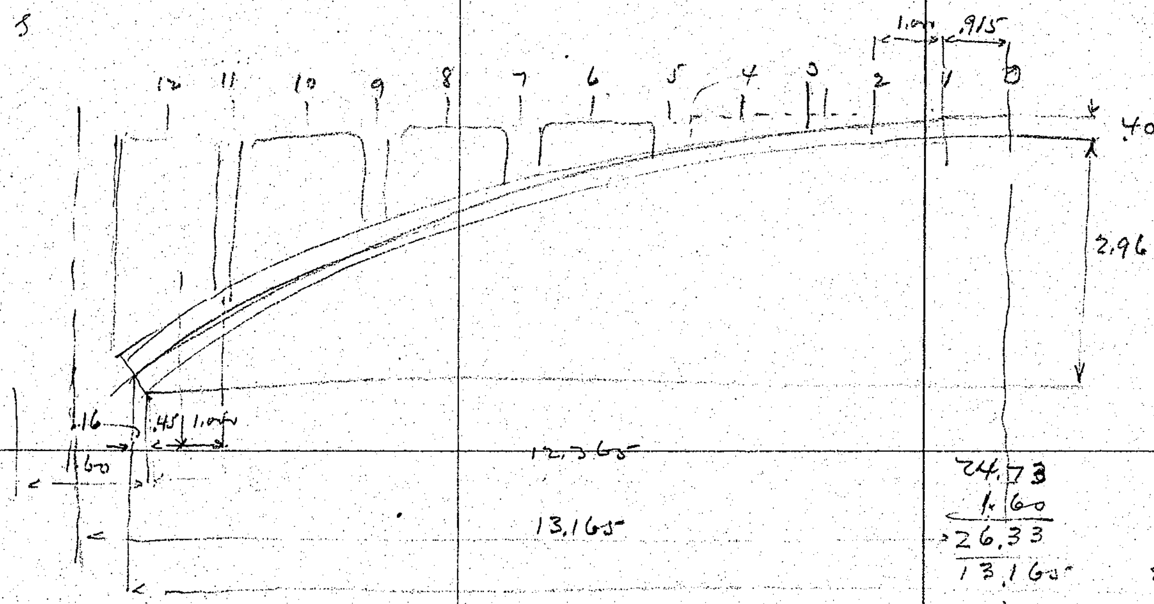
CALCULATIONS FOR

3 (B)

Shinobu Bashi. span no 2.



12.25

2.25
.80
1.45

13.165
12.25
.915

24.73
.32
25.05

24.73
1.60
26.33
13.165

25.05 span length

2.96
.20
3.16
.366
2.794 — rise neutral axis

at (11)

flooring	7182 × 2.0	=	14364
cross beam			3890
fascia girder			454
Col.	3460 × 1.43	=	4950
			23658
Arch ring	.72 × 8.5 @ 2400	=	14700
			38358

(12) springing 6650

(12) say 12000

(10) Arch ring .64 × 8.5 @ 2400 = 13100

(9)

flooring	7182 × 2.0	=	14364
cross beam			3890
fascia girder			454
Col.	3460 × .78	=	2700
			21408
Arch ring	.58 × 8.5 @ 2400	=	11820
			33228

(8) Arch ring .53 × 8.5 @ 2400 = 10800

(7)

flooring	7182 × 2.0	=	14364
cross beam			4220
fascia girder			454
~~wall~~	5980 × .26	=	1560
			20598
Arch ring	.50 × 8.5 @ 2400	=	10200
			30798

(6) Arch ring .48 × 8.5 @ 2400 = 9800

(5)

flooring	7182 × 2.0	=	14364
center cross beam			620
cross wall	5980 × 0.5	=	2990
fascia girder	½		227
long'l wall	.35 × .39 @ 1200	=	164
			18365
Arch ring	.45 × 8.5 @ 2400	=	9180
			27545

(4)

long'l wall	1.00 × .30 × 1200	=	360
Arch ring	.43 × 8.5 × 2400	=	8780
			9140

(3)

(3)

flooring	7182 × 1.5	=	10780
center cross beam			620
cross wall	5980 × .25	=	1500
outside long. wall	.19 × 1.00 × 1200	=	230
inside wall	.25 × .35 × 1200	300	100
Sand fill	.23 × .35 × 7.3 × 1800	=	1060
			14290
Arch ring	.42 × 8.5 × 2400	=	8560
			22850

(2)

flooring	7182 × 1.0	=	7182
outside wall	.11 × 1.00 × 1200	=	132
inside wall	.17 × 1.00 × 1200	=	187
filling	.15 × 1.00 × 7.3 × 1800	=	1970
			9471
Arch ring	.41 × 8.5 @ 2400	=	8350
			17821

(1)

floor	7182 × 1.0	=	7182
outside wall	1.00 × .06 × 1200	=	70
inside "	1.00 × .12 × 1200	=	144
Sand fill	1.00 × .10 × 7.3 × 1800	=	1315
			8711
Arch ring	.40 × 8.5 @ 2400	=	8150
			16861

(0)

flooring	7182 × .415	=	2980
outside	.415 × 0.05 × 1200	=	25
inside	.415 × 0.10 × 1200	=	50
fill	.415 × 0.09 × 7.3 × 1800	=	490
			3545
Arch ring	.415 × .40 × 8.5 × 2400		3390
			6935

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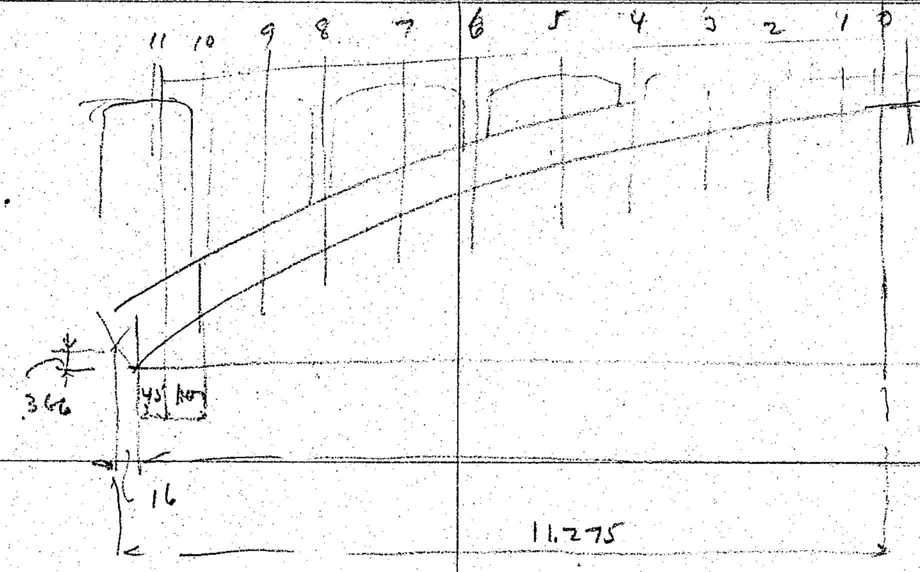
CALCULATIONS FOR

Shinsken Bashi

38

spandrel.



span length 2223
.32
2255 neutral axis
11.275

span 22.23
11.115
.800
11.915
-.25
11.665
11.000
.665

rise 2.65
.20
2.85
-.366
2.484 — rise neutral axes

10.61
.665
11.275 ✓

⑩ flooring. 7182 × 2.0 = 14364
cross beam. 3890
fascia girder .454
col. 3460 × .14 3940
22648
Arch ring .71 × 8.5 @ 2400 14500
37148

spring. 6650
at ⑪ say 12000.

⑨ Arch ring .625 × 8.5 @ 2400 12750

⑧ flooring. 7182 × 2.0 = 14364
cross beam 3890
fascia girder 454
col. 3460 × .52 1800
20508
Arch ring .56 × 8.5 @ 2400 = 11400
31908

⑦ Arch ring. .51 × 8.5 @ 2400 = 10400

⑥ flooring 7182 × 2.0 = 14364
cross beam 4220
fascia girder 454
wall. 5980 × 0.06 = 360
19398
Arch ring. .48 × 8.5 @ 2400 = 9780
29178

⑤ Arch ring. .45 × 8.5 @ 2400 = 9200

④ floor. 7182 × 1.5 = 10780
cross beam. 620
wall. 5980 × .35 = 2100
fascia girder 1/2 227
outside .28 × .35 × 1200 = 118
Inside - .34 × .35 × 1200 = 143
Sandfill - .32 × .35 × 7.3 × 1800 1470
15458
Arch ring. .43 × 8.5 @ 2400 = 8770
24228

③ floor. 7182 × 1.0 = 7182
outside wall .17 × 1.00 × 1200 = 204
Inside wall .23 × 1.00 × 1200 = 276
Sandfill. .21 × 1.00 × 7.3 × 1800 = 2760
10422
Arch ring. .42 × 8.5 @ 2400 = 8570
18992

② floor 7182 × 1.0 = 7182
outside wall .10 1.00 × 1200 = 120
Inside .16 1.00 × 1200 = 192
Sand fill. .14 × 1.00 × 7.3 × 1800 = 1840
9334
Arch ring. .41 × 8.5 @ 2400 = 8350
17684

① floor. 7182 × 1.0 = 7182
outside wall .06 × 1.00 × 1200 = 70
Inside .12 do = 144
Sand. 1.00 × .10 × 7.3 × 1800 = 1315
8711
arch ring. .40 × 8.5 @ 2400 = 8150
16861

⓪ floor 7182 × .165 = 1185
outside wall .165 × 0.05 × 1.00 × 1200 = 10
Inside wall .165 × 0.11 × 1.00 × 1200 = 22
Sandfill .165 × .09 × 7.3 × 1800 = 196
1413
Arch ring .165 × .40 × 8.5 × 2400 = 1350
2763

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CALCULATIONS FOR

Shimoku Bashi for Fukushima-Ken

.40 × 8.50 = 3400

Arm. 13.675 − 1.065 = 12.610

Span no. 4.

	load			arm	moment	
0	9440	9420	9420	13.675	128750	129000
1	16860		26280	12.610	212500	212500
2	17970		44250	11.610	208500	208500
3	19550		63800	10.610	207200	207500
4	24100	24750	88550	9.610	238000	232000
5	9490	9710	98260	8.610	83600	81700
6	28700	30010	128270	7.61	228200	218500
7	9800	10000	138270	6.61	66100	64800
8	32200	33940	172210	5.61	190400	180800
9	11200	11200	183410	4.61	51600	51600
10	33000	35280	218690	3.61	126800	119000
11	13050	13260	231950	2.61	34600	34000
12	39020	40490	272440	1.61	65200	62800
13		12000	284440	0.61	7320	7300
3/p.		6650	291090	0		

34000

~~29109~~0 ~~892~~ → 284030

1848770 ÷ 3.070 = 3.064 = 590000

(no 2) span

	load		arm		
0	~~6940~~	6940	12.525	=	81400
1	16860	23800	11.61	=	196000
2	17820	41620	10.61	=	189000
3	22850	64470	9.61	=	220000
4	9140	73610	8.61	=	78700
5	27550	101160	7.61	=	209500
6	9800	110960	6.61	=	64800
7	30800	141760	5.61	=	173000
8	10800	152560	4.61	=	49800
9	33230	185790	3.61	=	120000
10	13100	198890	2.61	=	34200
11	38400	237290	1.61	=	61800
12	12000	249290	.61	=	7300
3/2	6650	255940	0	=	0
	255940				

1485500 ÷ 2.794 = 531000

11.61 − .915 = 12.525

Rise 3.16 + .20 = 3.36 − .37 = 2.99

Span No 3.

13.375 − 0.765 = 12.610

				arm		
0		4390		13.375	58700	58,700
1		16860	21250	12.610	212500	212500
2		17680	38930	11.61	205500	205500
3	18860	~~18970~~	57900	10.61	200000	201000
4	23600	~~23880~~	81780	9.61	226500	229500
5	9440	~~9640~~	91420	8.61	81300	83000
6	28410	~~30070~~	121490	7.61	216500	228800
7	9900	~~10400~~	131890	6.61	65500	68800
8	32040	~~33830~~	165720	5.61	179800	189700
9	11200	~~11800~~	177520	4.61	51600	54400
10	33980	~~35940~~	213460	3.61	122500	129600
11	13250	~~14300~~	227760	2.61	34600	37300
12	39140	~~38560~~	268320	1.61	63000	65200
13		12000	280320	0.61	7300	7320
3/p		6650	286970			
		286970				

277400

1771320 ÷ 2.99 = 592000

÷ 2.994 = 576000

Span no. 1

	loads		arm		
0	2760	2760	11.275	=	31200
1	16860	19620	10.61	=	179000
2	17680	37300	9.61	=	170000
3	19000	56300	8.61	=	163500
4	24230	80530	7.61	=	185000
5	9200	89730	6.61	=	60900
6	29180	118910	5.61	=	164000
7	10400	129310	4.61	=	48000
8	31900	161210	3.61	=	115000
9	12750	173960	2.61	=	33200
10	37150	211110	1.61	=	59800
11	12000	223110	0.61	=	7300
3/p	6650	229760	0		
	229760				

1216900 ÷ 2.484 = 489000

10.61 + .665 = 11.275

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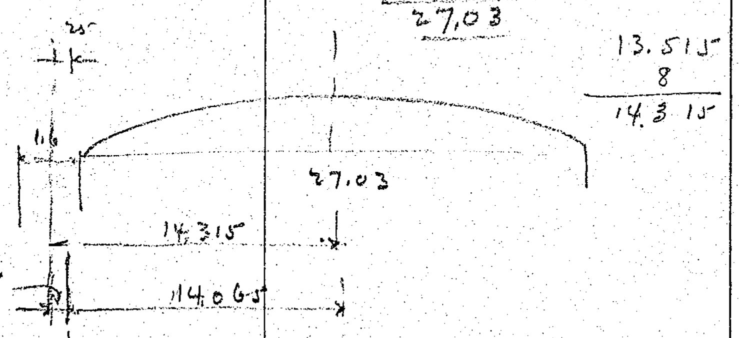
CALCULATIONS FOR

no. 4 span.

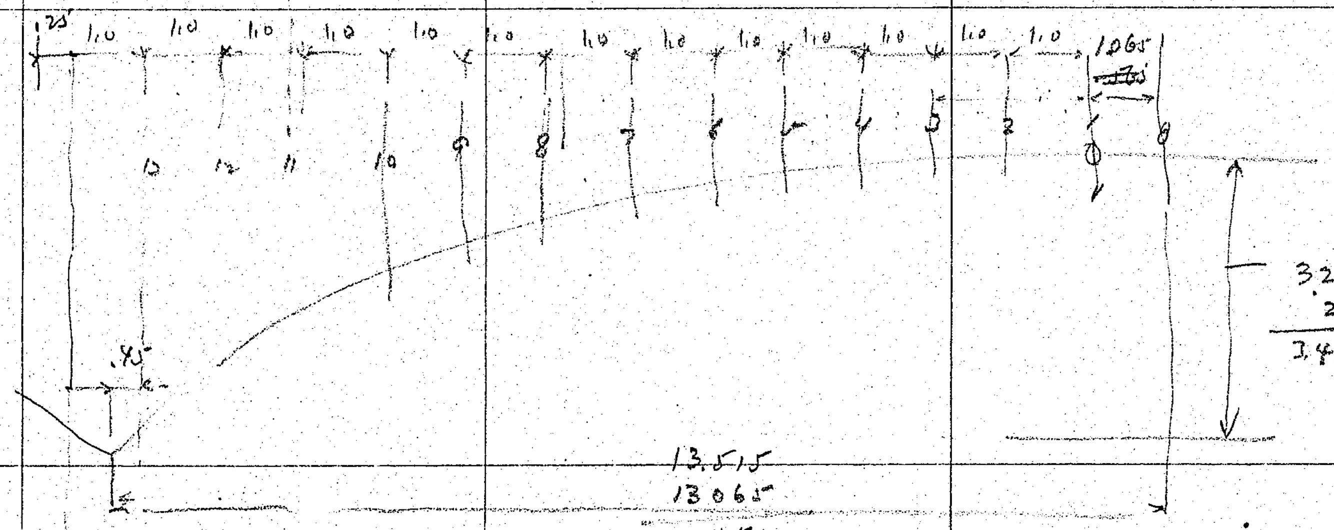
span Intrados, 13.515 × 2 = 27.03 rise. 3.23

13.515 + .8 = 14.315



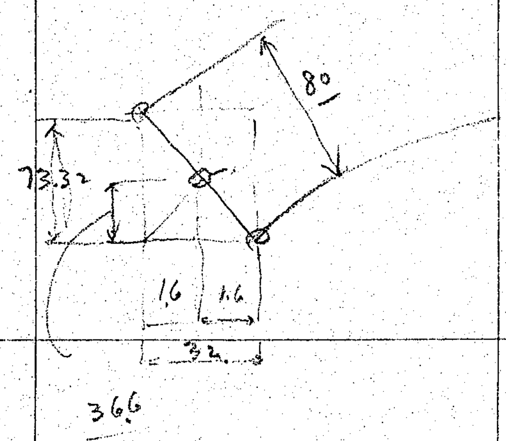
14.315 − .25 = 14.065

80
25



3.23 + .20 = 3.43

13.515 − 13.065 = .450



3.43 − .366 = 3.064 — 3.064 rise.

64.00 − 10.24 = 53.76 — 7332

span 13.515 + .16 = 13.675 × 2 = 27.350

27.03 + .32 = 27.35

0	1	2	3	4	5	6	7	8	9	10	11	12	13	
.200	201	2025	2050	2070	2135	2225	2325	2425	2575	2750	3000	3300	3675	400
455	455	455	455	45	45	45	45	45	45	45	45	45	45	45
.155	156	1575	.160	162	1685	1775	1875	1975	2125	230	255	285	3225	355

00533	540	553	574	591	648	734	838	952	1138	1385	1733	2690	3310	4265
105	107	109	112	115	124	138	154	171	198	464	570	712	910	1102
638	647	662	686	706	772	872	992	1123	1336	1849	2303	3402	4220	5367

$(a+b)^2 = a^2 + 2ab + b^2$

1006 — 101.2036.
1006
101.3032

1868689,
1368
1870057

122.7236
1106
4342

1705636
1306
170694

145.4436
1206
1642

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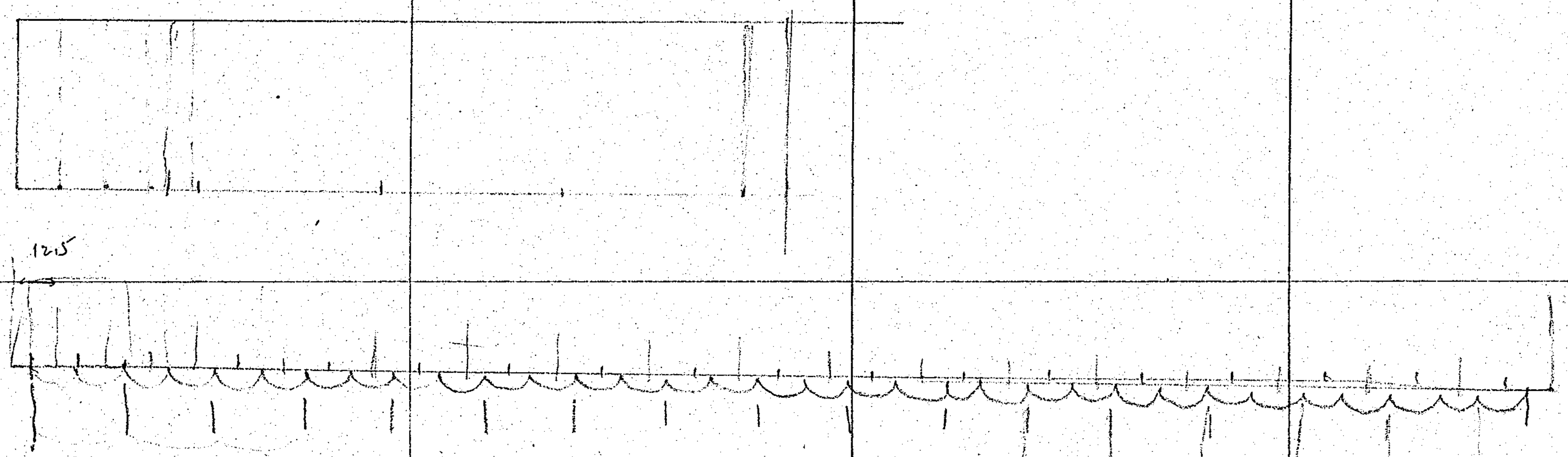
CALCULATIONS FOR 4

Shinsobu Bashi

Reinforcing Bars 22 cm bars 26 cm centers 16 spaces
no of bars 34 bars



$$\begin{array}{r} 4.25 \\ -10 \\ \hline 4.15 \end{array} \Big|\, 16$$

$$\begin{array}{r} 26 \\ 16 \\ \hline 156 \\ 36 \\ \hline 416 \\ 425 \\ \hline 9 \end{array}$$

16 spaces 26 cm
22 mm bars 3.80 top and bottom
for 1 meter strip $\frac{3.80 \times 1.00}{26} = 14.6$ □ cm
2 @ 29.2 □ cm

12 11 10 9 8 7 6 5 4 3 2 1 0

average steel

d		x	y	ds
.40	0	0	0	.565
.402	1	1.065	0.015	1.000
.405	2	2.065	0.060	1.000
.410	3	3.065	0.140	1.005
.414	4	4.065	0.260	1.010
.427	5	5.065	0.395	1.015
.445	6	6.065	0.570	1.025
.465	7	7.065	0.780	1.030
.485	8	8.065	1.015	1.040
.515	9	9.065	1.290	1.050
.550	10	10.065	1.600	1.060
.600	11	11.065	1.955	1.070
.660	12	12.065	2.350	1.080
.735	13.	13.065	2.775	0.875
.800	Sp.	13.675	3.064	0.350

Arch ring $\frac{1}{2} = 4.25$ meters

moment of inertia of concrete $= \frac{1}{12} d^3$.

moment of inertia of steel.

$$= \frac{29.2 \times 15}{10000}\left(\frac{d}{2} - 0.045\right)^2.$$

$$= \frac{.0438}{100.00}\left(\frac{d}{2} - 0.045\right)^2$$

from panel point no 10 reinf will be doubled

.45
1
.61

Division	Depth d.	d^3	$I_c = \frac{1}{12} d^3$	$\left(\frac{d}{2} - 0.045\right)^2$	@ .0438	$I_c + I_s$	Equivalent steel area	Concrete area
0 crown	.400	.0640	0.00533	0.0240	.00105	0.00638	.0.0438	.400
1	.402	.0649	0.00540	0.0244	.00107	647	"	.402
2	.405	.0664	0.00553	0.0248	.00109	662	"	.405
3	.410	.0689	.00574	0.0256	.00112	686	"	410
4	.414	.0709	.00591	0.0262	.00115	706	"	414
5	.427	.0778	.00648	0.0284	.00124	772	"	427
6	.445	.0881	.00734	0.0315	.00138	872	"	445
7	.465	.1005	.00838	0.0352	.00154	992	"	465
8	.485	.1141	.00952	0.0390	.00171	1123	"	485
9	.515	.1366	.01138	0.0452	.00198	1336	"	515
10	.550	.1664	.01385	0.0530	.~~00254~~ 464	1849	0.0876	550
11	.600	.2160	.01733	0.0650	.~~00285~~ 570	2303	"	600
12	.660	.2875	.02690	0.0813	.~~00356~~ 712	3402	"	660
13	.735	.3971	.03310	0.1040	.~~00459~~ 910	4220	"	735
Sp.	.800	.5120	.04265	0.1260	.~~00551~~ 1102	.05367	"	800

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CALCULATIONS FOR 4

[illegible]

Division	x	x²	y	y²	ds	I	ds/I	x ds/I	x² ds/I	y ds/I	y² ds/I
0	0	0	0	0	.565	0.00638	88.60	0	0	0	0
1	1.065	1.134	0.015	0.002	1.000	.00647	154.50	164.50	175.20	2.32	.31
2	2.065	4.264	0.060	0.004	1.000	.00662	151.20	312.00	644.00	9.07	.61
3	3.065	9.394	0.140	0.020	1.005	.00686	146.50	449.00	1375.00	20.50	2.93
4	4.065	16.524	.260	0.068	1.010	.00706	143.00	581.00	2361.00	37.20	9.72
5	5.065	25.654	.395	0.156	1.015	.00772	131.50	666.00	3370.00	51.90	20.51
6	6.065	36.784	.570	0.325	1.020	.00872	117.00	709.50	4300.00	66.70	38.00
7	7.065	49.914	.780	0.608	1.025	.00992	103.40	730.50	5160.00	80.65	62.90
8	8.065	65.044	1.015	1.030	1.035	.01122	92.20	744.00	6000.00	93.60	95.00
9	9.065	82.174	1.290	1.664	1.045	.01336	78.00	706.50	6405.00	100.60	129.70
10	10.065	101.303	1.600	2.560	1.055	.01849	57.10	574.20	5780.00	91.30	146.20
11	11.065	122.434	1.955	3.822	1.068	.02303	46.40	513.50	5680.00	90.65	177.40
12	12.065	145.564	2.350	5.523	1.080	.03402	31.76	383.00	4625.00	74.60	175.50
13	13.065	170.694	2.775	7.701	0.875	.04220	20.70	270.50	3562.00	57.40	159.40
Sp	13.675	187.006	3.064	9.388	0.350	.05267	6.52	89.15	1219.00	19.97	61.20
					14.145		1368.38	6892.85	50656.20	796.46	1079.38
								3.35			

	x	m	m ds/I	mx ds/I	my ds/I	m	m ds/I	mx ds/I	my ds/I	m	m ds/I	mx ds/I	my ds/I
			0				①				②		
0	0	0	0	0	0								
1	1.065	–	164.50	175.20	2.47	0							
2	2.065	–	312.00	644.00	18.73	1.0	151.20	312.00	9.07				
3	3.065	–	449.00	1375.00	62.80	2.0	293.00	898.00	41.00	1.00	146.50	449.00	20.50
4	4.065	–	581.00	2361.00	151.10	3.0	429.00	1743.00	111.60	2.00	286.00	1162.00	74.40
5	5.065	–	666.00	3370.00	263.00	4.0	526.00	2664.00	207.60	3.00	394.50	1998.00	155.70
6	6.065	–	709.50	4300.00	404.50	5.0	584.50	3547.50	333.50	4.00	468.00	2838.00	266.80
7	7.065	–	730.50	5160.00	570.00	6.0	620.40	4383.00 3652.50	483.90	5.00	517.00	3652.50	403.25
8	8.065	–	744.00	6000.00	755.00	7.0	645.40	5208.00	655.20	6.00	553.20	4464.00	561.60
9	9.065	–	706.50	6405.00	912.00	8.0	624.00	5682.00	804.80	7.00	546.00	4945.50	704.20
10	10.065	–	574.20	5780.00	919.00	9.0	513.90	5167.80	821.70	8.00	456.80	4593.60	730.40
11	11.065	–	513.50	5680.00	1002.50	10.0	464.00	5135.00	906.50	9.00	417.60	4621.50	815.85
12	12.065	–	383.00	4625.00	900.00	11.0	349.36	4213.00	820.60	10.00	317.60	3830.00	746.00
13	13.065	–	270.50	3562.00	750.00	12.0	248.40	3246.00	631.40	11.00	227.70	2975.50	631.40
Sp	13.675	–	89.15	1219.00	273.00	12.61	82.20	1124.18	251.82	11.61	75.69	1035.03	231.85
			6893.35	50656.20	6984.10		5334.96	42562.98	~~6084.09~~ 6078.69		4406.59	36564.63	5341.95

	m	m ds/I	mx ds/I	my ds/I	m	m ds/I	mx ds/I	my ds/I	m	m ds/I	mx ds/I	my ds/I
		③				④				⑤		
0												
1												
2												
3												
4	1.0	143.00	581.00	37.20								
5	2.0	263.00	1332.00	103.80	1.0	131.50	666.00	51.90				
6	3.0	351.00	2128.50	200.10	2.0	234.00	1419.00	133.40	1.0	117.00	709.50	66.70
7	4.0	413.60	2922.00	322.60	3.0	310.20	2191.50	241.95	2.0	206.80	1461.00	161.30
8	5.0	461.00	3720.00	468.00	4.0	368.80	2976.00	374.40	3.0	276.60	2232.0	280.80
9	6.0	468.00	4239.00	603.60	5.0	390.00	3532.50	503.00	4.0	312.00	2826.00	402.40
10	7.0	399.70	4019.40	639.10	6.0	342.60	3445.20	547.80	5.0	285.50	2871.00	456.50
11	8.0	371.20	4108.00	725.20	7.0	324.80	3594.50	634.55	6.0	278.40	3081.00	543.90
12	9.0	285.84	3447.00	671.40	8.0	254.08	3064.00	596.80	7.0	222.32	2681.00	522.20
13	10.0	207.00	2705.00	574.00	9.0	186.30	2434.50	516.60	8.0	165.60	2164.00	459.20
Sp	10.61	69.18	945.88	211.88	9.61	62.66	856.73	191.91	8.61	56.14	767.58	171.94
		3432.52	~~27147.78~~ 30147.78	4556.86		2604.94	24179.93	3792.31		1920.36	18793.08	3064.94

43293.48

6078.69
57.4
6136.09

57.4
12
114.8
57.4
688.8

631.4
688.8
~~631.4~~
57.4

JIUN MASUDA
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JIJI BLDG, TOKYO

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CALCULATIONS FOR 4

78 / 468

Shinobu Bashi

	⑥ m	$\frac{m\,ds}{I}$	$\frac{m\,y\,ds}{I}$		⑦ m	$\frac{m\,ds}{I}$			⑧ m	$\frac{m\,ds}{I}$		
7	1.0	103.40	730.50	80.65								
8	2.0	184.40	1488.00	187.20	1.0	92.20	744.00	93.60				
9	3.0	234.00	2119.50	301.80	2.0	156.00	1413.00	201.20	1.0	78.00	706.5	100.60
10	4.0	228.40	2296.8	365.20	3.0	171.30	1722.60	273.90	2.0	114.20	1148.40	182.60
11	5.0	232.00	2567.50	453.25	4.0	185.60	2056.40	362.60	3.0	139.20	1540.50	271.95
12	6.0	190.56	2298.00	447.60	5.0	158.80	1915.00	378.00	4.0	127.04	1532.00	298.40
13	7.0	144.90	1893.50	401.80	6.0	124.20	1623.00	344.40	5.0	103.50	1352.50	287.00
sp.	7.61	49.62	678.43	151.97	6.61	43.09	589.28	132.00	5.61	36.58	500.13	112.03
		1367.28	14072.23	2389.47		931.19	10060.88	1785.70		598.52	~~6784.03~~ 6780.03	1252.58

	⑨ m	$\frac{m\,ds}{I}$			⑩ m				⑪ m			
10	1.0	57.10	574.20	91.30								
11	2.0	92.80	1027.0	181.30	1.0	46.40	513.50	90.65				
12	3.0	95.28	1149.00	223.80	2.0	60.52	766.00	149.20	1.0	31.76	383.00	74.60
13	4.0	82.80	1082.0	229.60	3.0	62.10	811.50	172.20	2.0	41.40	541.00	114.80
sp	4.61	30.06	410.98	92.06	3.61	23.54	321.83	72.09	2.61	17.02	232.68	52.12
		358.04	~~4227.70~~ 4243.18	818.06		195.56	2413.83	484.14		90.18	1156.68	241.52

	⑫ m				⑬		
13	1.0	20.70	270.50	57.40			
sp	1.61	10.49	143.53	32.15	.61	3.97	54.38	12.18
		31.19	414.03	89.55		3.97	54.38	12.18

$$H_o = \frac{\int\frac{ds}{I}\int\frac{m\,y\,ds}{I} - \int\frac{m\,ds}{I}\int\frac{y\,ds}{I}}{2\left[\int\frac{ds}{I}\int\frac{y^2\,ds}{I} - \left(\int\frac{y\,ds}{I}\right)^2\right]} = \frac{A}{B}$$

1477.00 2.0044

$$B = 2\left[\begin{array}{l}1368.38 \times 1079.38 \\ - 796.46^2\end{array}\right]$$

1477.002
634.348
842.654
2
1685.308

634.348 / 5316

= 1685.308

0	1368.38 × 6984.10 / 796.46 6893.33	9556902 / 5490.3 / 4066000	1368.38 × 2.411	
1	× 6078.64 / 6136.09	8317957 / 4408 / 3910000	2	8,396,500 / 4408 / 3988500
	5534.96		2.368	
2	× 5341.95 / 4406.59	7309817 / 3509 / 3800000	2.254	
3	× 4556.88 / 3432.52	6235543 / 2733 / 3502000	2.078	
4	3792.31 / 2684.94	5189321 / 2074 / 3117000	1.847	
5	3064.94 / 1920.36	4,194,002 / 1529 / 2665000	1.580	
6	2389.47 / 1367.28	3269,702 / 1089000 / 2180700	1.292	1.06
7	1785.70 / 931.19	2,443,516 / 741,600 / 1701911	1.009	
8	1252.58 / 598.52	1714005.4 / 476600 / 1237400	0.734	
9	818.06 / 358.04	1119416 / 285132 / 834380	.493	
10	484.14 / 195.56	662487 / 155,787 / 506700	.301	
11	241.52 / 90.18	330491.1 / 71,840 / 258650	.153	
12	89.55 / 31.19	122538 / 24,849 / 16,666	97690	.058 / .008 / 16666 / 3185 / 13471
13	12.18 / 3.97			

0 1 2 3 … 8 9 10 11 12 13

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CALCULATIONS FOR

796.46 / 1592.92   1368.38 / 2736.76

Nijugbu Bashi 4

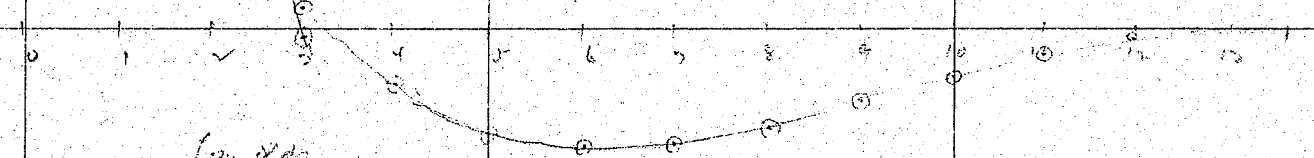
$$M_0 = \frac{-H_0\, 2\int y\frac{ds}{I} + \int m\frac{ds}{I}}{2\int\frac{ds}{I}} = \frac{C}{D}$$

1367.88

$-2H_0\int y\frac{ds}{I}$ C $2\int\frac{ds}{I}$ D

Crown 0	2 × 2.411 × 796.46	= −3840.50	+	6889.35	=	+ 3052.85	÷ 2736.76	= 1.1185	+
1	2 × 2.365 ×	= −3767.25	+	5534.96		+ 1767.75		.6460	
2	2 2.254	= −3590.44		4406.59		+ 816.15		.2980	
3	2 2.078	= −3310.09		3432.52		+ 122.43		.0447	
4	2 1.847	= −2942.12		2604.94		− 337.18		.1232	−
5	2 1.580	= −2516.81		1920.36		− 596.45		.2180	
6	2 1.292	= −2058.05		1367.28		− 690.77		.2525	
7	2 1.009	= −1607.25		931.19		− 676.06		.2470	
8	2 0.734	= −1169.20		598.52		− 570.68		.2084	
9	2 0.495	= −788.50		358.04		− 430.46		.1573	
10	2 0.301	= −479.46		195.56		− 283.90		.1036	
11	2 0.153	= −243.72		90.18		− 153.54		.0552	
12	2 0.058	= −92.38		31.19		− 61.19		.0224	
13	2 0.008	= −12.74		3.97		− 8.77		.0032	
½	0.000								

0 1 2 3 4 5 6 7 8 9 10 11 12 13



73050 / 6 / 43830 / 36525.0 / 73050 / 42562.98 / 43292.48

$$V_0 = \frac{\int m\, y\frac{ds}{I}}{2\int y^2\frac{ds}{I}} = \frac{E}{F}$$

50656.20 / 101312.40

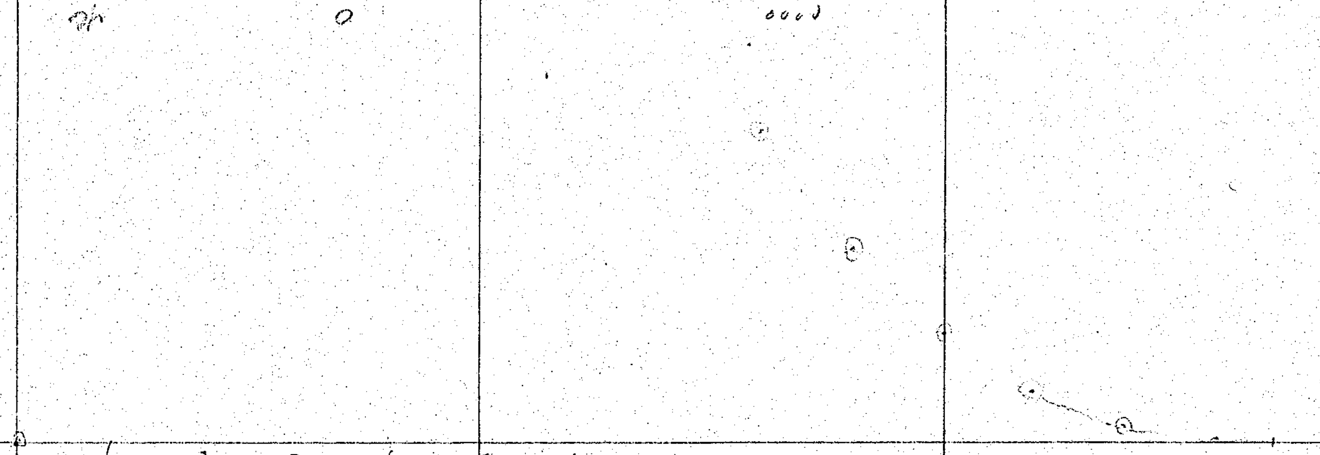
	E		F		
Crown 0	50656.20	÷	101312.40	=	.5000
1	43562.98		43292.48		.4270
2	36564.69				.3609
3	30147.78				.2975
4	24179.93				.2385
5	18973.08				.1872
6	14072.23				.1389
7	10060.88				.0993
8	6780.03				.0669
9	4243.18				.0419
10	2412.83				.0238
11	1156.68				.0114
12	414.03				.0041
13	54.38				.0005
½	0				.0000

V_0

0	.5000
1	.4270
2	.3609
3	.2975
4	.2385
5	.1872
6	.1389
7	.0993
8	.0669
9	.0419
10	.0238
11	.0114
12	.0041
13	.0005
½	0

H_0

0	2.411
1	2.365
2	2.254
3	2.078
4	1.847
5	1.580
6	1.292
7	1.009
8	.734
9	.495
10	.301
11	.153
12	.058
13	.008
½	0



1 2 3 4 5 6 7 8 9 10 11 12 13 ½

CALCULATIONS FOR

Hiroshe Bashi 4

12.61
1.065
13.675

d' lever arm of unit load about centre of section origin at crown
left Hand

$M_L = M_0 + H_0 y + V_0 x - d'$

$M_R = M_0 + H_0 y - V_0 x$

$x = 13.675$ $y = 3.000$

	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
0	+1.1155	7.3873	6.8375	13.675	+1.6653	+1.6653
1	+0.6460	7.2464	5.8392	12.610	+1.1216	+2.0532
2	+0.2980	6.9063	4.9353	11.610	+.5296	+2.2690
3	+0.0447	6.3670	4.0683	10.610	-.1300	+2.3434
4	-.1232	5.6592	3.2615	9.610	-.8125	+2.2745
5	-.2180	4.8411	2.5600	8.610	-1.4269	+2.0631
6	-.2525	3.9587	1.8995	7.61	-2.0043	+1.8067
7	-.2470	3.0916	1.3792	6.61	-2.3862	+1.4654
8	-.2084	2.2490	.9148	5.61	-2.6546	+1.1258
9	-.1772	1.5167	.5730	4.61	-2.6776	+0.7864
10	-.1036	.9223	.3254	3.61	-2.4659	+0.4933
11	-.0552	.4688	.1559	2.61	-2.0405	+0.2577
12	-.0224	.1777	.0560	1.61	-1.3987	+0.0993
13	-.0032	.0245	.0068	.61	-0.5819	+0.0145
sp.	-.0000	.0000	.0000	0	0.0000	

Point (12) $x = 12.065$ $y = 2.350$

	$H_0 y$	$V_0 x$	d'	M_L	M_R
0	5.6659	6.0325	12.065		
1	5.5578	5.1518	11.00		
2	5.2969	4.2543	10.00		
3	4.8833	3.5893	9.00		
4	4.3405	2.8775	8.00		
5	3.7130	2.2586	7.00		
6	3.0362	1.6758	6.00		
7	2.3712	1.1981	5.00		
8	1.7249	.8071	4.00		
9	1.1633	.5055	3.00		
10	0.7074	.2871	2.0		
11	0.3596	.1375	1.0		
12	0.1363	.0495	0		
13	0.0188	.0060			
sp	.0000	.0000			

(10) $x = 10.065$ $y = 1.600$

	$H_0 y$	$V_0 x$	d'
0	3.8576	5.0325	10.065
1	3.7840	4.2978	9.0
2	3.6064	3.6325	8.0
3	3.3248	2.9943	7.0
4	2.9552	2.4005	6.0
5	2.5280	1.8842	5.0
6	2.0672	1.3980	4.0
7	1.6144	0.9995	3.0
8	1.1744	.6734	2.0
9	0.7920	.4217	1.0
10	.4816	.2395	0
11	.2448	.1147	
12	.0928	.0413	
13	.0128	.0050	
sp	0.0000	.0000	

(8) $x = 8.065$ $y = 1.015$

	$H_0 y$	$V_0 x$	d'
0	2.4472	4.0325	8.065
1	2.4005	3.4438	7.0
2	2.2878	2.9107	6.0
3	2.1092	2.3993	5.0
4	1.8747	1.9235	4.0
5	1.6037	1.5098	3.0
6	1.3114	1.1202	2.0
7	1.0241	0.8009	1.0
8	0.7450	.5395	0
9	.5024	.3379	
10	.3055	.1919	
11	.1553	.0919	
12	.0589	.0331	
13	.0081	.0040	
sp	.0000	.0000	

(6) $x = 6.065$ $y = .570$ .560

		$H_0 y$	$V_0 x$	d'
0	13502	1.3743	3.0325	6.065
1	13244	1.3481	2.5898	5.0
2	12622	1.2848	2.1889	4.0
3	11637	1.1845	1.8043	3.0
4	10393	1.0528	1.4465	2.0
5	.08848	0.9006	1.1354	1.0
6	.7235	.7364	0.8424	0
7	.5650	.5751	.6023	
8	.4110	.4184	.4057	
9	.2772	.2822	.2541	
10	.1686	.1716	.1443	
11	.0857	.0872	.0691	
12	.0325	.0331	.0249	
13	.0045	.0046	.0030	
sp	0	.0000	.0000	

(4) $x = 4.065$ $y = .260$

	$H_0 y$	$V_0 x$	d'
0	0.6269	2.0325	4.065
1	.6149	1.7358	3.0
2	.5860	1.4671	2.0
3	.5403	1.2093	1.0
4	.4802	0.9695	0
5	.4108	.7610	
6	.3359	.5646	
7	.2623	.4037	
8	.1908	.2719	
9	.1287	.1703	
10	.0783	.0967	
11	.0398	.0463	
12	.0151	.0167	
13	.0021	.0020	
sp	.0000	.0000	

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CALCULATIONS FOR 4

② x = 2.065 y/ = 0.060

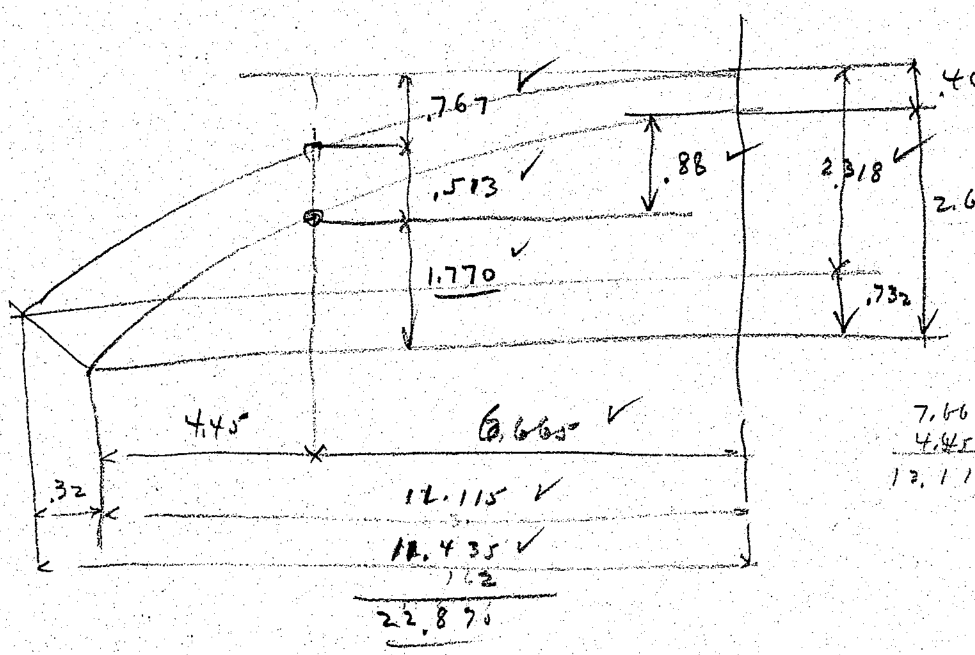
	Mo	Mhy	Voy	d'	ML	MR
0		0.1447	1.0325	2.065		
1		.1419	0.8818	1.0		
2		.1352	.7453	0		
3		.1247	.6143			
4		.1108	.4925			
5		.0948	.3866			
6		.0775	.2868			
7		.0600	.2051			
8		.0440	.1381			
9		.0297	.0865			
10		.0181	.0491			
11		.0092	.0235			
12		.0035	.0085			
13		.0005	.0010			
14		.0000				

Point load.

			12			10			8	
BL	12000	+.0216	260		+0.0146	175		.0089	107	
12	39020	+.1643	6410		+0.1117	4360		.0696	2730	
11	13050	-.5581		7280	+0.3043	3970		.1920	2500	
10	33000	-1.1091		36600	+0.6175	20400		.3938	13000	
9	11200	-1.4885		16650	+0.0564	630		.6830	7650	
8	32200	-1.6764		54000	-0.3606		11610	1.0761	34600	
7	9800	-1.6777		16480	0.6331		6210	.5780	5650	
6	28700	-1.5405		44200	0.7873		22600	+.1791	5140	
5	9490	-1.2464		11800	0.8058		7650	-.1045		990
4	24100	-.9052		21800	0.7675		18500	.3250		7830
3	19550	-.4828		9450	0.6362		12440 ~~12700~~	.4468		~~8900~~ 8735
2	17970	-.0508		915	0.4631		8340	.4935		8870
1	16860	+.3556	6000		0.2822		4750	.5097		8600
0	18880	+.7489	14120		-0.0594		1120	.4698		8870
1	16860	+1.0520	17720		+0.1222	2060		.3973		6700
2	17970	+1.2406	22350		.2719	4880		.3249		5850
3	19550	+1.3387	26200		.3752	~~7490~~ 7335		.2454		~~4900~~ 4800
4	24100	+1.3398	32300		.4315	10400		.1720		4150
5	9490	+1.2364	11710		.4258	4040		.1241		1180
6	28700	+1.1079	31800		.4167	11950		.0613		1760
7	9800	+.9261	9080		.3679	3600		.0238		234
8	32200	+.7094	22800		.2926	9430		-.0029		93
9	11200	+.5005	5600		.2130	2380		+.0072	80	
10	33000	+.3167	10450		.1385	4570		.0100	330	
11	13050	+.1669	2180		.0749	977		.0082	107	
12	39020	+.0644	2510		.0291	1135		.0034	132	
13	12000	+.0096	115		.0046	55		.0009	10.	
			+ 221605	- 219175		+ ~~92502~~ 347	- ~~93480~~ 220		+ 72036	- ~~68927~~ 68662
			219175			- 93323			~~68927~~ 68662	
			+ 2430			- ~~978~~ 873			+ 3109	3374

增田淳氏関係資料（独立行政法人 土木研究所蔵）

no1.



$$\begin{array}{r} .305 \\ .732 \\ \hline 2.318 \end{array}$$

1.28

$$\begin{array}{r} 2.96 \\ 2.65 \\ \hline .31 \end{array} \qquad \begin{array}{r} 2.318 \\ .31 \\ \hline 2.628 \end{array} \qquad \begin{array}{r} 2.65 \\ 1.77 \\ \hline .88 \end{array}$$

$$\begin{array}{r} 7.665 \\ 4.45 \\ \hline 12.115 \end{array} \qquad \begin{array}{r} 3.05 \\ 1.28 \\ \hline 1.77 \end{array}$$

Radius of Extrados $= r = \dfrac{4b^2 + c^2}{8b}$

$2.318^2 = 5.3731$
$\times 4$
21.4924
$22.87^2 \quad 523.0369$
$544.4593 \;|\; 18.544$

$\begin{array}{r} 2.318 \\ \times 8 \\ \hline 18.544 \end{array}$

$\underline{29.360}$

$29.36^2 = 862.0010$
$6.665^2 \quad 44.4222$
817.5788
$28.593 \quad 817.5881$
$1907 / 5720$

$\begin{array}{r} 29.360 \\ 28.593 \\ \hline .767 \\ .513 \\ \hline 1.280 \end{array}$

Intrados. $c_1 = \begin{array}{r} 6.665 \\ \times 2 \\ \hline 13.330 \end{array} \qquad b = \begin{array}{r} .88 \\ \times 8 \\ \hline 7.04 \end{array}$

$.88^2 = .7744$
$\times 4$
3.0976
$13.33^2 = 177.6889$
$180.7865 \;|\; 7.04$
$r = 25.680$

$\theta_1 = \sin^{-1}\dfrac{x}{r} = \dfrac{6.665}{25.680}$ — 0.8238002
1.4095950
9.4142052 — $15° - 02' - 34''$
$.4139381$
$\dfrac{2671}{4700} \times 60$

$\phi = \tan^{-1}\dfrac{1.770}{4.450}$ $\quad 0.2479733$
0.6483600
9.5996133 — $21° - 41' - 25''$
94588
1545
3680

$\sin\phi$ — 9.5675868
1322
$3178 \quad 9.5677190$

$\dfrac{\theta}{2} = \phi - \theta_1 = \begin{array}{r} 21 - 41 - 25 \\ 15 - 02 - 34 \\ \hline 6° - 38 - 51 \end{array}$

$\sin\dfrac{\theta_2}{2}$ — 9.0626386
9220
9.0635606

$c_2 = \dfrac{1.770}{\sin\phi} = \begin{array}{r} 0.2479733 \\ 9.5677190 \\ \hline 0.6802543 \\ 30103 \\ \hline .3792243 \end{array}$

$R = \dfrac{c/2}{\sin\frac{\theta_2}{2}} = \begin{array}{r} 0.3792243 \\ 9.0635606 \\ \hline .3156637 \end{array}$ — $\underline{20.685}$

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CALCULATIONS FOR 4

Shinobu - Bashi

	load	M	.6				4			2	
13 L	12000	.0062	.0058	74.	70	0.0009	10.		- 0.0017		20.
12	39020	.0356	.0350	1390	1370	.0094	367.		- .0104		406.
11	13050	.1011	.0996	1320	1300	.0309	403		- .0225		294.
10	33000	.2123	.2093	7020	6910	.0714	2360		- .0364		1,200.
9	11200	.3790	.3740	4250	4190	.1419	1588		- .0411		460
8	32200	.6157	.6083	19820	19580	.2543.	8200		- .0263		847.
7	9800	.9304	.9203	9120	9020	.4190	4110		+ .0181	177.	
6	28700	1.3263	1.3134	38100	37740	.6480	18600		.1118	3210.	
5	9490	~~8180~~	.8022	8700	7610	.9538	9030 9052		.2634	2,500.	
4	24100	.3761	.3576	9060	8620	1.3265	32000		.4801	11,560.	
3	19550	+ .0335	+ .0127	655	248	.7943	15500		.7837	15,320.	
2	17970	- .2283	- .2509	4110	4510	+ .3511	6320		1.1785	21,180.	
1	16860	- .4161	- .4398	7000	7400	- .0033		75 - 56	0.6697	11,280.	
0	18880	- .5427	- .5668	10250	10720	- .2901		5480	+ 0.2277	4,300.	
1	16860	- .5957	- .6194	10020	10430	- .4749		8000	- 0.0939		1,585.
2	17970	- .6061	- .6287	10900	11290	- .5831		10500	- .3121		5,610.
3	19550	- .5751	- .5959	11280	11660	- .6243		12200	- .4449		8,700.
4	24100	- .5164	- .5354	12450	12910	- .6125		14750	- .5049		12,160.
5	9490	- .4528	- .4686	3540	4450	- .5682		5380	- .5098		4,835.
6	28700	- .3585	- .3714	10300	10670	- .4806		13800	- .4618		13,250.
7	9800	- .2742	- .2843	2690	2790	- .3884		3810	- .3921		3,840.
8	32200	- .1957	- .2031	6300	6540	- .2895		9550 9320	- .3025		9,740.
9	11200	- .1292	- .1342	1450	1505	- .1989		2230	- .2141		2,380.
10	33000	- .0763	- .0793	2520	2620	- .1220		4030	- .1346		4,440.
11	13050	- .0371	- .0386	484	504	- .0617		805	- .0695		910.
12	39020	- .0142	- .0148	554.	578	- .0240		935	- .0274		1,070.
13 R	12000	+ .0002	- .0017	2	20	- .0031		37.	- .0037		44

99511
995
98516
84688
03828

\+ 99511 496,658
\- 83618 - 98597
\+ 15863 - 1939

83688
7000
6688

\+ 98488
\- 89583
\+ 8,906

89583 - 91,333

\+ 98510
\- 91333
\+ 7177

\+ 69527

\- 71791
\+ 69527
\- 2264

4300

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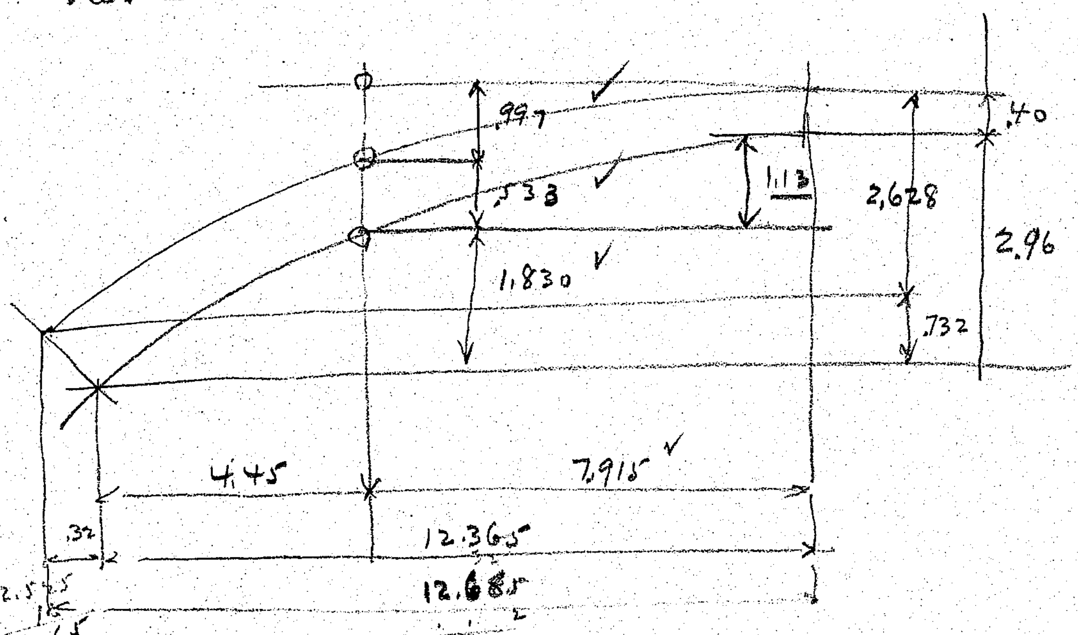
No. 2



2.96 × 4 = 3.36
3.36 − .732 = 2.628

2.96 − 1.83 = 1.13

3.36 − 1.53 = 1.83

.997 + .533 = 1.530

12.585 − .32 = 12.365
12.365 − 4.45 = 7.915

12.685 × 2 = 25.370

Radius of extrados. $r = \dfrac{4b^2 + c^2}{8b}$

$2.628 \times 8 = 21.024$

$2.628^2 = 6.9064$, × 4 = 27.6256
$25.37^2 = 643.6369$
671.2625 ÷ 21.024 − 31.928

$31.928^2 = 1019.3971$
$7.915^2 = 62.6472$
956.7499

2.9807939
41
2.9807984
1.4903992 − 30.931

31.928 − 30.931 = .997

Intrados.

$c_1 = 7.915 \times 2 = 15.830$ $b_1 = 1.13 \times 8 = 9.04$

$1.13^2 = 1.2769$, × 4 = 5.1076
$15.83^2 = 250.5889$
255.6965 ÷ 9.04, r = 28.282 — $c_1 = 15.830$ $b = 1.13$

1808
7489
7232
2576
1808
7685
7489
196

$\theta_1 = \sin^{-1}\dfrac{x}{r} = \dfrac{7.915}{28.282}$ — 0.8984509
1.4515101
9.4469408
4468927 — $16° - 15' - 06.6''$
481 × 60
4332

$\dfrac{\theta_2}{2} = \phi - \theta_1 =$ 22 − 21 − 15
16 − 15 − 07
$6° - 06 - 08$

$\sin\dfrac{\theta_2}{2}$ 9.0263865
1570
9.0265435

$\phi = \tan^{-1}\dfrac{1.830}{4.450} =$ 0.2624511
0.6483600
9.6140911
614 — $22° - 21' - 15''$
911 × 60

$\sin\phi =$ 9.5800845
770
9.5801615

$c_2 = \dfrac{1.830}{\sin\phi} =$ 0.2624511
9.5801615
0.6822896 — 4.812
30103
0.3812596

$R = \dfrac{c_2/2}{\sin\frac{\theta_2}{2}} =$ 0.3822944
9.0265435
1.3557509 — 22.686

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(13)

Shino-ba-Bashi

	V shear	Normal thrust unit load		Horizontal thrust		Normal thrust
0	0	0.000		587480	× 1.000	587500
1	17870					
2	35285	0.070	2570		× 0.999	587000
3	54045					
4	75870	0.125	9500		× 0.990	581500
5	92665					
6	111760	0.185	20600		× 0.980	576000
7	131010					
8	152010	0.250	38000		× 0.970	570000
9	173710					
10	195810	0.325	63500		× 0.95	558000
11	218835					
12	244870	0.390	95500		× 0.920	540000
13	270380					
sp	283030	0.440	124500		× 0.905	532000

	0	2	4	6	8	10	12	sp
Vertical		2570	9500	20600	38000	63500	95500	124500
	587500	587000	581500	576000	570000	558000	540000	532000
	587500	589570	591000	596600	608000	621500	635500	656500

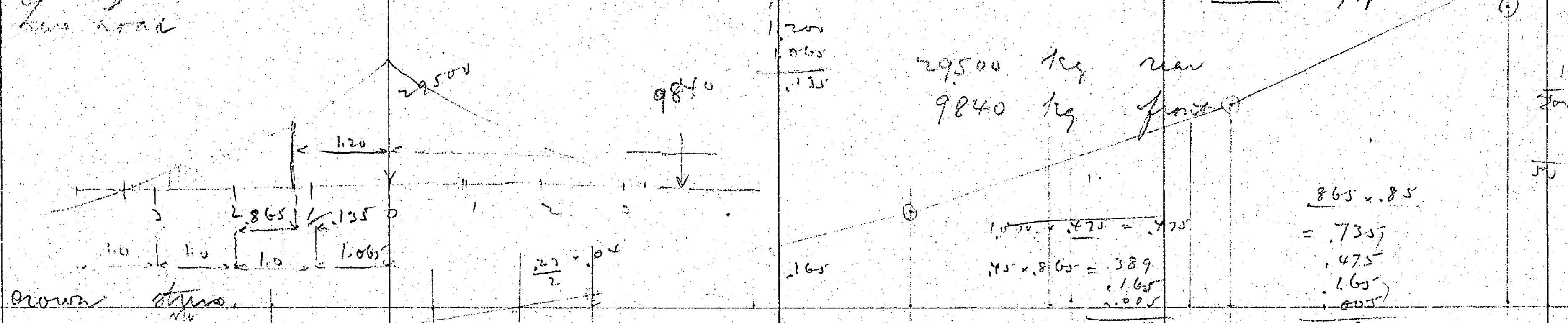
Eccentricity

	0	2	4	6	8	10	12	sp
Moment	−1.260 t-m	−2.264	+8.906	+3.828	+3.109	−978	+2430	−9.710
Ecc	−.00214	−0.00385	.01.51	.0064	.0052	.0016	0.0038	.0148

Live Load

Uniform load 500 × 11.0 = 5500 kg. per meter

29500 kg rear
9840 kg front



865 × .85 = .7355
.475
.165
.005
1,380

1.0 × .475 = .475
.45 × .865 = .389
.165
.005
area = .559

Crown stress

rear $\frac{1.115}{1.1155}$ × 29500 = + ~~41100~~ 32,900
front 0.04 9840 − 400
32,500

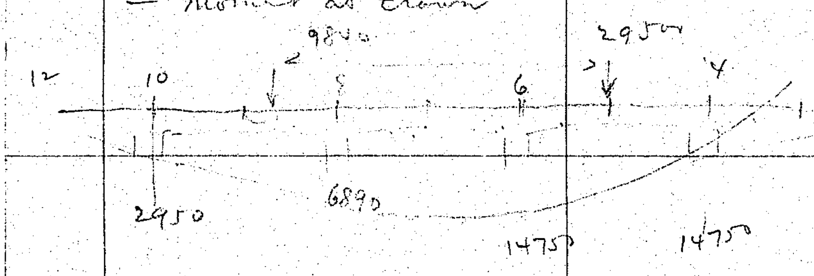
Uniform load. $\frac{.559}{1.380}$ × 5500 = 3080
~~40,080~~ 35,580

+ Moment.

crown thrust. say
29,500 × 3.0 = 90,000 kg

360
3.065
.535

− Moment at crown



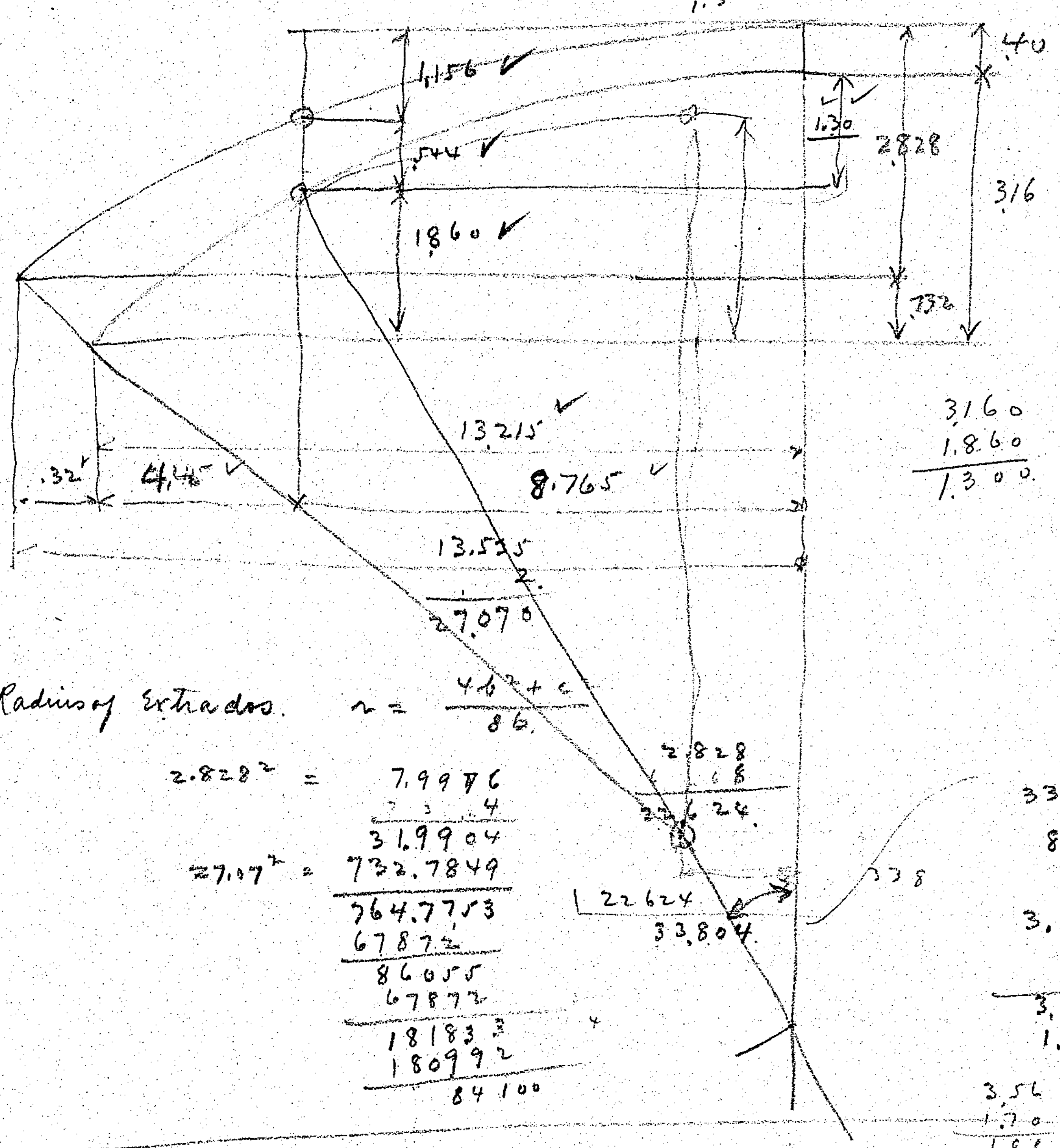
9840
2950
6890

(4) − .1232 × 14750 = 1820
(6) − .2525 × 14750 = 3720
(8) − .2084 × 6890 = 1440
10 − .1036 × 2950 = 306
86

no 3

33.56

1.156
544
1.700
1.300



3.56
732
2.828

01.9765

3160
1.860
1.300

9.765
3.45
13.215
32
13.535

8.765
4.45
13.215

Radius of Extrados $r = \frac{4b^2+c}{8b}$

$2.828^2 =$ 7.9976
3.14
31.9904
$27.07^2 =$ 732.7849
764.7753
67872
86055
67872
181833
180992
84100

$y = r - \sqrt{r^2 - x^2}$

33.804
33.56
.244

33.804^2 = 1142.7104
8.765^2 = − 76.8252
1065.8852

3.02770831
326
20
3.02771187
1.5138559 − 33804
32.648
1.156
544
1.700

3.56
1.70
1.86

Radius intrados

$c = \frac{8.765 \times 2}{17.530}$ $b =$ 1.30
8
10.4

25.00
3.16
28.16

30.198
2816
2.038

$1.30^2 =$ 1.6900
4
6.7600
$17.53^2 =$ 307.3009
314.0609
312
206
104
1020
936
849

10.4) r= 30.198 − 30.2 $c_1 =$ 17.53 b = 1.30

33.56
30.12
3.44

$\theta_1 = \sin^{-1}\frac{x}{r} = \frac{8.765}{30.198}$ 0.9427519
− 1.4799782
9.4627737
.4626158
01579 × 60
4165
− 16°−52′−23″

$\frac{\theta_2}{2} = \phi - \theta_1 =$ 22°− 41′− 02
16− 52− 23
5°− 48′− 39″

$\sin\frac{\theta_2}{2}$ = 9.0045634
8100
9.0053734

$\phi = \tan^{-1}\frac{1.860}{4.450}$ − 0.2695129
0.6483600
9.6211529
9.6210423
1106 × 60 =
3550
22°−41′−02″

$\sin\phi$ = 9.5861795
90
9.5861885

$c_2 = \frac{1.860}{\sin\phi}$ = 0.2695129
9.5861885
0.6833244 − 4.823
30103
0.3822944

$R = \frac{c_2/2}{\sin\frac{\theta_2}{2}}$ = 0.3822944
9.0053734
1.3769210 − 23.819

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CALCULATIONS FOR 4

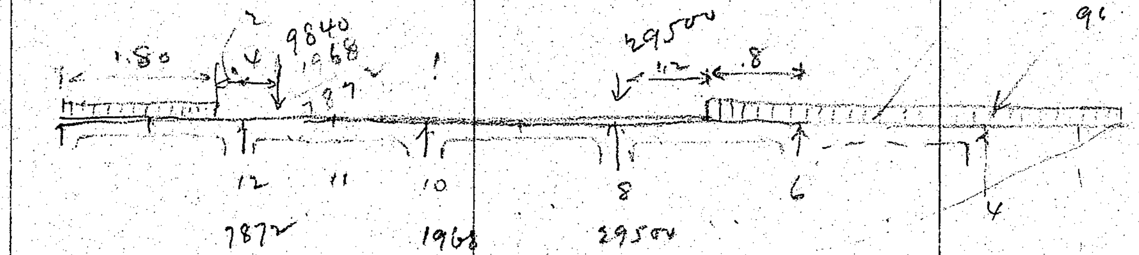
Shimokin Bashi

.400 / .0485 / .4438 × 8.5 = 3.770   8.5 × 4.0   (14)

	moment	thrust	Ecc
crown 4.260 DL. / + 29.000 LL. / + 35.670 / + 23500 / 83910	− 1.260 / + 35.580 / + 27.600 / + 18100 / 80.020	587500 / 90500	156000 @ .92 = 144000 / 21500 / 177500 / − 12000 / 165500 ÷ 252 / 65.5%
Stat % 380 × 1.00 / 36	= 14.6 / 2 / 29.2 / .400 × 1.00 = 0.73%	80020	Ecc = .123 / .400 = .307

80020 / .114 × 8.5 × .402 = 51.5 kg/cm² 54.2 (56.3)

springing − moment.



1660 1.3987 | 11.091 2.4659 | 2.6546 | 15405 2.0043 | .9050 .8125 .1300

9900 × .9 / 2.0 = 4450 / 5450

4400 × .40 / 2.00 = 88 / 880 / 3520

5450 4450 3520 880 3520 / 5500 / 9020 5500

motor truck

1.3987	× 7872	=	11,000
2.4659	× 1968	=	4,850
2.6546	× 29500	=	78,200
2.0043			94050

94050 / 44270 / 138320

Unif. 0. 1.3987	@ 4450	=	6210
2.4659	@ 3520	=	8680
2.6546	@ 880	=	2330
2.0043	9020	=	18100
? .8125	11000	=	8950
			44270

Stat % 0.73

		moment	thrust	Ecc.
+ 4.549	DL.	− 9.710	587500	146000
− 111.000	LL.	− 138.320	50	258 / 655
− 158.000	Imp.	− 118.400	637500	Ecc = .54 / .80 = .675
104.000 / 369.000	Rib.	78.000 / 344430		.45 / 80.0 = .0562

Reinf. 344430.000 / .116 × 8.5 × .80² = 54.5 kg/cm²

k' = .435   k' .435   k₂

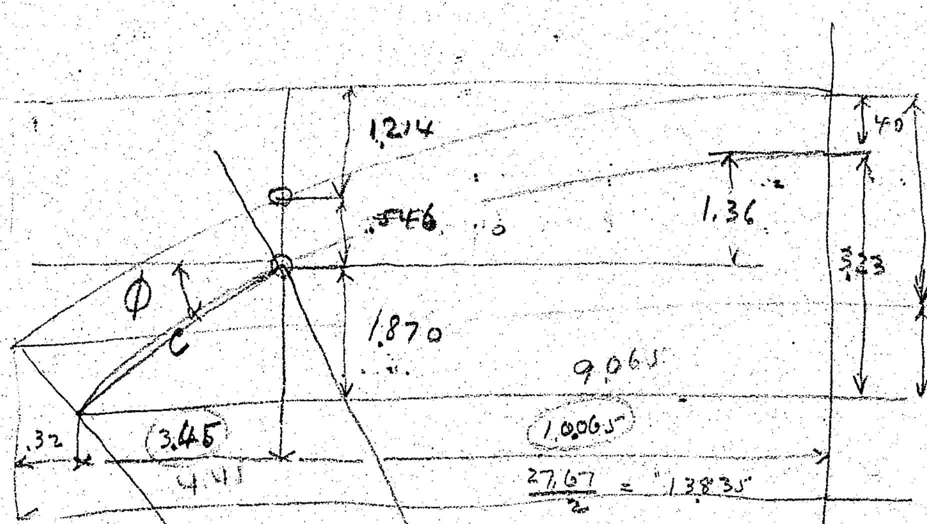
− .021 / .414   k" .360 / .075 × 5 × 0.056 = .021   0.0715 × 0.73 = 0.052 / 0.075 / 0.127

$f_c = \frac{344430.}{.127 \times 8.5 \times .80^2} = 50 \text{ kg/cm}^2$ 53.5

0.42 / .75 / .117

Span No. 4

$y = r - \sqrt{r^2 - x^2}$



$\frac{3.230 + .400 = 3.630 - .732}{2.898} = b$

$\frac{27.35 + .32}{27.67} = c$

Radius of Extrados $r = \dfrac{4b^2 + c^2}{8b}$

$b^2 = 8.3984 \times 4 = 33.5936$

$c^2 = 765.6289$

799.2225 ÷ 23.184 = 34.473

$2.898 \times 8 = 23.184$

$r = 34.473^2 = 1188.387729$

$x^2 = 10.065^2 = \cancel{101.304225}$

$\cancel{1087.083504}$ — 34.473 − 33.259 = 1.214

1188.3877 − 82.1742 = 1106.2135 — 3.0438337 ... 3.0438389 1.5219194 — 33.259

Intrados. $\frac{9.065}{2}$ $c_1 = 18.130$ $b = 1.36$

$1.36^2 = 1.8496 \times 4 = 7.3984$

$18.13^2 = 328.6969$

336.0953

(30.891)

$r = 30.891$ $c_1 = 18.13$ $b = 1.36$

$\theta_1 = \sin^{-1}\dfrac{x}{R} = \dfrac{9.065}{30.891}$ — 0.9573678 − 1.4898320 = 9.4675358 — 17°−03′−53″

$\phi = \tan^{-1}\dfrac{1.870}{4.450}$ — 0.2718416 − 0.6483600 = 9.6234816 — 22−47−36″

$\dfrac{\theta_2}{2} = \phi - \theta_1 = 22-47-36 - 17-03-53 = 5-43-43$

$\sin\dfrac{\theta_2}{2} = 8.9982994 + 9030 = 8.9992024$

$\sin\phi = 9.5879885 + 1850 = 9.5881735$

$c_2 = \dfrac{1.870}{\sin\phi}$ = 0.2718416 − 9.5881735 = 0.6836681 — 4.826 —

0.3826381

$R_2 = \dfrac{c/2}{\sin\frac{\theta_2}{2}}$ = 0.3826381 − 8.9992024 = 1.3834357 — 24.179

1.214 + .54 = 1.754; 3.630 − 1.754 = 1.876

3.23 − 1.87 = 1.36

34.473 − 31.13 = 3.343

13.675 − 10.065 = 3.61 − .16 = 3.45

1.502 + .585 = 2.087; 1.502 + .590 = 2.092

3.63 − 2.087 = 1.543; 3.63 − 2.092 = 1.538

3.23 − 1.538 = 1.692

1.600 − 1.302 = .298

1.36 × 8 = 10.88

31.13 − .40 = 30.73

30.891 − 30.73 = .161

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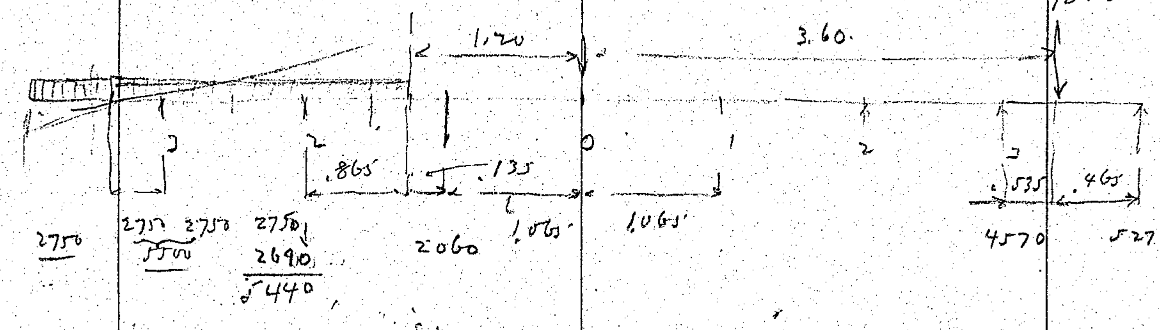
Shimo ku -

Crown ~~Stres~~ + moment.



3.600
3.065
.535

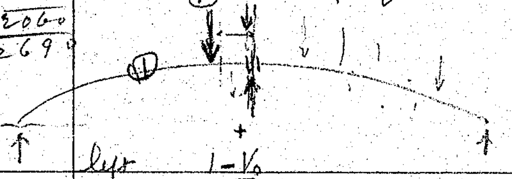
9840
5270
4570

4750
2060
2690

V₀ from right.

1−V₀ section to crown

① −V₀ left of section.



left
right.

motor truck loading

Point	load	Unit M.	M.	H unit.	H.	Shear unit.	shear
4R	5270	−.1232	−650	1.847	9740	+.2385 ✓	+1250
3R	4570	+.0447	+200	2.078	9500	+.2975 ✓	+1360
2R	0						
1R	0						
0	29500	+1.1155	+32900	2.411	71300	±.5000	+14750
			+32450 −		90340		17360

} +2610 downward.

14750 − ~~14750~~ =

+2610

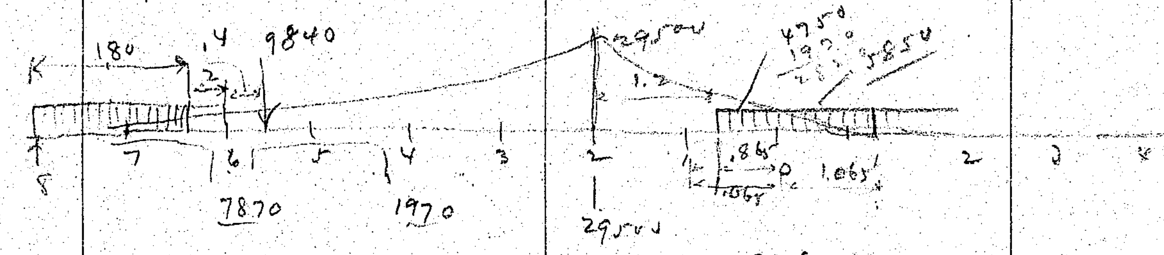
Uniform load M unit load.

Point	load	+.1—	moment.	H.	H thrust	shear unit load	shear
1L	2060	+.6460	1330	2.365	4870	.5730	−1180
2L	5440	+.2980	1620	2.254	12250	.6391	−3480
3L	5500	+.0447	246	2.087	11500	.7025	−3860
			+3196		28620		−8520 upward.

Summary for moment + thrust.

	moment.	Hor. thrust	vert. shear	
motor truck	32.450	90340	17360	+2610
Unif. load.	3196	28620	−8520	−8520
	35646	118960	+8840	−5910

At panel Point. 2 + moment,



1930 2925 2820 5745 2925

9840
1970
7870

40

Unif load. 5500 × 1.8 = 9900 ✓
4460
5440

motor truck loading

Point	load	Unit M	M	H unit	H. thrust	Shear unit load	Shear
2L	29500	1.1785	34700	2.254	66500	1 − 0.3609 (.6391)	18800
4L	1970	.4801	945	1.849	3640	− 0.2385	− 470 ~~4700~~
6L	8870	.1118	990	1.292	11460	− 0.1389	− 1230
			36635		81600		17100

18800
1700
17100

Uniform live load

	load	M unit load	M	H unit.	H thrust	Shear unit load	shear
1R	2925	−.0938	− 274	2.365	6910	+.4270	1250
0	5745	+.2277	+ 1305	2.411	13800	+.5000	2372
1L	1930	+.6697	+ 1290	2.365	4560	+.5730	1110
6L	4460	+.1118	+ 500	1.292	5760	−.1389	− 618
8L	5440	−.0263	− 143	0.734	4000	−.0669	− 363
			3095 / 417 / + 2678		35030		+ 3751

4732
981
3751
440
5040
4810
9850

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CALCULATIONS FOR

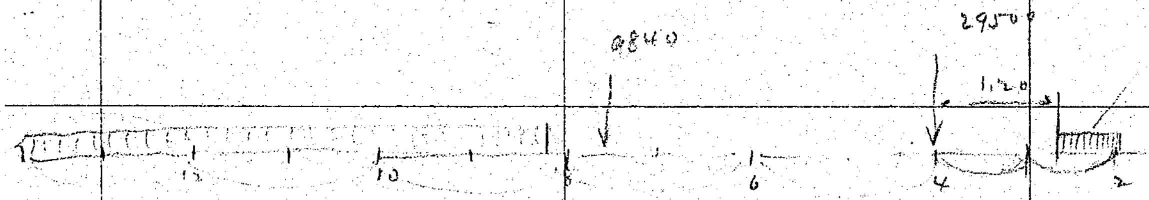
Shinobu Bashi.

Summary for + moment + thrust

		moment.	H. thrust.	vert. shear
motor truck	+	36635	81600	17100
unif. load.	+	2678	35030	3251
		39313	116630	20851
			crown	

normal thrust.
116630 × .999 = 116500
20851 × .070 = 1460
117960 – kg. at. (2)

at panel Point (4) + moment.



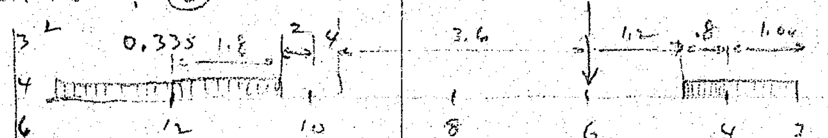
7870 1970 29500

5500 + 5500 = 11000   5440 + 5500 = 10940   4460 + ~~4450~~ = 12330   1970   29500 1760 2640

Point.	load.	M.I	moment.	Ho.	Hor. thrust.	shear unit load.	vert. shear
2 L	3640	.3511	925	2.254	5950	.6396	+ 1690
3	1760	.7943	1400	2.087	3680	.7025	+ 1235
4	29500	1.3265	39100	1.847	54500	.7615	+ 22450
6	1970	.6480	1276	1.292	2540	– .1389	– 2740
8	12330	.2543	3140	0.734	9050	– .0669	– 825
10	10940	.0714	780	0.301	3300	– .0238	– 260
12	11000	.0094	104	0.058	640	– .0041	– 45
			46725		79660		+ 25375
							– 3870
							21505

normal thrust. 79660 × 0.990 = 78800
21505 × 0.125 = 2690
81490

Panel Point, (6)



4400 − 880 = 3520   4400 ÷ 2 = 880

5440 + 5500 = 10940   7840 + 4460 = 12300   1970   1970   29500 + 880 = 30380   2750 + 3520 = 6270   2750   2750

		load	moment.	Ho. unit load	H thrust.	V unit load.	V. shear
3	.0335	× 2750	92	2.087	5740	+ .7025	1930
4	.3761	× 6270	2360	1.847	11580	+ .7615	4780
6	1.3263	× 30380	40200	1.292	39200	+ .8611	26150
8	.6157	1970	1214	0.734	1445	– .0669	– 132
10	.2123	× 12300	2610	0.301	3700	– .0238	– 293
12	.0356	× 10940	390	0.058	635	– .0041	– 45
			46866		62300		32860
							+ 460
							32400

normal thrust
62300 × .98 = 61100
32400 × .185 = 6000
67100

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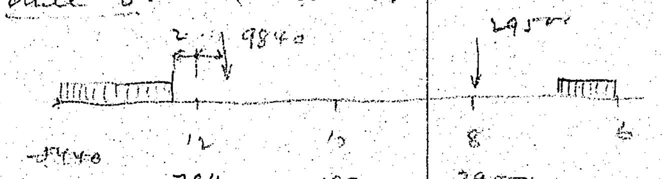
CALCULATIONS FOR

Shinobu Bashi.

a^2 $a \times a$ $2 \log a$ $a \times b = ab$ $\log a + \log b = \log(ab)$

Panel 8. + mom.



12	10	8	6
7840	1970	29500	
4460		880	3520
12300	1970	30380	3520

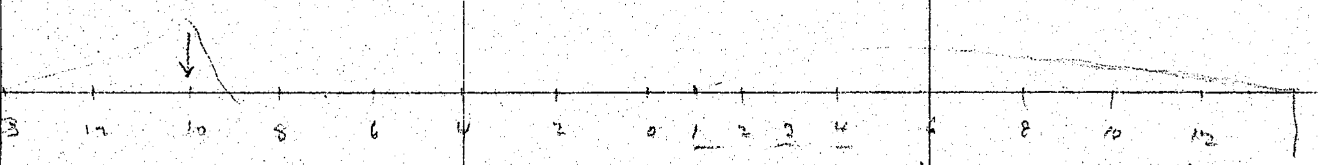
-5440

Panel	load	M.	Mom.	H.	H. thrust	shear inf. load	shear
6^L	3520	.1791	630	1.292	4550	+ .8611	+ 3030
8^L	30380	1.0761	32600	.734	22300	+ .9311	+ 28300
10^L	1970	.3938	775	.301	592	− .0238	− 47
12^L	12300	.0696	855	.058	714	− .0041	− 50
10	11000	.0100	110	.301	3320	+ .0238	+ 262
12	11000	.0034	37	.058	640	+ .0041	+ 45
			35007		32116		31540

32116 × .97 = 31100
31540 × .25 = 7870
38970

31330
307
31637
97
31540

Panel 10, + mom.



12 10 8 6 4 2 0 1 2 3 4 6 8 10 12

29500

5500 5500 5500 5500 11000 11000 11000 11000

2750
8250

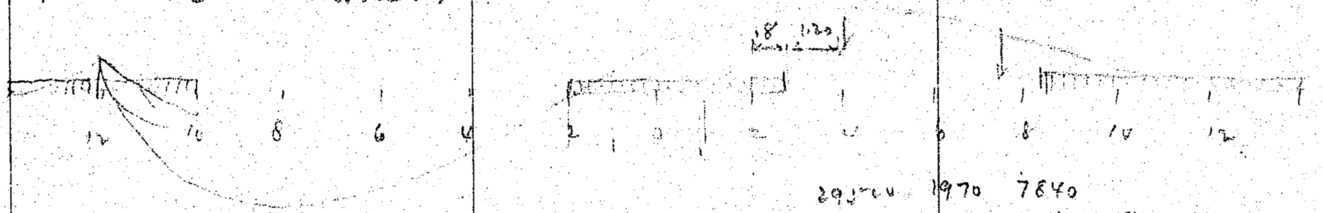
load.

Pan.	load		Mom.	H.	Thrust	Inf. shear	shear
12^R	11000	.0291	320	0.058	638	.0041	45
10	11000	.1385	1525	0.301	3310	.0238	262
8	11000	.2926	3220	0.734	8070	.0669	735
6	11000	.4167	4580	1.292	14210	.1389	1527
4	8250	.4315	3560	1.847	15210	.2385	1970
3	5500	.3752	2060	2.087	11500	.2975	1630
2	5500	.2719	1495	2.254	12400	.3609	1985
1^R	5500	.1222	672	2.365	13000	.4270	2350
10^L	29500	.6175	18200	0.301	8880	.9762	28800
			35632		87218		39304

87218 × .95 = 82700
39304 × .325 = 12750
95450

9840
4300
5540

Panel 12 + mom.



12 10 8 6 4 2 0 2 4 6 8 10 12

29500 1970 7840
4460 − 5440
5500
10940 11000

.08
.92

5050
2320
2730

4321 ×
94
137214
358
136856

3609
3065
544

1.065
525
52

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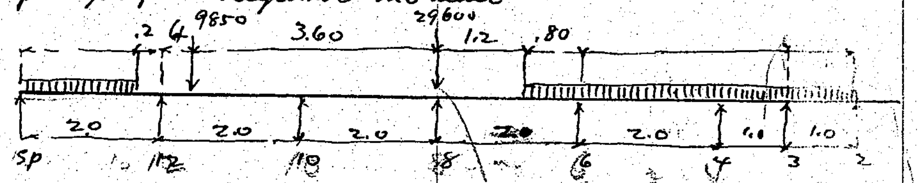
CALCULATIONS FOR

Shinobu- Bashi for Fukushima- Ken

Panel Point 12 negative moment

Point	load	M unit load	moment	H unit load	Hor. thrust	V unit load	Ver. shear	normal thrust
2	5910	+.0622	+367	2.312	13650	.6206	3670	76940 × .925 = 71000
3	3940	−.3906	−1540	2.142	8450	.6886	2710	51450 × .385 = 19800
4 6	30480	−1.4538	−44300	1.351	44300	.8536	26000	90800
6 8	9020	−1.6052	−14480	.775	7000	.9286	8370	
8 10	11000	−1.0694	−11790	.322	3540	.9742	10700	
10			−71743		76940		51450	

Springing negative moment



7880	1970	29600	3520	5500	2750
4460		880	5540	2750	1300
12340	1970	30480	9020	8250	neglected

Void

Point	load	M unit load	moment	H unit load	Hor. thrust	V unit load	Vert. shear	normal thrust
4	8250	−.6323	−5220	1.914	15800	.7498	6200	52978 × .900 = 47600
6	9020	−1.8500	−16700	1.351	12200	.8536	7700	56420 × .425 = 24000
8	30480	−2.5401	−77500	.775	23600	.9286	28300	
10	1970	−2.4046	−4730	.322	635	.9742	1920	71600
12	12340	−1.3881	−17100	.062	743	.9956	12300	
			−121250		52978		56420	

Temperature stresses

Crown section $H_0 = \dfrac{E\omega t l \int \frac{ds}{I}}{2\left[\int \frac{ds}{I} \int \frac{y^2 ds}{I} - \left(\int \frac{y\,ds}{I}\right)^2\right]} = \dfrac{G}{B}$ where $E = 1400.000.000$ kg/m²

Exp. coef $\omega = 0.000012$ for 1°C

variation of temperature ± 15°C

l = span length 26.75 meters

$E\omega t$ = 252000 kg.

For fall of 15° in temperature

$H_0 = -\dfrac{252000 \times 26.75 \times 127908}{1385939} = -6210$ $\quad -6210 \times 8.5 = -52800$ kg.

$M_0 = +52800 \times \dfrac{705.47}{1279.08} = +29100$ kgm.

Temperature stress at other panel points

Point					normal thrust
2	M = 29100 − 52800 × .048	= +26560	52800 × .999	=	52800
4	29100 − 52800 × .225	= +17200	× .992	=	52500
6	29100 − 52800 × .525	= +1400	× .985	=	52000
8	29100 − 52800 × .955	= −21400	× .975	=	51500
10	29100 − 52800 × 1.530	= −51800	× .950	=	50200
12	29100 − 52800 × 2.270	= −90900	× .925	=	48900
Sp.	29100 − 52800 × 2.994	= −128900	× .900	=	47500

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CALCULATIONS FOR (1)

$\begin{array}{r} 10.665 \\ .61 \\ \hline 11.275 \end{array}$

Shimoka Bashi   Span no. 1.   (1)

	x	y	d	ds
0	0	0	.400	.165
1	.665	0.010	.401	1.000
2	1.665	0.055	.408	1.002
3	2.665	0.130	.41~~0~~4	1.004
4	3.665	0.250	.430	1.011
5	4.665	0.400	.448	1.014
6	5.665	0.590	.475	1.020
7	6.665	0.820	.500	1.033
8	7.665	1.090	.538	1.041
9	8.665	1.415	.590	1.055
10	9.665	1.780	.662	1.077
11	10.665	2.200	.745	.890
sp	11.275	2.484	.800	.340

1 meter wide I_s.

Division	Depth d	d^3	$I_c=\frac{1}{12}d^3$	$(\frac{d}{2}-0.045)^2$	@ .00438 ($.00438\times2$)	I_c+I_s	Equivalent area	concrete area
0 crown	.400	.0640	.00533	.0240	.00105	.00638	0.0438	.400
1	.401	.0645	.00537	.0242	.00106	.00643	"	.401
2	.408	.0679	.00566	.0253	.00111	.00677	"	.408
3	.41~~0~~	.0710	.00592	.0263	.00115	.00707	"	.41~~0~~
4	.430	.0795	.00662	.0289	.00127	.00789	"	.430
5	.448	.0899	.00749	.0320	.00140	.00889	"	.448
6	.475	.1072	.00893	.0371	.00162	.01055	"	.475
7	.500	.1250	.01042	.0420	.00184	.01226	"	.500
8	.538	.1557	.01297	.0502	.00440	.01737	0.0876	.538
9	.590	.2054	.01712	.0625	.00548	.02260	"	.590
10	.662	.2901	.02417	.0818	.00717	.03134	"	.662
11	.745	.4135	.03446	.1073	.00940	.04386	"	.745
sp.	.800	.5120	.04267	.1260	.01104	.05371	"	.800

	x	x^2	y	y^2	ds	I	ds/I	$x\frac{ds}{I}$	$x^2\frac{ds}{I}$	$y\frac{ds}{I}$	$y^2\frac{ds}{I}$
0	0	0	0	0	.165	.00638	25.86	0	0	0	0
1	.665	0.442	0.010	0.0001	1.000	.00643	155.52	103.42	68.74	1.56	0.01
2	1.665	2.772	0.055	0.003	1.002	.00677	148.01	246.44	410.28	8.14	0.44
3	2.665	7.102	0.130	0.017	1.004	.00707	142.01	378.46	1008.56	18.46	2.41
4	3.665	13.432	0.250	0.063	1.011	.00789	128.14	469.63	1721.18	32.04	8.07
5	4.665	21.762	0.400	0.160	1.014	.00889	114.06	532.09	2482.17	45.62	18.25
6	5.665	32.092	0.590	0.348	1.020	.01055	96.68	547.69	3102.65	57.04	33.64
7	6.665	44.422	0.820	0.672	1.033	.01226	84.26	561.59	3743.00	69.09	56.62
8	7.665	58.752	1.090	1.188	1.041	.01737	59.93	459.36	3521.01	65.32	71.20
9	8.665	75.082	1.415	2.002	1.055	.02260	46.68	404.48	3504.83	66.05	93.45
10	9.665	93.412	1.780	3.168	1.077	.03134	34.37	332.19	3210.57	61.18	108.88
11	10.665	113.742	2.200	4.840	.890	.04386	20.29	216.39	2307.83	44.64	98.20
sp.	11.275	127.126	2.484	6.170	.340	.05371	6.33	71.37	804.71	15.72	39.06
					11.652		1062.17	4323.11	25885.53	484.86	530.23

Shinobu-Bashi Span no. 1

Division	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ①	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ②	$my\frac{ds}{I}$
0	0	0	0	0	0	0							
1	.665	–	103.42	68.74	1.04	0	0	0	0				
2	1.665	–	246.44	410.28	13.55	1.0	148.01	246.44	8.14	0	0	0	0
3	2.665	–	378.46	1008.56	49.20	2.0	284.02	756.92	36.92	1.0	142.01	378.46	18.46
4	3.665	–	469.63	1721.18	117.43	3.0	384.42	1408.89	96.12	2.0	256.28	939.26	64.08
5	4.665	–	532.09	2482.17	212.82	4.0	456.24	2128.36	182.48	3.0	342.18	1596.27	136.86
6	5.665	–	547.69	3102.65	323.13	5.0	483.40	2738.45	285.20	4.0	386.72	2190.76	228.16
7	6.665	–	561.59	3743.00	460.48	6.0	505.56	3369.54	414.54	5.0	421.30	2807.95	345.45
8	7.665	–	459.36	3521.01	500.68	7.0	419.51	3215.52	457.24	6.0	359.58	2756.16	391.92
9	8.665	–	404.48	3504.83	572.32	8.0	373.44	3235.84	528.40	7.0	326.76	2831.36	462.35
10	9.665	–	332.19	3210.57	591.30	9.0	309.33	2989.71	550.62	8.0	274.96	2657.52	489.44
11	10.665	–	216.39	2307.83	476.09	10.0	202.90	2163.90	446.40	9.0	182.61	1947.51	401.76
sp.	11.275	–	71.37	804.71	177.24	10.61	67.16	757.24	166.79	9.61	60.83	685.87	151.07
			4323.11	25885.53	3495.28		3633.99	23010.81	3172.85		2753.23	18791.12	2689.55

Division	x	m	$m\frac{ds}{I}$ ③	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ④	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ⑤	$my\frac{ds}{I}$
0													
1													
2													
3		0	0	0	0								
4		1.0	128.14	469.63	32.04	0	0	0	0				
5		2.0	228.12	1064.18	91.24	1.0	114.06	532.09	45.62	0	0	0	0
6		3.0	290.04	1643.07	171.12	2.0	193.36	1095.38	114.08	1.0	96.68	547.69	57.04
7		4.0	337.04	2246.36	276.36	3.0	252.78	1684.77	207.27	2.0	168.52	1123.18	138.18
8		5.0	299.65	2296.80	326.60	4.0	239.72	1837.44	261.28	3.0	179.79	1378.08	195.96
9		6.0	280.08	2426.88	396.30	5.0	233.40	2022.40	330.25	4.0	186.72	1617.92	264.20
10		7.0	240.59	2325.33	428.26	6.0	206.22	1993.14	367.08	5.0	171.85	1660.95	305.90
11		8.0	162.32	1731.12	357.12	7.0	142.03	1514.73	312.48	6.0	121.74	1298.34	267.84
sp		8.61	54.50	614.50	135.35	7.61	48.17	543.13	119.63	6.61	41.84	471.76	103.91
			2,020.48	14,817.87	2,214.39		1,429.74	11,223.08	1,757.69		967.14	8,097.92	1,333.03

Division	x	m	$m\frac{ds}{I}$ ⑥	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ⑦	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ⑧	$my\frac{ds}{I}$
0													
1													
2													
3													
4													
5													
6		0	0	0	0								
7		1.0	84.26	561.59	69.09	0	0	0	0				
8		2.0	119.86	918.72	130.64	1.0	59.93	459.36	65.32	0	0	0	0
9		3.0	140.04	1213.44	198.15	2.0	93.36	808.96	132.10	1.0	46.68	404.48	66.05
10		4.0	137.48	1328.76	244.72	3.0	103.11	996.57	183.54	2.0	68.74	664.38	122.36
11		5.0	101.45	1081.95	223.20	4.0	81.16	865.56	178.56	3.0	60.87	649.17	133.92
sp		5.61	35.51	400.39	88.19	4.61	29.18	329.02	72.47	3.61	22.85	257.65	56.75
			618.60	5,504.85	953.99		366.74	3,459.47	631.99		199.14	1,975.68	379.08

(1)

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CALCULATIONS FOR

Shinobu-Bashi   Span no. 1

③

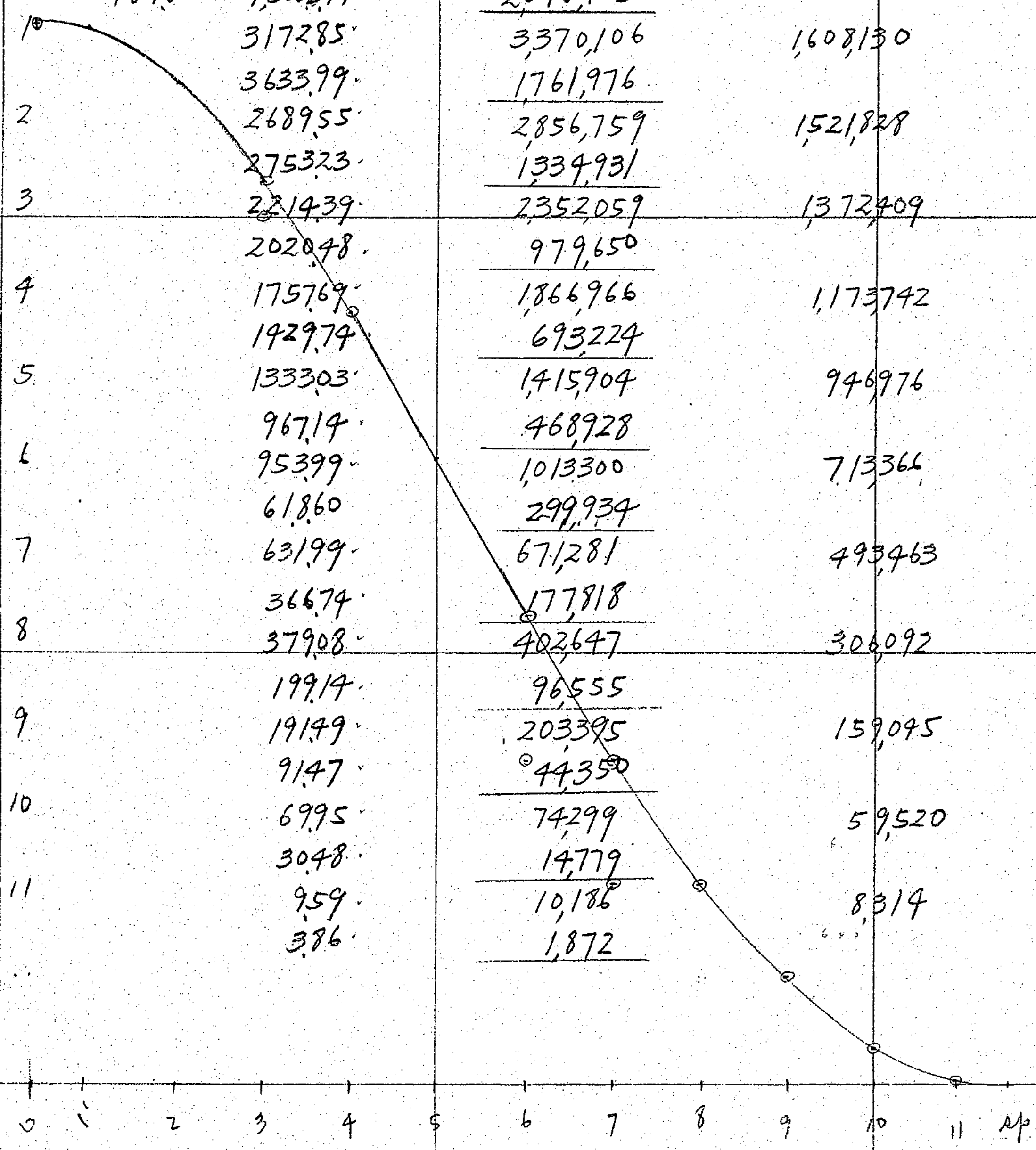
Division x	m	$m\frac{ds}{I}$ ⑨	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$ ⑩	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$ ⑪	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0												
1												
2												
3												
4												
5												
6												
7												
8												
9	0	0	0	0								
10	1.0	34.37	332.19	61.18	0	0	0	0				
11	2.0	40.58	432.78	89.28	1.0	20.29	216.39	44.64	0	0	0	0
sp	2.61	16.52	186.28	41.03	1.61	10.19	114.91	25.31	0.61	3.86	43.54	9.59
		91.47	951.25	191.49		30.48	331.30	69.95		3.86	43.54	9.59

$$H_0 = \frac{\int\frac{ds}{I}\int my\frac{ds}{I} - \int m\frac{ds}{I}\int y\frac{ds}{I}}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = \frac{A}{B}$$

$B = 2\left[106217 \times 53023 - 48486^2\right] = 656210.~~3590~~$

563194.3991
2350892196
3281051795
2
656,2103590

			A	$\frac{A}{B} = H_0$	
0	106217 × 3495.28	3,712,582	1,616,479	2.462	0
	48486 × 4323.11	2,096,103			
1	3172.85	3,370,106	1,608,130	2.450	
	3633.99	1,761,976			
2	2689.55	2,856,759	1,521,828	2.318	2
	2753.23	1,334,931			
3	2214.39	2,352,059	1,372,409	2.091	
	2020.48	979,650			
4	1757.69	1,866,966	1,173,742	1.788	4
	1429.74	693,224			
5	1333.03	1,415,904	946,976	1.442	
	967.14	468,928			
6	953.99	1,013,300	713,366	1.086	6
	618.60	299,934			
7	631.99	671,281	493,463	.752	
	366.74	177,818			
8	379.08	402,647	306,092	.466	8
	199.14	96,555			
9	191.49	203,395	159,045	.242	
	91.47	44,350			
10	69.95	74,299	59,520	.091	10
	30.48	14,779			
11	9.59	10,186	8,314	.013	
	3.86	1,872			



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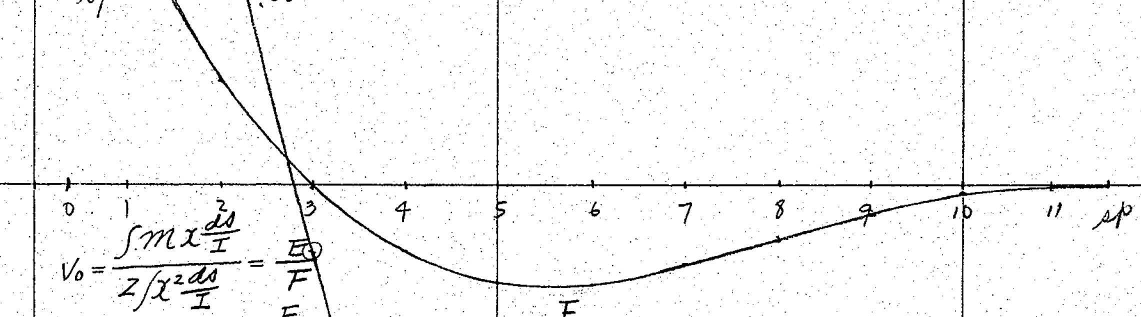
CALCULATIONS FOR (1)

Shinobu-Bashi Span no. 1 ④

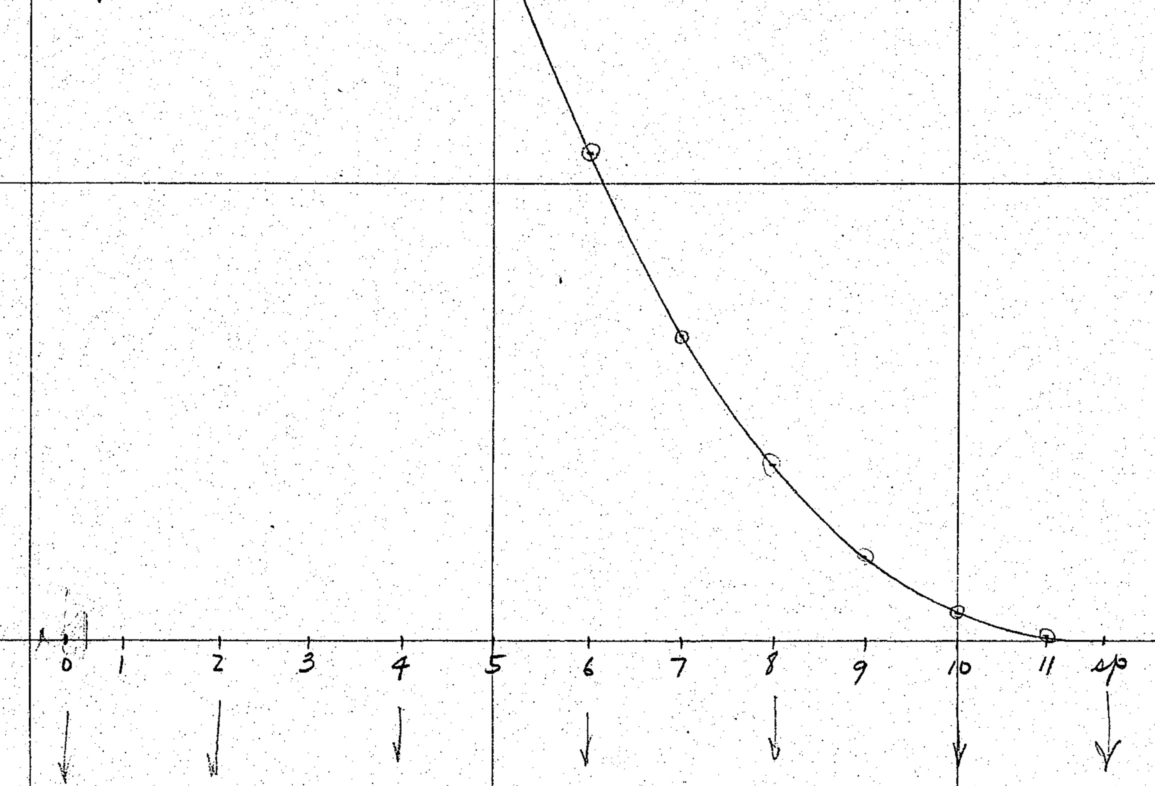
$$M_0 = \frac{-H_0 2\int y \frac{ds}{I} + \int m \frac{ds}{I}}{2\int \frac{ds}{I}} = \frac{C}{D}$$

	$-2H_0\int y\frac{ds}{I}$					C	$2\int\frac{ds}{I}$ / D	
Crown 0	2 × 2.462 × 484.86	= − 2,387.45	+	4,323.11	=	+ 1,935.66	÷ 2,124.34	= + 0.9112
1	2 × 2.450 ,	− 2,375.81	+	3,633.99		+ 1,258.18		= + .5923
2	2 × 2.318 ,	− 2,247.81	+	2,753.23		+ 505.42		+ .2379
3	2 × 2.091 ,	− 2,027.68	+	2,020.48		− 7.20		− .0034
4	2 × 1.788 ,	− 1,733.86	+	1,429.74		− 304.12		− .1432
5	2 × 1.442 ,	− 1,398.34	+	967.14		− 431.20		− .2030
6	2 × 1.086 ,	− 1,053.12	+	618.60		− 434.52		− .2045
7	2 × .752 ,	− 729.23	+	366.74		− 362.49		− .1706
8	2 × .466 ,	− 451.89	+	199.14		− 252.75		− .1190
9	2 × .242 ,	− 234.67	+	91.47		− 143.20		− .0674
10	2 × .091 ,	− 88.24	+	30.48		− 57.76		− .0272
11	2 × .013 ,	− 12.61	+	3.86		− 8.75		− .0041
sp	.000 ,							.0000



$$V_0 = \frac{\int m x \frac{ds}{I}}{2\int x^2 \frac{ds}{I}} = \frac{E}{F}$$

	E		F		
Crown 0	25,885.53	÷	51,771.06	=	.5000
1	23,010.81			=	.4445
2	18,791.12				.3630
3	14,817.87				.2862
4	11,223.08				.2168
5	8,097.92				.1564
6	5,504.85				.1063
7	3,459.47				.0668
8	1,975.68				.0382
9	951.25				.0184
10	331.30				.0064
11	43.54				.0008
sp	0				0



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CALCULATIONS FOR 1

Shinobu-Bashi Span no.1 ⑤

d' clear arm of unit load about center of section origin at crown

left hand $M_L = M_0 + H_0 y + V_0 x - d'$

$M_R = M_0 + H_0 y - V_0 x$

Point (sp)

$x = 11.275$ $y = 2.484$

	M_0	H_0y	V_0x	d'	M_L	M_R
0	+0.9112	6.1156	5.6375	11.275		
1	+.5923	6.0858	5.0117	10.610		
2	+.2379	5.7579	4.0928	9.610		
3	-.0034	5.1940	3.2269	8.610		
4	-.1432	4.4414	2.4494	7.610		
5	-.2030	3.5819	1.7634	6.610		
6	-.2045	2.6976	1.1985	5.610		
7	-.1706	1.8680	.7532	4.610		
8	-.1190	1.1575	.4307	3.610		
9	-.0674	.6011	.2075	2.610		
10	-.0272	.2260	.0722	1.610		
11	-.0041	.0323	.0090	.610		
sp	-.0000	0	0			

Point ⑩

$x = 9.665$ $y = 1.780$

	H_0y	V_0x	d'	M_L	M_R
0	4.3824	4.8325	9.665		
1	4.3610	4.2961	9.000		
2	4.1260	3.5084	8.0		
3	3.7220	2.7661	7.0		
4	3.1826	2.0954	6.0		
5	2.5668	1.5116	5.0		
6	1.9331	1.0274	4.0		
7	1.3386	.6456	3.0		
8	.8290	.3692	2.0		
9	.4308	.1778	1.0		
10	.1620	.0619	0		
11	.0231	.0077			
sp	0	0			

Point ⑧

$x = 7.665$ $y = 1.090$

	M_0	H_0y	V_0x	d'	M_L	M_R
0	-	2.6836	3.8325	7.665		
1	-	2.6705	3.4071	7.0		
2	-	2.5266	2.7824	6.0		
3	-	2.2792	2.1937	5.0		
4	-	1.9489	1.6618	4.0		
5	-	1.5718	1.1988	3.0		
6	-	1.1837	.8148	2.0		
7	-	.8197	.5120	1.0		
8	-	.5079	.2928	0		
9	-	.2638	.1410			
10	-	.0992	.0491			
11	-	.0142	.0061			
sp	-	0	0			

Point ⑥

$x = 5.665$ $y = 0.590$

	H_0y	V_0x	d'	M_L	M_R
0	1.4526	2.8325	5.665		
1	1.4455	2.5181	5.0		
2	1.3676	2.0564	4.0		
3	1.2337	1.6213	3.0		
4	1.0549	1.2282	2.0		
5	.8508	.8860	1.0		
6	.6407	.6022	0		
7	.4437	.3784			
8	.2749	.2164			
9	.1428	.1092			
10	.0537	.0363			
11	.0077	.0045			
sp	0	0			

Point ④

$x = 3.665$ $y = 0.250$

	M_0	H_0y	V_0x	d'	M_L	M_R
0	-	.6155	1.8325	3.665		
1	-	.6125	1.6291	3.0		
2	-	.5795	1.3304	2.0		
3	-	.5228	1.0489	1.0		
4	-	.4470	.7946	0		
5	-	.3605	.5732			
6	-	.2715	.3896			
7	-	.1880	.2448			
8	-	.1165	.1400			
9	-	.0605	.0674			
10	-	.0228	.0235			
11	-	.0033	.0029			
sp	-	0	0			

Point ②

$x = 1.665$ $y = 0.055$

	H_0y	V_0x	d'	M_L	M_R
0	.1354	.8325	1.665		
1	.1348	.7401	1.0		
2	.1275	.6044	0		
3	.1150	.4765			
4	.0983	.3610			
5	.0793	.2604			
6	.0597	.1770			
7	.0414	.1112			
8	.0256	.0636			
9	.0133	.0306			
10	.0050	.0107			
11	.0007	.0013			
sp	0	0			

Point ⓪

$x = 0$ $y = 0$

0	M_0	H_0y	V_0x	d'
1	—	0	0	0
2	—	0	0	0
3	—	0	0	0

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CALCULATIONS FOR (1) Shinohu-Bashi span no.1

		0	1	2	3	4	5	6	7	8	9	10	11
(SP)	Mo	+.09112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
	Hoy	+.61156	+.60858	+.57579	+.51940	+.44414	+.35819	+.26976	+.18680	+.11575	+.6011	-.2260	+.0323
	Sum	+.70268	+.66781	+.59958	+.51906	+.42984	+.33789	+.24931	+.16979	+.10385	+.5337	+.1988	+.0282
	Tox	.56375	.50117	.40928	.32269	.24444	.17634	.11985	.7532	.4307	.2075	.0722	.0090
		1.26643	1.16898	1.00886	.84175	.67428	.51423	.36916	.24506	.14692	.7412	.2710	.0372
	d'	11.275	10.610	9.610	8.610	7.610	6.610	5.610	4.610	3.610	2.610	1.610	.610
	ML	+1.3893	+1.0798	⊕.04786	⊖.1925	-.8672	-1.4677	-1.9189	-2.1594	-2.1408	-1.8688	-1.3390	-.5728
	MR	+1.3893	+1.6664	+1.9030	+1.9637	+1.8540	+1.6155	+1.2946	+.9442	+.6078	+.3262	+.1266	+.0192
(10)	Mo	+.09112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
	Hoy	~~.43024~~ 8	.43610	.41260	.37220	.31826	.25668	.19331	.13386	.8290	.4308	.1620	.0231
	Sum	+.52036	+.49533	+.43639	+.37186	+.30396	+.23638	+.17286	+.11680	+.7100	+.3634	+.1348	+.0190
	Tox	.48325	.42961	.35084	.27661	.20954	.15116	.10274	.6456	.3692	.1778	.0619	.0077
		1.06261	.92499	.78723	.64847	.51350	.38754	.27560	.18136	.10792	.5412	.1967	.0267
	d'	9.665	90	80	70	60	50	40	30	20	10	0	
	ML	+.4011	⊕.2494	⊖.1277	-.5153	-.8650	-1.1246	-1.2440	-1.1864	-.9208	⊖.4588	⊕.1967	+.0267
	MR	+.4011	+.6572	+.8555	+.9521	+.9442	+.8522	+.7012	+.5224	+.3408	+.1856	+.0729	+.0113
(8)	Mo	+.9112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
	Hoy	.26836	.26705	.25266	.22792	.19489	.15718	.11837	.8197	.5079	.2638	.0992	.0142
	Sum	+.35948	+.32628	+.27645	+.22758	+.18059	+.13688	+.9792	+.6491	+.3889	+.1964	+.0720	+.0101
	Tox	.38325	.34071	.27824	.21937	.16618	.11988	.8148	.5120	.2928	.1410	.0491	.0061
		.74273	.66699	.55469	.44695	.34677	.25676	.17940	.11611	.6817	.3374	.1211	.0162
	d'	7.665	70	60	50	40	30	20	10	0			
	ML	-.2377	-.3301	-.4531	-.5305	-.5323	-.4324	⊖.2060	⊕.1611	+.6817	+.3374	+.1211	+.0162
	MR	-.2377	-.1443	-.0179	+.0821	+.1441	+.1700	+.1649	+.1371	+.0961	+.0554	+.0229	+.0040
(6)	Mo	+.9112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
	Hoy	.14526	.14455	.13676	.12337	.10549	.8508	.6407	.4437	.2749	.1428	.0537	.0077
	Sum	+.23638	+.20378	+.16055	+.12303	+.9119	+.6478	+.4362	+.2731	+.1559	+.0754	+.0265	+.0036
	Tox	.28325	.25181	.20564	.16213	.12282	.8860	.6022	.3784	.2164	.1042	.0363	.0045
		.51963	.45559	.36619	.28516	.21401	.15338	.10389	.6515	.3723	.1796	.0638	.0081
	d'	5.665	50	40	30	20	10	0					
	ML	-.4687	-.4441	-.3381	⊖.1489	⊕.1401	+.5338	+1.0389	+.6515	+.3723	+.1796	+.0638	+.0081
	MR	-.4687	-.4803	-.4509	-.3910	-.3163	-.2382	-.1660	-.1053	-.0605	-.0288	-.0098	-.0009
(4)	Mo	+.9112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
	Hoy	.6155	.6125	.5795	.5228	.4470	.3605	.2715	.1880	.1165	.0605	.0228	.0033
	Sum	+.15267	+.12048	+.8174	+.5194	+.3040	+.1575	+.0670	+.0174	-.0025	-.0069	-.0049	-.0008
	Tox	.18325	.16291	.13304	.10489	.7946	.5732	.3896	.2448	.1400	.0674	.0235	.0029
		.33592	.28339	.21478	.15683	.10986	.7307	.9566	.2622	+.1375	+.0605	+.0191	+.0021
	d'	3.665	30	20	10	0							
	ML	-.3058	⊖.1661	⊕.1478	+.5683	+1.0986	+.7307	+.4566	+.2622	+.1375	+.0605	+.0191	+.0021
	MR	-.3058	-.4243	-.5130	-.5295	-.4906	-.4157	-.3226	-.2274	-.1425	-.0743	-.0279	-.0037

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CALCULATIONS FOR (1)

Shinobu-Bashi Span no. 1

⑦

	0	1	2	3	4	5	6	7	8	9	10	11
Mo	+.9112	+.5923	+.2379	-.0034	-.1430	-.2030	-.2045	-.1706	-.1190	-.0674	-.0272	-.0041
H.y	.1354	.1348	.1275	.1150	.0983	.0793	.0597	.0414	.0256	.0133	.0050	.0007
I Vox	+1.0466	+.7271	+.3654	+.1116	-.0447	-.1237	-.1448	-.1292	-.0934	-.0541	-.0222	-.0034
	.8325	.7401	.6044	.4765	.3610	.2604	.1770	.1112	.0636	.0306	.0107	.0013
d'	1.8791	.14672	.9698	.5881	+.3163	+.1367	+.0322	-.0180	-.0298	-.0235	-.0115	-.0021
	1.665	1.0	0									
ML	+.2141	+.4672	+.9698	+.5881	+.3163	+.1367	⊕.0322	⊖.0180	-.0298	-.0235	-.0115.0	-.0021
MR	⊕.2141	⊖.0130	-.2390	-.3649	-.4057	-.3841	-.3218	-.2404	-.1570	-.0847	-.0329	-.0047

②

⓪

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CALCULATIONS FOR (1)

Shinobu-Bashi Span no. 1

Point load		M (SP)	+	−	M (10)	+	−	M (8) (9)	+	−
11	12000	−.5728		6875	+.0267	320		+.0162	194	
10	37150	−1.3390		49720	+.1967	7306		+.1211	4500	
9	12750	−1.8688		23820	−.4588		5850	+.3374	4305	
8	31900	−2.1408	68290	~~67650~~	−.9208		29370	+.6817	21720	
7	10400	−2.1594		22460	−1.1864		12340	+.1611	1676	
6	29180	−1.9184		55950	−1.2440		36280	−.2060		6010
5	9200	−1.4677		13495	−1.1246		10340	−.4324		3976
4	24230	−.8672		21000	−.8650		20960	−.5323		12910
3	19000	−.1925		3658	−.5153		9790	−.5305		10080
2	17680	+.4786	8470		−.1277		2260	−.4531		8015
1	16860	+1.0798	18200		+.2494	4205		−.3301		5569
0	5520	+1.3893	7665		+.4511	2490		−.2377		1310
1	16860	+1.6664	28090		+.6572	11075		−.1443		2432
2	17680	+1.9030	33650		+.8555	15125		−.0179		317
3	19000	+1.9637	37300		+.9521	18090		+.0821	1560	
4	24230	+1.8540	44910		+.9442	22900		+.1441	3491	
5	9200	+1.6155	14860		+.8522	7843		+.1700	1563	
6	29180	+1.2946	37740		+.7012	20450		+.1644	4795	
7	10400	+.9442	9825		+.5224	5438		+.1371	1426	
8	31900	+.6078	19370		+.3408	10860		+.0961	3065	
9	12750	+.3262	4162		+.1856	2368		+.0554	706	
10	37150	+.1266	4705		+.0729	2710		+.0229	851	
11	12000	+.0192	230	265268	+.0113	136		+.0040	48	
			+269177	−~~264628~~		+131316	−127190		+49900	−50614
			+~~4549~~ 3909			+4126			−714	

Point load		M (6)	+	−	M (4)	+	−	M (2)	+	−
11	12000	+.0081	97		+.0021	25		−.0021		25
10	37150	+.0638	2370		+.0191	710		−.0115		427
9	12750	+.1796	2291		+.0605	772		−.0235		300 ~~230~~
8	31900	+.3723	11870		+.1375	4385		−.0298		950
7	10400	+.6515	6780		+.2622	2728		−.0180		187
6	29180	+1.0384	30300		+.4566	13320		+.0322	940	
5	9200	+.5338	4908		+.7307	6721		+.1367	1256	
4	24230	+.1401	3396		+1.0986	26620		+.3163	7668	
3	19000	−.1484		2820	+.5683	10800		+.5881	11175	
2	17680	−.3381		5980	+.1478	2615		+.9698	17150	
1	16860	−.4441		7488	−.1661		2800	+.4672	7880	
0	5520	−.4687		2587 ~~2685~~	−.3058		1687	+.2141	1181	
1	16860	−.4803		8100	−.4243		7155	−.0130		219
2	17680	−.4509		7980	−.5130		9070 ~~9960~~	−.2390		4228
3	19000	−.3910		7430	−.5295		10060	−.3649		6932
4	24230	−.3163		7664 ~~7567~~	−.4906		11880	−.4057		9830
5	9200	−.2382		2191	−.4157		3820	−.3841		3564
6	29180	−.1660		4842	−.3226		9530	−.3218		9390 ~~9488~~
7	10400	−.1053		1096	−.2274		2365	−.2404		2502
8	31900	−.0605		1930	−.1425		4545	−.1570		5070
9	12750	−.0288		367	−.0743		948	−.0847		1080
10	37150	−.0098		364	−.0279		1036	−.0329		1222
11	12000	−.0009		11	−.0037		44	−.0047		56
			+62012	−~~60851~~ 60850		+68696	−~~65830~~ 64940		+47250	−~~46010~~ 45982
			+~~1151~~ +1162			+~~2866~~ 3756			+~~1240~~ 1268	

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Shinobu-Bashi Span no. 1 (10)

(0)

point	load	M	+	−
11	12,000	−.0041		49
10	37,150	−.0272		1,010
9	12,750	−.0674		860
8	31,900	−.1190		3,795
7	10,400	−.1706		1,775
6	29,180	−.2045		5,968
5	9,200	−.2030		1,867
4	24,230	−.1430		3,465
3	19,000	−.0034		65
2	17,680	+.2379	4,210	
1	16,860	+.5923	10,000	
0	2,760	+.9112	2,515	
			2× 16,725	2× 18,854
			+33,450	−37,708

$$\underbrace{+33{,}450 \quad -37{,}708}_{-4{,}258}$$

Dead load thrust

point	load	H₀ vert. load	H₀				normal thrust	vertical shear				normal thrust
0	2,760	2462	6,794	492,862	×	1.000	= 492,862	0	×	0	=	0
1	16,860	2,950	41,320					11,190				
2	17,680	2,318	40,990	"	×	.998	= 491,800	28,460	×	.060	=	1,707
3	19,000	2,091	39,740					46,800				
4	24,230	1,788	43,350	"	×	.992	= 489,000	68,415	×	.130	=	8,900
5	9,200	1,442	13,260					85,130				
6	29,180	1,086	31,680	"	×	.982	= 484,000	104,320	×	.205	=	21,380
7	10,400	.752	7,825					123,110				
8	31,900	.466	14,850	"	×	.958	= 472,100	145,260	×	.285	=	41,380
9	12,750	.242	3,086					167,585				
10	37,150	.091	3,380	"	×	.935	= 460,700	192,535	×	.365	=	70,250
11	12,000	.013	156					217,110				
sp.	6,650	0	0	"	×	.912	= 449,400	229,760	×	.415	=	95,300
	229,760		246,431									
			492,862									

Summary of Dead load normal thrust

	0	2	4	6	8	10	sp
Due to vertical shear	0	1,707	8,900	21,380	41,380	70,250	95,300
Due to horizontal thrust	492,862	491,800	489,000	484,000	472,100	460,700	449,400
	492,862	493,507	497,900	505,380	513,480	530,950	544,700

Temperature stress

$$H_0 = \frac{E\omega t l \int \frac{ds}{I}}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = \frac{1{,}400{,}000{,}000 \times .000012 \times 15 \times 22.55 \times 1062.17}{656{,}210.\cancel{359}} = \underline{\underline{9198}}$$

$9{,}198 \times 8.5 = 78{,}190$ Kg

$t = 15°$

$E = 1{,}400{,}000{,}000$

$\omega = .000012$

$$M_0 = -78{,}190 \times \frac{484.86}{1{,}062.17} = -35{,}670 \text{ Kgm}$$

$$M_0 = -\frac{H_0 \int y \frac{ds}{I}}{\int \frac{ds}{I}}$$

moment at spring

$M_0 - H \times y$

$35{,}670 - 78{,}190 \times 2.484 =$

$-194{,}000$
$+35{,}670$

$-158{,}330$ Kgm

D.L. $+4{,}549$

Crown D.L. $-4{,}258$

temp $-35{,}670$

Temperature stress

$$H_0 = \frac{1900{,}000{,}000 \times .000012 \times 15 \times 22.55 \times 1062.17}{656210} = 9198$$ for 1 metr. strip for 8.5 metr wide $9198 \times 8.5 = 78183$ Kg

$$M_0 = \frac{78183 \times 484.86}{1062.17} = 35{,}689$$

panel point

		normal thrust
2	M = 35,689 − 78,183 × .055 = +31,389 Kgm	78,183 × .998 = 78,027
4	〃 − 〃 × .250 = +16,143 Kgm	× .992 = 77,558
6	〃 − 〃 × .590 = −10,439	× .982 = 76,776
8	〃 − 〃 × 1.090 = −49,530	× .958 = 74,899
10	〃 − 〃 × 1.780 = −103,477	× .935 = 73,101
sp	〃 − 〃 × 2.484 = −158,518	× .912 = 71,303

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CALCULATIONS FOR

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.200 — .045 — .155
.2005 — .1555
.204 — .159
.207 — .209 — .163 — .168
.215 — .170
.224 — .179
.2375 — .1925
.2500 — .205
.269 — .224
.295 — .250
.331 — .286
.3705 — .3275
.400 — .355

.2000 — .095 — .155
.2005 — .1555
.2025 — .1575
.2060 — .1610
.2100 — .1650
.2140 — .1710
.2224 — .1810
.2375 — .1925
.250 — .205
.2635 — .2185
.2825 — .2375
.3675 — .2825
.3375 — .2925
.3775 — .3325
.400 — .355

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CALCULATIONS FOR Coefficient for normal thrust of arch ring

Span no. 3

0	~~H × 1.000~~	0
2	H × 0.999	V – 0.050
4	0.992	0.118
6	0.985	0.180
8	0.975	0.245
10	0.950	0.320
12	0.925	0.385
½	0.900	0.425

Span no 2

0	1.000	0
1	.999	V 0.030
3	.995	0.095
5	.985	0.162
7	.975	0.230
9	.955	0.305
11	.925	0.380
½	.900	0.425

Span no 1.

0	1.000	V 0.000
2	.998	V 0.060
4	.992	0.130
6	.982	0.205
8	.958	0.285
10	.935	0.365
Sp	.912	0.415

増田淳氏関係資料（独立行政法人 土木研究所蔵）

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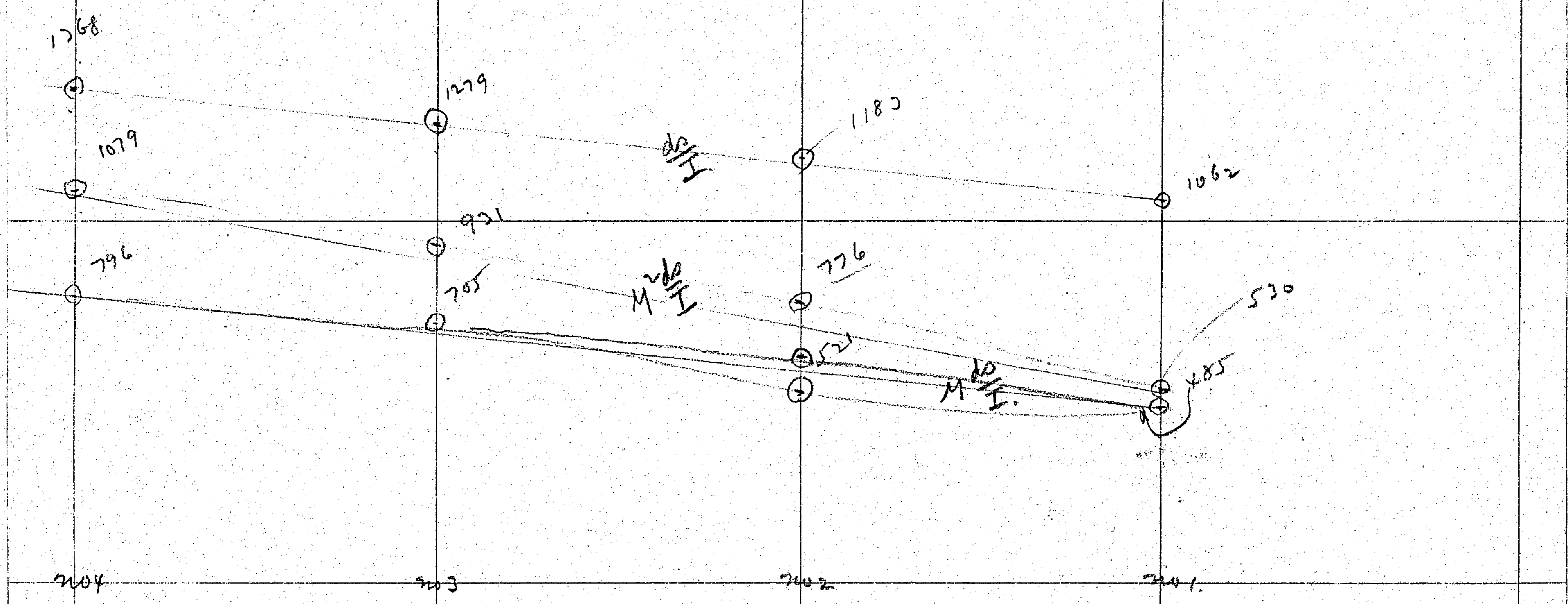
CALCULATIONS FOR 2

Shinobu - Bashi Span no. 2 ⓪

Span no 2.

	x	y	d		d cos φ	
0	0	0	.400		.415	.0438
1	.915	.018	.402		1.000	
2	1.915	.062	.408 ✓		1.001	
3	2.915	.140 ✓	.416 ✓		1.003	
4	3.915	.260 ✓	.430		1.007	
5	4.915	.405 ✓	.446	446	1.013	
6	5.915	.585 ✓	~~.460~~	466	1.019	
7	6.915	.810 ✓	.490	482	1.028	
8	7.915	1.060 ✓	.515		1.038	
9	8.915	1.360 ✓	.550		1.050	.0876
10	9.915	1.700 ✓	.600		1.063	
11	10.915	2.080 ✓	.660		1.077	
12	11.915	2.510 ✓	.740		0.890	
℄	12.525	2.794 ✓	.80		0.340	



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CALCULATIONS FOR 2

Span no 2

Division	Depth d	d^3	$I_c = \frac{1}{12} d^3$	$(\frac{d}{2} - 0.045)^2$		I_s	$I = I_c + I_s$	Equivalent A concrete
Crown 0	.400	0.0640	0.00533	0.0240	× 0.0438 =	0.00105	0.00638	0.0438
1	.402	0.0650	0.00542	0.0243	"	0.00106	0.00648	
2	.408	0.0679	0.00566	0.0253	"	0.00111	0.00677	
3	.416	0.0720	0.00600	0.0266	"	0.00117	0.00717	
4	.430	0.0795	0.00663	0.0289	"	0.00127	0.00790	
5	.446	0.0887	0.00739	0.0317	"	0.00139	0.00878	
6	.466	0.1012	0.00843	0.0353	"	0.00155	0.00998	
7	.488	0.1162	0.00968	0.0396	"	0.00173	0.01141	
8	.515	0.1366	0.01138	0.0452	"	0.00198	0.01336	
9	.550	0.1664	0.01387	0.0529	× 0.0876	0.00463	0.01850	
10	.600	0.2160	0.01800	0.0650	"	0.00569	0.02369	
11	.660	0.2875	0.02396	0.0812	"	0.00711	0.03107	
12	.740	0.4052	0.03377	0.1056	"	0.00925	0.04302	
Sp.	.800	0.5120	0.04267	0.1260	"	0.01104	0.05371	

Division	x	x^2	y	y^2	ds	I	$\frac{ds}{I}$	$x\frac{ds}{I}$	$x^2\frac{ds}{I}$	$y\frac{ds}{I}$	$y^2\frac{ds}{I}$
0	0	0	0	0	.415	0.00638	65.05	0	0	0	0
1	.915	0.837	.018	0.0003	1.000	0.00648	154.32	141.20	129.17	2.78	0.05
2	1.915	3.667	.062	0.004	1.001	0.00677	147.86	283.15	542.20	9.17	0.59
3	2.915	8.497	.140	0.020	1.003	0.00717	139.89	407.78	1188.65	19.58	2.80
4	3.915	15.327	.260	0.068	1.007	0.00790	127.47	499.05	1953.73	33.14	8.67
5	4.915	24.157	.405	0.164	1.013	0.00878	115.38	567.09	2,787.23	46.73	18.92
6	5.915	34.987	.585	0.342	1.019	0.00998	102.10	603.92	3,572.17	59.73	34.92
7	6.915	47.817	.810	0.656	1.028	0.01141	90.10	623.04	4308.31	72.98	59.11
8	7.915	62.647	1.060	1.124	1.038	0.01336	77.69	614.92	4867.05	82.35	87.32
9	8.915	79.477	1.360	1.850	1.050	0.01850	56.76	506.02	4511.11	77.19	105.01
10	9.915	98.307	1.700	2.890	1.063	0.02369	44.87	444.89	4411.04	76.28	129.67
11	10.915	119.137	2.080	4.326	1.077	0.03107	34.66	378.31	4129.29	72.09	149.94
12	11.915	141.967	2.510	6.300	0.890	0.04302	20.69	246.52	2,937.30	51.93	130.35
Sp.	12.525	156.876	2.794	7.806	0.340	0.05371	6.33	79.28	993.03	17.69	49.41
					12.944		1183.17	5395.17	36,330.28	521.64	776.76

0 — 1 — 2

Division	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$xm\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0	0	0	0	0	0							
1	.915	.915	141.20	129.17	2.54	0	0						
2	1.915	—	283.15	542.20	17.56	1	147.86	283.15	9.17	0			
3	2.915	—	407.78	1188.65	57.08	2	279.78	815.56	39.16	1	139.89	407.78	19.58
4	3.915	—	499.05	1,953.73	129.74	3	382.41	1497.15	99.42	2	254.94	998.10	66.28
5	4.915	—	567.09	2,787.23	229.68	4	461.52	2268.36	186.92	3	346.14	1701.27	140.19
6	5.915	—	603.92	3,572.17	353.30	5	~~510.50~~	3,019.60	298.65	4	408.40	2415.68	238.92
7	6.915	—	623.04	4,308.31	504.66	6	540.60	3738.24	437.88	5	450.50	3115.20	364.90
8	7.915	—	614.92	4,867.05	651.80	7	543.83	4304.44	576.45	6	466.14	3689.52	494.18
9	8.915	—	506.02	4,511.11	688.15	8	454.08	4048.16	617.52	7	397.32	3542.14	540.33
10	9.915	—	444.89	4,411.04	756.32	9	403.83	4004.01	686.52	8	358.96	3559.12	610.24
11	10.915	—	378.31	4129.29	786.86	10	346.60	3783.10	720.90	9	311.94	3404.79	648.81
12	11.915	11.915	246.52	2,937.30	618.75	11	227.59	2711.72	571.23	10	206.90	2465.20	519.30
Sp.	12.525	12.525	79.28	993.03 ~~9,930.20~~	2,215.77	11.61	73.49	920.47	205.33	10.61	67.16	841.93	182.95
			~~6105.72~~	~~45,267.45~~	~~7,011.61~~		~~5,033.51~~	39678.25	~~[illegible]~~		~~[illegible]~~	33710.73	
			5,395.17	36,330.28	5,018.01		4,392.09	31,393.93	4,449.20		3408.29	26,139.96	5519
													383034

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CALCULATIONS FOR 2

2

Division	x	③ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	④ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	⑤ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
4		1	127.47	499.05	33.14	0				0			
5		2	230.76	1134.18	93.46	1	115.38	567.09	46.73	0			
6		3	306.30	1811.76	179.19	2	204.20	1207.84	119.46	1	102.10	603.92	59.73
7		4	360.40	2492.16	291.87 (92)	3	270.30	1869.12	218.94	2	180.20	1246.08	145.96
8		5	388.45	3074.60	411.75	4	310.76	2459.68	329.40	3	233.07	1844.76	247.05
9		6	340.56	3036.12	463.14	5	283.80	2530.10	385.95	4	227.04	2024.08	308.76
10		7	314.09	3114.23	533.96	6	269.22	2669.34	457.68	5	224.35	2224.45	381.40
11		8	277.28	3026.48	576.72	7	242.62	2648.17	504.63	6	207.96	2269.86	432.54
12		9	186.21	2218.68	467.37	8	165.52	1972.16	415.44	7	144.83	1725.64	363.51
Sp.		9.61	608.3X	7619.10 (88)	~~1699.62~~ 1700.00	8.61	545.0X	6826.87	1522.76 (31)	7.61	481.7X	6033.44	134.59 (62)
			~~3139.83~~ 2,592.35	~~28026.36~~ 21,169.14	~~4750.22~~ 3220.65		2406.81 1,916.30	~~22749.77~~ 16,606.10	~~4000.99~~ 2,630.54		~~1801.26~~ 1,367.72	~~17972.23~~ 12,542.11	~~3284.85~~ 2,073.57

Division	x	⑥ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	⑦ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	⑧ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
7		1	90.10	623.04	72.98	0				0			
8		2	155.38	1229.84	164.70	1	77.69	614.92	82.35	0			
9		3	170.28	1518.06	231.57	2	113.52	1012.04	154.38	1	56.76	506.02	77.19
10		4	179.48	1779.56	305.12	3	134.61	1334.67	228.84	2	89.74	889.78	152.56
11		5	173.30	1891.55	360.45	4	138.64	1513.24	288.36	3	103.98	1134.93	216.27
12		6	124.14	1479.12	311.58	5	103.45	1232.60	259.65	4	82.76	986.08	207.72
Sp.		6.61	418.4X	5240.61 (4)	1169.64 (3)	5.61	355.1X	4447.78 (6)	992.25 (4)	4.61	291.8X	3654.95 (8)	815.32 (5)
			~~1311.09~~ 934.52	~~13761.78~~ 9,045.21	~~2615.44~~ 1563.33		~~923.02~~ 603.42	~~10155.25~~ 6,152.23	~~2005.86~~ 1,112.82		~~635.05~~ 362.42	~~7171.76~~ 3882.29	~~1469.06~~ 735.29

Division	x	⑨ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	⑩ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	⑪ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
10		1	44.87	444.89	76.28	0				0			
11		2	69.32	756.62	144.18	1	34.66	378.31	72.09	0			
12		3	62.07	739.56	155.79	2	41.38	493.04	103.86	1	20.69	246.52	51.93
Sp.		3.61	228.5X	2862.12	638.46 (6)	2.61	165.2X	2069.29	461.8 (7)	1.61	101.9X	1276.48 (7)	284.74 (8)
			~~404.77~~ 199.11	~~4803.19~~ 2227.28	~~1014.71~~ 440.11		~~241.25~~ 92.56	~~2940.64~~ 1078.27	~~427.55~~ 222.12		~~122.60~~ 30.88	~~1522.98~~ 374.16	~~336.67~~ 80.41

Division	x	⑫ m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
Sp.		.61	3.86	792.81 483.63	17.69 9 107.88

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CALCULATIONS FOR 2

No 2

$$H_0 = \frac{\int\frac{ds}{I}\int my\frac{ds}{I} - \int m\frac{ds}{I}\int y\frac{ds}{I}}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = \frac{A}{B}$$

$B = 2\{1183.17 \times 776.76 - (521.64)^2\} = 1065206$ ~~1293864~~

621.64

919039.1
272108.3
646930.8
× 2
1293861.6

$H_0 = \frac{A}{B}$

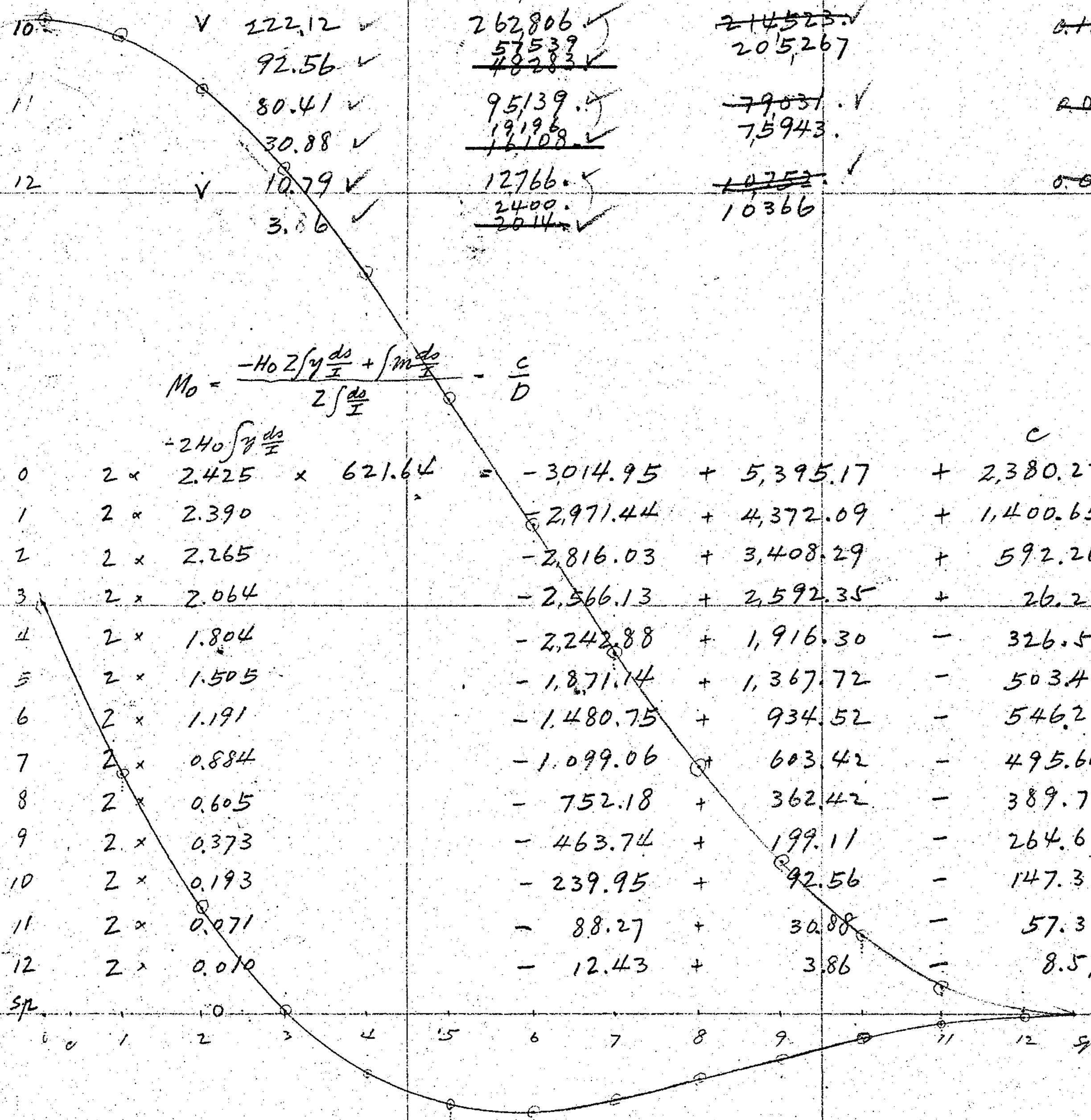
	$\int my\frac{ds}{I}$		A	H_0
0	1183.17 × 5018.01	5937159.	~~3122878.~~	~~2.414~~ 2.425
	$y\frac{ds}{I}$ ~~521.64~~ 621.64 — 5395.17	3353853.	2583306.	
1	4449.20	~~5264160.~~	~~2985503.~~	~~2.356~~ 2.390
	4372.09	2717866. ~~2280657~~	2546294.	
2	3830.34	~~4531943.~~	~~2354043.~~	~~2.129~~ 2.265
	3408.29	2118729.	2413214.	
3	3220.65	3810517.76	~~2458344~~	~~1.900~~ 2.064
	2592.35	1611508. ~~1352773~~	2199068	
4	2630.54	3112376	~~2112768.~~	~~1.633~~ 1.804
	1916.30	1191249. ~~999211~~	1921127.	
5	2073.57	2453386.	~~1739929.~~	~~1.345~~ 1.505
	1367.72	850229 ~~713457~~	1603157.	
6	1563.33	1849685.	~~1362202.~~	~~1.053~~ 1.191
	934.52	580935. ~~487483~~	1268750.	
7	1112.86	1316703.	~~1001935.~~	~~0.774~~ 0.884
	603.42	375110. ~~314768~~	941593.	
8	735.29	869973.	~~680920.~~	~~0.526~~ 0.605
	362.42	225295. ~~189053.~~	644678.	
9	440.11	520725.	~~416861.~~	~~0.322~~ 0.373
	199.11	123775 ~~103864~~	396950.	
10	222.12	262806.	~~214523.~~	~~0.166~~ 0.193
	92.56	57539 ~~48283~~	205267	
11	80.41	95139.	~~79031.~~	~~0.061~~ 0.071
	30.88	19196 ~~16108.~~	75943.	
12	10.79	12766.	~~10752.~~	~~0.008~~ 0.010
	3.86	2400. ~~2014.~~	10366	

919039.1
386436.3
532602.8
× 2
1065205.6

2.79
25.06
125.
12.16

$$M_0 = \frac{-H_0 2\int y\frac{ds}{I} + \int m\frac{ds}{I}}{2\int\frac{ds}{I}} = \frac{C}{D}$$

$2\int\frac{ds}{I}$



		$=2H_0\int y\frac{ds}{I}$			C		D		Mo
Crown 0	2 × 2.425 × 621.64	= −3014.95	+	5,395.17	+	2,380.22	÷ 2366.34	=	+ 1.0059
1	2 × 2.390	−2,971.44	+	4,372.09	+	1,400.65			+ 0.5919
2	2 × 2.265	−2,816.03	+	3,408.29	+	592.26			+ 0.2503
3	2 × 2.064	−2,566.13	+	2,592.35	+	26.22			+ 0.0111
4	2 × 1.804	−2,242.88	+	1,916.30	−	326.58			− 0.1380
5	2 × 1.505	−1,871.14	+	1,367.72	−	503.42			− 0.2127
6	2 × 1.191	−1,480.75	+	934.52	−	546.23			− 0.2308
7	2 × 0.884	−1,099.06	+	603.42	−	495.64			− 0.2095
8	2 × 0.605	− 752.18	+	362.42	−	389.76			− 0.1647
9	2 × 0.373	− 463.74	+	199.11	−	264.63			− 0.1118
10	2 × 0.193	− 239.95	+	92.56	−	147.39			− 0.0623
11	2 × 0.071	− 88.27	+	30.88	−	57.39			− 0.0243
12	2 × 0.010	− 12.43	+	3.86	−	8.57			− 0.0036

CALCULATIONS FOR 2

no2

$$V_0 = \frac{\int m x \frac{ds}{I}}{2\int x^2 \frac{ds}{I}} = \frac{E}{F}$$

	E		F	=	
0	36,330.28	÷	72,660.56	=	0.5000
1	31,393.93			=	.4321
2	26,139.96			=	.3598
3	21,169.14			=	.2913
4	16,606.10			=	.2285
5	12,542.11			=	.1726
6	9,045.21			=	.1245
7	6,152.23			=	.0847
8	3,882.29			=	.0534
9	2,227.27			=	.0307
10	1,078.27			=	.0148
11	374.16			=	.0051
12	48.36			=	.0007
SP.	0			=	0

d′ clear arm of unit load about center of section origin at crown

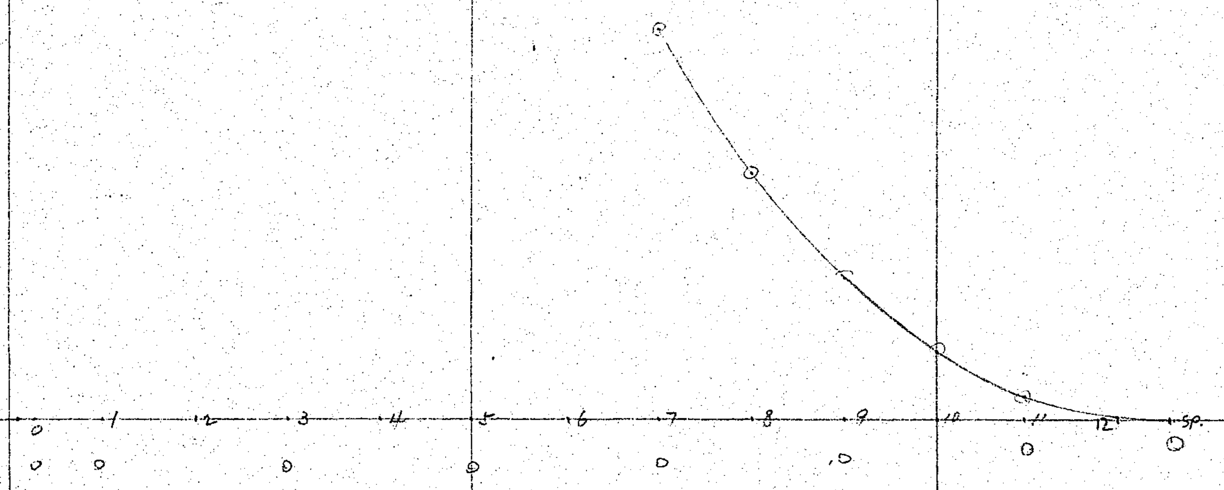
$$M_L = M_0 + H_0 y + V_0 x - d'$$
$$M_R = M_0 + H_0 y - V_0 x$$

Point SP: $x = 12.525$ $y = 2.794$

Point 11: $x = 10.915$ $y = 2.080$

Point 9: $x = 8.915$ $y = 1.360$

	Point SP M_0	SP H_0y	SP V_0x	SP d'		11 H_0y	11 V_0x	11 d'		9 H_0y	9 V_0x	9 d'
0	+1.0059	6.7755	6.2625	12.525	0	5.0440	5.4575	10.915	0	3.2980	4.4575	8.915
1	+.5919	6.6777	5.4121	11.61	1	4.9712	4.7164	10.	1	3.2504	3.8522	8.
2	+.2503	6.3284	4.5065	10.61	2	4.7112	3.9272	9.	2	3.0804	3.2076	7.
3	+.0111	5.7668	3.6485	9.61	3	4.2931	3.1795	8.	3	2.8070	2.5969	6.
4	−.1380	5.0404	2.8620	8.61	4	3.7523	2.4941	7.	4	2.4534	2.0371	5.
5	−.2127	4.2050	2.1618	7.61	5	3.1304	1.8839	6.	5	2.0468	1.5387	4.
6	−.2308	3.3277	1.5594	6.61	6	2.4773	1.3589	5.	6	1.6198	1.1099	3.
7	−.2095	2.4699	1.0609	5.61	7	1.8387	.9245	4.	7	1.2022	.7551	2.
8	−.1647	1.6904	.6688	4.61	8	1.2584	.5829	3.	8	.8228	.4761	1.
9	−.1118	1.0422	.3845	3.61	9	0.7758	.3351	2.	9	.5073	.2737	0
10	−.0623	.5392	.1854	2.61	10	.4014	.1615	1.	10	.2625	.1319	
11	−.0243	.1984	.0639	1.61	11	.1477	.0557	0	11	.0966	.0455	
12	−.0036	.0279	.0088	.61	12	.0208	.0076		12	.0136	.0062	
SP.	0			0	SP.							



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CALCULATIONS FOR 2

Point ⑦
x=6.915 y=.810

	Mo	Hoy	Vox	d'
0	+ 1.0059	1.9643	3.4575	6.915
1	+ .5919	1.9359	2.9880	6
2	+ .2503	1.8347	2.4880	5
3	+ .0111	1.6718	2.0143	4
4	- .1380	1.4612	1.5801	3
5	- .2127	1.2191	1.1935	2
6	- .2308	.9647	.8609	1
7	- .2095	.7160	.5857	0
8	- .1647	.4901	.3693	
9	- .1118	.3021	.2123	
10	- .0623	.1563	.1023	
11	- .0243	.0575	.0353	
12	- .0036	.0081	.0048	
SP	- 0			

⑤
x=4.915 y=.405

	Hoy	Vox	d'
0	.9821	2.4575	4.915
1	.9680	2.1238	4
2	.9173	1.7684	3
3	.8359	1.4317	2
4	.7306	1.1231	1
5	.6095	.8483	0
6	.4824	.6119	
7	.3580	.4163	
8	.2450	.2625	
9	.1511	.1509	
10	.0782	.0727	
11	.0288	.0251	
12	.0041	.0034	
SP			

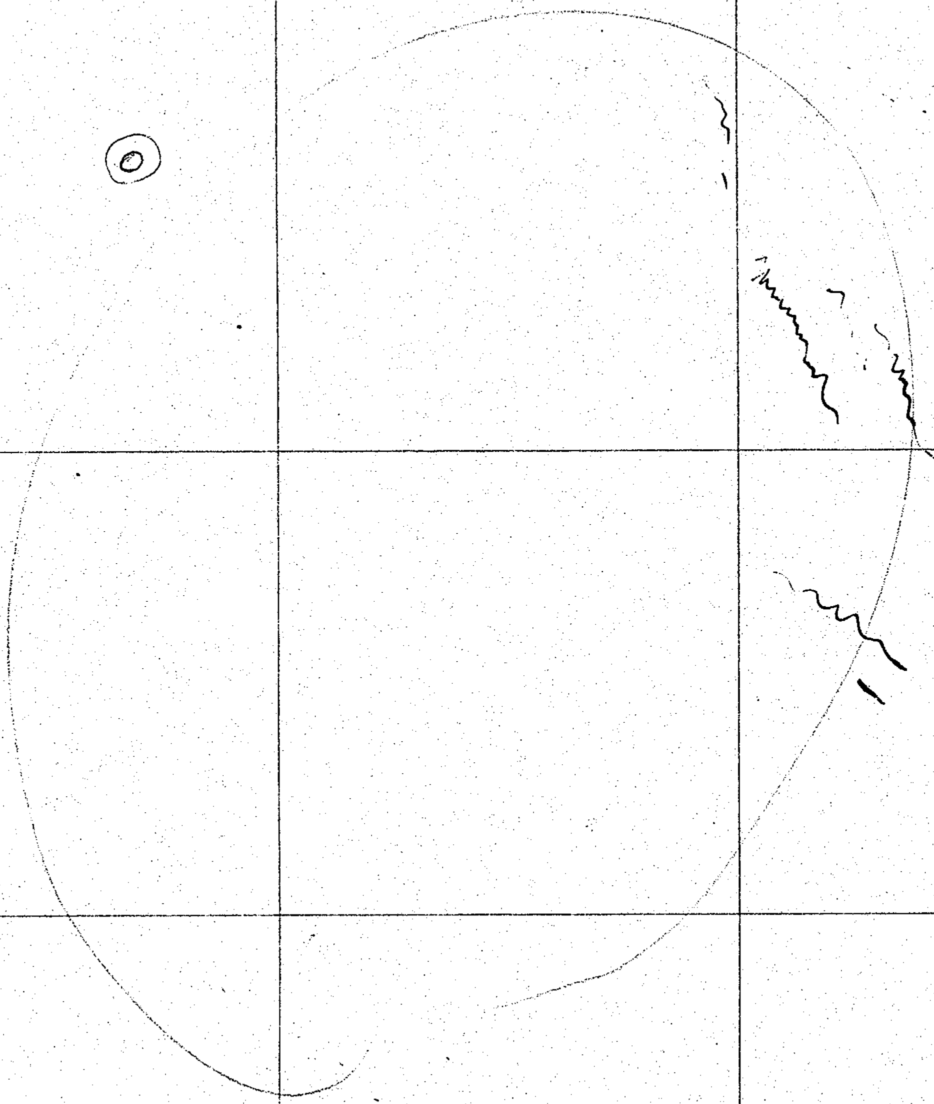
③
x=2.915 y=.140

	Hoy	Vox	d'
0	.3395	1.4575	2.915
1	.3346	1.2596	2.
2	.3171	1.0488	1.
3	.2890	.8491	0
4	.2526	.6661	
5	.2107	.5031	
6	.1667	.3629	
7	.1238	.2469	
8	.0847	.1557	
9	.0522	.0895	
10	.0270	.0431	
11	.0099	.0149	
12	.0014	.0020	
SP.			

Point ①
x=.915 y=.018

	Mo	Hoy	Vox	d'
0	+ 1.0059	.0437	.4575	.915
1	+ .5919	.0430	.3954	0
2	+ .2503	.0408	.3292	
3	+ .0111	.0372	.2665	
4	- .1380	.0325	.2091	
5	- .2127	.0271	.1579	
6	- .2308	.0214	.1139	
7	- .2095	.0159	.0775	
8	- .1647	.0109	.0489	
9	- .1118	.0067	.0281	
10	- .0623	.0035	.0135	
11	- .0243	.0013	.0047	
12	- .0036	.0002	.0006	
SP.	0	0	0	

⓪



JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY ______ DATE ______ **FILE NO** ______

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CALCULATIONS FOR No. 2

		0	1	2	3	4	5	6	7	8	9	10	11	12
SP	Mo	⊕ 1.0059	⊕ 0.5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036
	Hoy	6.7775	6.6777	6.3284	5.7668	5.0404	4.2050	3.3277	2.4699	1.6904	1.0422	.5392	.1984	.0279
	MR –	7.7834	7.2696	6.5787	5.7779	4.9024	3.9923	3.0969	√2.2604	√1.5257	.9304	.4769	.1741	.0243
	Vox	6.2625	5.4121	4.5065	3.6485	2.8620	2.1618	1.5594	1.0609	.6688	.3845	.1854	.0639	.0088
	ML –	14.0459	12.6817	11.0852	9.4264	7.7644	6.1541	4.6563	√3.3213	2.1945	1.3149	.6623	.2380	.0331
	d'	12.5250	11.61	10.61	9.61	8.61	7.61	6.61	5.61	4.61	3.61	2.61	1.61	.61
	ML	⊕ 1.5209	⊕ 1.0717	⊕ 0.4752	⊖ .1836	⊖ .8456	⊖ 1.4559	⊖ 1.9537√	⊖ 2.2887√	⊖ 2.4155	⊖ 2.2951	⊖ 1.9477	⊖ 1.3720	⊖ .5769
	MR	⊕ 1.5209	⊕ 1.8575	⊕ 2.0722	⊕ 2.1294	⊕ 2.0404	⊕ 1.8305	⊕ 1.5375√	⊕ 1.1995√	⊕ .8569	⊕ .5459	⊕ .2915	⊕ .1102	⊕ .0155
11	Mo	⊕ 1.0059	+ 0.5919	+ .2503	+ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036
	Hoy	5.0440	4.9712	4.7112	4.2931	3.7523	3.1304	2.4773	1.8387	1.2584	.7758	.4014	.1477	.0208
	MR –	6.0499	5.5631	4.9615	4.3042	3.6143	2.9177	2.2465	1.6292	1.0937	.6640	.3391	.1234	.0172
	Vox	5.4575	4.7164	3.9272	3.1795	2.4941	1.8839	1.3589	.9245	.5829	.3351	.1615	.0557	.0076
	ML –	11.5074	10.2795	8.8887	7.4837	6.1084	4.8016	3.6054	2.5537	1.6766	.9991	.5006	.1791	.0248
	d'	10.915	10.	9	8.	7.	6.	5.	4.	3.	2.0	1.0		
	ML	⊕ .5924	⊕ .2795	⊖ .1113	⊖ .5163	⊖ .8916	⊖ 1.1984	⊖ 1.3946	⊖ 1.4463	⊖ 1.3234	⊖ 1.0009	⊖ .4994	⊕ .1791	⊕ .0248
	MR	⊕ .5924	⊕ .8467	⊕ 1.0343	⊕ 1.1247	⊕ 1.1202	⊕ 1.0338	⊕ .8876	⊕ .7047	⊕ .5108	⊕ .3289	⊕ .1776	⊕ .0677	⊕ .0096
9	Mo	⊕ 1.0059	⊕ 0.5919	.2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036
	Hoy	3.2980	3.2504	3.0804	2.8070	2.4534	2.0468	1.6198	1.2022	.8228	.5073	.2625	.0966	.0136
	MR –	4.3039	3.8423	3.3307	2.8181	2.3154	1.8341	1.3890	√ .9927	√ .6581	√ .3955	.2002	.0723	.0100
	Vox	4.4575	3.8522	3.2076	2.5969	2.0371	1.5387	1.1099	.7551	.4761	.2737	.1319	.0455	.0062
	ML –	8.7614	7.6945	6.5383	5.4150	4.3525	3.3728	2.4989	√ 1.7478	√ 1.1342	√ .6692	.3321	.1178	.0162
	d'	8.9150	8.	7.	6.	5.	4.	3.	2.	1.				
	ML	⊖ .1536	⊖ .3055	⊖ .4617	⊖ .5850	⊖ .6475	⊖ .6272	⊖ .5011	⊖ √.2522	⊕ √.1342√	⊕ √ .6692	⊕ .3321	⊕ .1178	⊕ .0162
	MR	⊖ .1536	⊖ .0099	⊕ .1231	⊕ .2212	⊕ .2783	⊕ .2954	⊕ .2791	⊕ √.2376	⊕ √.1820	⊕ √ .1218	⊕ .0683	⊕ .0268	⊕ .0038
7	Mo	⊕ 1.0059	⊕ .5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036
	Hoy	1.9643	1.9359	1.8347	1.6718	1.4612	1.2191	.9647	.7160	.4901	.3021	.1563	.0575	.0081
	MR (	2.9702	2.5278	2.0850	1.6829	1.3232	1.0064	.7339	.5065	.3254	.1903	.0940	.0332	.0045
	Vox	3.4575	2.9880	2.4880	2.0143	1.5801	1.1935	.8609	.5857	.3693	.2123	.1023	.0353	.0048
	ML (	6.4277	5.5158	4.5730	3.6972	2.9033	2.1999	1.5948	1.0922	.6947	.4026	.1963	.0685	.0093
	d'	6.915	6	5	4	3	2	1						
	ML	⊖ .4873	⊖ .4842	⊖ .4270	⊖ .3028	⊖ .0967	⊕ .1999	⊕ .5948	⊕ 1.0922	⊕ .6947	⊕ .4026	⊕ .1963	⊕ .0685	⊕ .0093
	MR	⊖ .4873	⊖ .4602	⊖ .4030	⊖ .3314	⊖ .2569	⊖ .1871	⊖ .1270	⊖ .0792	⊖ .0439	⊖ .0220	⊖ .0083	⊖ .0021	⊖ .0003
5	Mo	⊕ 1.0059	⊕ 0.5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036
	Hoy	.9821	.9680	.9173	.8359	.7306	.6095	.4824	.3580	.2450	.1511	.0782	.0288	.0041
	MR (	1.9880	1.5599	1.1676	.8470	.5926	.3968	.2516	.1485	.0803	.0393	.0159	.0045	.0005
	Vox	2.4575	2.1238	1.7684	1.4317	1.1231	.8483	.6119	.4163	.2625	.1509	.0727	.0251	.0034
		4.4455	3.6837	2.9360	2.2787	1.7157	1.2451	.8635	.5648	.3428	.1902	.0886	.0296	.0039
	d'	4.9150	4	3	2	1								
	ML	⊖ .4695	⊖ .3163	⊖ .0640	⊕ .2787	⊕ .7157	⊕ 1.2451	⊕ .8635	⊕ .5648	⊕ .3428	⊕ .1902	⊕ .0886	⊕ .0296	⊕ .0039
	MR	⊖ .4695	⊖ .5639	⊖ .6008	⊖ .5847	⊖ .5305	⊖ .4515	⊖ .3603	⊖ .2678	⊖ .1822	⊖ .1116	⊖ .0568	⊖ .0206	⊖ .0029

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

CALCULATIONS FOR

No. 2

MADE BY ______ DATE ______ **FILE NO** ______

CHECKED BY ______ DATE ______ **PAGE NO** ______

		0	1	2	3	4	5	6	7	8	9	10	11	12	
	Mo	⊕ 1.0059	⊕ .5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036	
	Hog	.3395	.3346	.3171	.2890	.2526	.2107	.1667	.1238	.0847	.0522	.0270	.0099	.0014	
MR (		⊕ 1.3454	⊕ .9265	⊕ .5674	⊕ .3001	⊕ .1146	⊖ .0020	⊖ .0641	⊖ .0857	⊖ .0800	⊖ .0596	⊖ .0353	⊖ .0144	⊖ .0022	3
	Vot	1.4575	1.2596	1.0488	.8491	.6661	.5031	.3629	.2469	.1557	.0895	.0431	.0149	.0020	
ML (	d'	2.8029 2.915	2.1861 2.	1.6162 1.	1.1492	.7807	.5011	.2988	.1612	.0757	.0299	.0078	.0005	⊖ .0002	
	ML	⊖ .1121	⊕ .1861	⊕ .6162	⊕ 1.1492	⊕ .7807	⊕ .5011	⊕ .2988	⊕ .1612	⊕ .0757	⊕ .0299	⊕ .0078	⊕ .0005	⊖ .0002	
	MR	⊖ .1121	⊖ .3331	⊖ .4814	⊖ .5490	⊖ .5515	⊖ .5051	⊖ .4270	⊖ .3326	⊖ .2357	⊖ .1491	⊖ .0784	⊖ .0293	⊖ .0042	
	Mo	⊕ 1.0059	⊕ .5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036	
	Hog	.0437	.0430	.0408	.0372	.0325	.0271	.0214	.0159	.0109	.0067	.0035	.0013	.0002	
MR (		1.0496	.6349	.2911	.0483	⊖ .1055	⊖ .1856	⊖ .2094	⊖ .1936	⊖ .1538	⊖ .1051	⊖ .0588	⊖ .0230	⊖ .0034	
	Vot	.4575	.3954	.3292	.2665	.2091	.1579	.1139	.0775	.0489	.0281	.0135	.0047	.0006	
ML (	d'	1.5071 .915	1.0303	.6203	⊕ .3148	⊕ .1036	⊖ .0277	⊖ .0955	⊖ ~~.1151~~ .1161	⊖ .1049	⊖ .0770	⊖ .0453	⊖ .0183	⊖ .0028	1
	ML	⊕ .5921	⊕ 1.0303	⊕ .6203	⊕ .3148	⊕ .1036	⊖ .0277	⊖ .0955	⊖ .1161 ~~.1151~~	⊖ .1049	⊖ .0770	⊖ .0453	⊖ .0183	⊖ .0028	
	MR	⊕ .5921	⊕ .2395	⊖ .0381	⊖ .2182	⊖ .3146	⊖ .3435	⊖ .3233	⊖ .2711	⊖ .2027	⊖ .1332	⊖ .0723	⊖ .0277	⊖ .0040	
	Mo Hog	⊕ 1.0059	⊕ .5919	⊕ .2503	⊕ .0111	⊖ .1380	⊖ .2127	⊖ .2308	⊖ .2095	⊖ .1647	⊖ .1118	⊖ .0623	⊖ .0243	⊖ .0036	0

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY ______ DATE ______ **FILE NO** ______

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CALCULATIONS FOR

SP Span No 2

Point load		(unit M.) SP	M	⑪	M	⑨	M	⑦	M
12	12,000	−.5769	−6,918	+.0248	+298	+.0162	+1194	+.0093	+112
11	38,400	−1.3720	−52,620	+.1791	+6875	+.1178	+4,524	+.0685	+2,630
10	13,100	−1.9477	−25,515	−.4994	−6,542	+.3321	+4,350	+.1963	+2,572
9	33,230	−2.2951	−76,265	−1.0009	−33,260	+.6692	+22,240	+.4026	+13,380
8	10,800	−2.4155	−26,087	−1.3234	−14,293	+.1342	+1,448	+.6947	+7,503
7	30,800	−2.2887	−70,490	−1.4463	−44,545	−.2522	−7,770	+1.0922	+33,640
6	9,800	−1.9537	−19,145	−1.3946	−13,665	−.5011	−4,910	+.5948	+5,830
5	27,550	−1.4559	−40,110	−1.1984	−33,015	−.6272	−17,280	+.1999	+5,505
4	9,140	−.8456	−7,730	−.8916	−8,150	−.6475	−5,920	−.0967	−884
3	22,850	−.1836	−4,195	−.5163	−11,800	−.5850	−13,365	−.3028	−6,920
2	17,820	+.4752	+8,468	−.1113	−1,983	−.4617	−8,227	−.4270	−7,610
1	16,860	+1.0717	+18,070	+.2795	+4,710	−.3055	−5,150	−.4842	−8,165
0	13,880	+1.5209	+21,110	+.5924	+8,223	−.1536	−2,132	−.4873	−6,764
1	16,860	+1.8575	+31,320	+.8467	+14,275	−.0099	−167	−.4602	−7,760
2	17,820	+2.0722	+36,930	+1.0343	+18430	+.1231	+2,194	−.4030	−7,180
3	22,850	+2.1294	+48,657	+1.1247	+25,700	+.2212	+5,055	−.3314	−7,572
4	9,140	+2.0404	+18,650	+1.1202	+10,240	+.2783	+2,544	−.2569	−2,348
5	27,550	+1.8305	+50,430	+1.0338	+28,480	+.2954	+8,138	−.1871	−5,155
6	9,800	+1.5375	+15,070	+.8876	+8,700	+.2791	+2,735	−.1270	−1,245
7	30,800	+1.1995	+36,945	+.7047	+21,705	+.2376	+7,318	−.0792	−2,440
8	10,800	+.8569	+9,255	+.5108	+5,517	+.1820	+1,965	−.0439	−474
9	33,230	+.5459	+18,140	+.3289	+10,930	+.1218	+4050	−.0220	−731
10	13,100	+.2915	+3,820	+.1776	+2,327	+.0683	+895	−.0083	−109
11	38,400	+.1102	+4,220	+.0677	+2,600	+.0268	+1,028	−.0021	−81
12	12,000	+.0155	+186	+.0096	+115	+.0038	+46	−.0003	−4
			−329075		+169,125		+68,724		+71,172
			+321,271		−167,253		−64921		−65,442
			−7,804		+1,872		+3,803		+5,730

Point load		⑤ M		③ M		① M		⓪ M.	
12	12,000	+.0039	+47	−.0002	−2	−.0028	−34	−.0036	−43
11	38,400	+.0296	+1,136	+.0005	+19	−.0183	−703	−.0243	−933
10	13,100	+.0886	+1,162	+.0078	+102	−.0453	−594	−.0623	−817
9	33,230	+.1902	+6,320	+.0299	+ ~~970~~ 990	−.0770	−2,560	−.1118	−3,715
8	10,800	+.3428	+3,705	+.0757	+818	−.1049	−1,132	−.1647	−1,778
7	30,800	+.5648	+17,395	+.1612	+4965	−.1161	−3,575	−.2095	−6,453
6	9,800	+.8635	+8,460	+.2988	+2,930	−.0955	−936	−.2308	−2,260
5	27,550	+1.2451	+34,300	+.5011	+13,805	−.0277	−763	−.2127	−5,860
4	9,140	+.7157	+6,540	+.7807	+7,135	+.1036	+947	−.1380	−1,262
3	22,850	+.2787	+6,370	+1.1492	+26,260	+.3148	+7,195	+.0111	+254
2	17,820	−.0640	−1,140	+.6162	+10,980	+.6203	+11,055	+.2503	+4,460
1	16,860	−.3163	−5,333	+.1861	+3,138	+1.0303	+17,370	+.5919	+9,980
0	13,880	−.4695	−6,517	−.1121	−1,556	+.5921	+8,220	+1.0059	+6981
1	16,860	−.5639	−9,507	−.3331	−5,615	+.2395	+4,037		
2	17,820	−.6008	−10,705	−.4814	−8,580	−.0381	−679		
3	22,850	−.5847	−13,360	−.5490	−12,545	−.2182	−4,985		
4	9,140	−.5305	−4,850	−.5515	−5,040	−.3146	−2,875		
5	27,550	−.4515	−12,440	−.5051	−13,915	−.3435	−9,460		
6	9,800	−.3603	−3,530	−.4270	−4,185	−.3233	−3,170		
7	30,800	−.2678	−8,250	−.3326	−10,245	−.2711	−8,350		
8	10,800	−.1822	−1,967	−.2357	−2,547	−.2027	−2,190		
9	33,230	−.1116	−3,710	−.1491	−4,955	−.1332	−4,428		
10	13,100	−.0568	−744	−.0784	−1,026	−.0723	−948		
11	38,400	−.0206	−791	−.0293	−1,125	−.0277	−1,063		
12	12,000	−.0029	−35	−.0042	−50	−.0040	−48		
			+85,435		−71,386		−48,493		
			82,879		+ ~~71,122~~ 71,142		+47,877		
			+2,556		− ~~264~~ 244		−616		

½ load

−23,121 × 2 = 46,242

+21,675 × 2 = 43,350

− 2,892

増田淳氏関係資料
(独立行政法人 土木研究所蔵)

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY______ DATE______ **FILE NO**______

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CALCULATIONS FOR

Dead load thrust

	Point	load					normal thrust	vertical shear		normal thrust
	0	6,940	2.425	16,830	531,640 ×	1,000 =	531,640	0	× 0	= 0
23,800	1	16,860	2.390	40,300	〃 ×	.999 =	531,110	15,370	× 0.030	= 460
41,620	2	17,820	2.265	40,360				32,710		
64,470	3	22,850	2.064	47,160	〃 ×	.995 =	529,000	53,045	× 0.095	= 5,040
73,610	4	9,140	1.806	16,500				69,040		
101,160	5	27,550	1.505	41,460	〃 ×	.985 =	523,660	87,385	× 0.162	= 14,160
110,960	6	9,800	1.191	11,670				106,060		
141,760	7	30,800	0.884	27,230	〃 ×	.975 =	518,350	126,360	× 0.230	= 29,060
152,560	8	10,800	.605	6,535				147,160		
[illegible]	9	33,230	.373	12,400	〃 ×	.955 =	507,720	169,175	× 0.305	= 51,600
198,880	10	13,100	.193	2,530				192,340		
237,290	11	38,400	.071	2,725	〃 ×	.925 =	491,680	218,090	× 0.380	= 82,870
249,290	12	12,000	.010	120				243,290		
	SP.	6,650	0	0	〃 ×	.900 =	478,480	255,940	× 0.425	= 108,770
		255,940		265,820 × 2 = 531640						

Summary of dead load normal thrusts

	0	1	3	5	7	9	11	SP.
Due to vertical shear	0	460	5,040	14,160	29,060	51,600	82,870	108,770
Due to Horizontal thrust	531,640	531,110	529,000	523,660	518,350	507,720	491,680	478,480
	531,640	531,570	534,040	537,820	547,410	559,320	574,550	587,250

Temperature stress

$$H_0 = \frac{Ewt l \int \frac{ds}{I}}{2\left[\int \frac{ds}{I} \int y^2 \frac{ds}{I} - \left(\int y \frac{ds}{I}\right)^2\right]} = \frac{Ewt\ 252000 \times 25.05 \times 1183.17}{1065206} = 7,010$$

746928000   29640

for 1 meter strip for 85 meter width
$7.010 \times 85 = 59,590$

$t = 15°$
$E = 1,400,000,000$
$w = 0.000012$

$Ewt = 252000$

$$M_0 = -\frac{H_0 \int y \frac{ds}{I}}{\int \frac{ds}{I}} = \frac{59,590 \times 621.64}{1183.17} = 31,310$$

Panel Point									normal thrust
1	31,310	−	59,590 × 0.018	=	+ 30,240	59,590	× .999	=	59,530
3	〃	−	〃 × .140	=	+ 22,970	〃	× .995	=	59,290
5	〃	−	〃 × .405	=	+ 7,180	〃	× .985	=	58,700
7	〃	−	〃 × .810	=	− 16,960	〃	× .975	=	58,100
9	〃	−	〃 × 1.360	=	− 49,730	〃	× .955	=	56,900
11	〃	−	〃 × 2.080	=	− 92,640	〃	× .925	=	55,120
SP	〃	−	〃 × 2.794	=	− 135,180	〃	× .900	=	53,630

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CALCULATIONS FOR 3

①

Span no. 3.

	x	y	d	do
0	0	0	.400	.265
1	.765	0.010	.401	1.000
2	1.765	0.048	.405	1.002
3	2.765	0.120	.412	1.003
4	3.765	0.225	.420	1.006
5	4.765	0.355	.432	1.010
6	5.765	0.525	.452	1.016
7	6.765	0.725	.475	1.022
8	7.765	0.955	.500	1.030
9	8.765	1.225	.527	1.039
10	9.765	1.530	.565	1.051
11	10.765	1.880	.615	1.066
12	11.765	2.270	.675	1.084
13	12.765	2.690	.755	.890
Sp.	13.375	2.994	.800	.340

Division	d	d^3	$I_c=\frac{1}{12}d^3$	$(\frac{d}{2}-0.045)^2$ @ .00438	I_s .00438×2	I_c+I_s	Equivalent area	Concrete area
0	.400	.0640	.00533	.0240	.00105	.00638	.0438	.400
1	.401	.0645	.00537	.0242	.00106	.00693	〃	.401
2	.405	.0664	.00553	.0248	.00109	.00662	〃	.405
3	.412	.0699	.00557	.0259	.00113	.00670	〃	.412
4	.420	.0741	.00617	.0272	.00119	.00736	〃	.420
5	.432	.0806	.00672	.0292	.00128	.00800	〃	.432
6	.452	.0923	.00769	.0328	.00144	.00913	〃	.452
7	.475	.1072	.00893	.0371	.00162	.01055	〃	.475
8	.500	.1250	.01042	.0420	.00184	.01226	〃	.500
9	.527	.1464	.01220	.0477	.00209	.01429	〃	.527
10	.565	.1804	.01503	.0569	.00494	.01997	.0876	.565
11	.615	.2326	.01938	.0689	.00604	.02542	〃	.615
12	.675	.3075	.02562	.0856	.00750	.03312	〃	.675
13	.755	.4304	.03587	.1106	.00969	.04556	〃	.755
Sp	.800	.5120	.04267	.1260	.01104	.05371	〃	.800

Division	x	x^2	y	y^2	do	I	do/I	$x\frac{do}{I}$	$x^2\frac{do}{I}$	$y\frac{do}{I}$	$y^2\frac{do}{I}$
0	0	0	0	0	.265	.00638	41.54	0	0	0	0
1	.765	.585	.010	.0001	1.000	.00643	155.52	118.97	90.98 ✓	1.56	.02
2	1.765	3.115	.048	.002	1.002	.00662	151.36	267.15	471.49 ✓	7.27	.30
3	2.765	7.645	.120	.014	1.003	.00670	149.70	413.92	1144.46 ✓	17.96	2.10
4	3.765	14.175	.225	.051	1.006	.00736	136.68	514.60	1937.44 ✓	30.75	6.97
5	4.765	22.705	.355	.126	1.010	.00800	126.25	601.58	2866.51 ✓	44.82	15.91
6	5.765	33.235	.525	.276	1.016	.00913	111.28	641.53	3698.39 ✓	58.42	30.71
7	6.765	45.765	.725	.526	1.022	.01055	96.87	655.33	4433.26 ✓	70.23	50.95
8	7.765	60.295	.955	.912	1.030	.01226	84.01	652.39	5065.38 ✓	80.23	76.62
9	8.765	76.825	1.225	1.501	1.039	.01429	72.71	637.30	5585.95 ✓	89.07	109.14
10	9.765	95.355	1.530	2.341	1.051	.01997	52.63	513.93	5018.53 ✓	80.52	123.21
11	10.765	115.885	1.880	3.534	1.066	.02542	41.94	451.48	4860.22 ✓	78.85	148.22
12	11.765	138.415	2.270	5.153	1.084	.03312	32.73	385.07	4530.32 ✓	74.30	168.66
13	12.765	162.945	2.690	7.236	.890	.04556	19.53	249.30	3182.32 ✓	52.54	141.32
Sp	13.375	178.891	2.994	8.969	.340	.05371	6.33	84.66	1132.38 ✓	18.95	56.79
					13.829 ✓		1279.08 ✓	6187.16	44017.63 ✓	705.47 ✓	930.87 ✓

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CALCULATIONS FOR

3

Shinoba-Bashi Span no. 3

②

Division	x	m	⓪ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	① $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	② $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0	0	0	0	0	0				0			
1	.765	–	118.97	90.98	1.19	0	0	0	0	0			
2	1.765	–	267.15	471.49	12.83	1.0	151.36	267.15	7.27	0	0	0	0
3	2.765	–	413.92	1144.46	49.66	2.0	299.40	827.84	35.92	1.0	149.70	413.92	17.96
4	3.765	–	519.60	1937.44	115.77	3.0	410.04	1543.80	92.25	2.0	273.36	1209.20	61.50
5	4.765	–	601.58	2866.51	213.57	4.0	505.00	2406.32	179.28	3.0	378.75	1804.74	134.46
6	5.765	–	641.53	3698.39	336.79	5.0	556.40	3207.65	292.10	4.0	445.12	2566.12	233.68
7	6.765	–	655.33	4433.26	475.11	6.0	581.22	3931.98	421.38	5.0	484.35	3276.65	351.15
8	7.765	–	652.34	5065.38	622.99	7.0	588.07	4566.38	561.61	6.0	504.06	3914.04	481.38
9	8.765	–	637.30	5585.95	780.70	8.0	581.68	5098.40	712.56	7.0	508.97	4461.10	623.49
10	9.765	–	513.93	5018.53	786.28	9.0	473.67	4625.37	724.68	8.0	421.04	4111.44	644.16
11	10.765	–	451.48	4860.22	848.82	10.0	419.40	4514.80	788.50	9.0	377.46	4063.32	709.65
12	11.765	–	385.07	4530.32	874.14	11.0	360.03	4235.77	817.30	10.0	327.30	3850.70	743.00
13	12.765	–	249.30	3182.32	670.67	12.0	234.36	2991.60	630.48	11.0	214.83	2742.30	577.94
sp	13.375	–	84.66	1132.38	253.46	12.61	79.82	1067.56	238.96	11.61	73.49	982.94	220.01
			6187.16	44017.63	6041.98		5240.45√	39289.62√	5502.29√		4158.43√	33396.47√	4798.38√

Division	x	m	③ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	④ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑤ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
4		1.0	136.68	514.60	30.75	0	0	0	0	0			
5		2.0	252.50	1203.16	89.64	1.0	126.25	601.58	44.82	0	0	0	0
6		3.0	333.84	1924.59	175.25	2.0	222.56	1283.06	116.84	1.0	111.28	641.53√	58.42
7		4.0	387.48	2621.32	280.92	3.0	290.61	1965.99	210.69	2.0	193.74	1310.66√	140.46
8		5.0	420.05	3261.70	401.15	4.0	336.04	2609.36	320.92	3.0	252.03	1957.02√	240.69
9		6.0	436.26	3823.80	534.42	5.0	363.55	3186.50	445.35	4.0	290.84	2549.20√	356.28
10		7.0	368.41	3597.51	563.64	6.0	315.78	3083.58	483.12	5.0	263.15	2569.65	402.60
11		8.0	335.52	3611.84	630.80	7.0	293.58	3160.36	551.95	6.0	251.64	2708.88√	473.10
12		9.0	294.57	3465.63	668.70	8.0	261.84	3080.56	594.40	7.0	229.11	2695.49√	520.10
13		10.0	195.30	2493.00	525.40	9.0	175.77	2243.70	472.86	8.0	156.24	1994.40√	420.32
sp		10.61	67.16	898.24	201.06	9.61	60.83	813.58	182.11	8.61	54.50	728.92√	163.16
			3227.77√	27415.39√	4101.73√		2446.81√	22028.27√	3423.06√		1802.53√	~~16655.75~~√ 17155.75	2775.13√

Division	x	m	⑥ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑦ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑧ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
7		1.0	96.87	655.33	70.23	0	0	0	0	0			
8		2.0	168.02	1304.68	160.46	1.0	84.01	652.34	80.23	0	0	0	0
9		3.0	218.13	1911.90	267.21	2.0	145.42	1274.60	178.14	1.0	72.71	637.30	89.07
10		4.0	210.52	2055.72	322.08	3.0	157.89	1541.79	241.56	2.0	105.26	1027.86	161.04
11		5.0	209.70	2257.40	394.25	4.0	167.76	1805.92	315.40	3.0	125.82	1359.44	236.55
12		6.0	196.38	2310.42	445.80	5.0	163.65	1925.35	371.50	4.0	130.92	1540.28	297.20
13		7.0	136.71	1745.10	367.78	6.0	117.18	1495.80	315.24	5.0	97.65	1246.50	262.70
sp		7.61	48.17	644.26	144.21	6.61	41.84	559.60	125.26	5.61	35.51	474.94	106.31
			1284.50√	12884.81√	2172.02√		877.75√	9255.40√	1627.33√		567.87√	6281.32√	1152.87√

Division	x	m	⑨ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑩ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑪ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
10		1.0	52.63	513.93	80.52	0	0	0	0	0			
11		2.0	83.88	902.96	157.70	1.0	41.94	451.48	78.85	0	0	0	0
12		3.0	98.19	1155.21	222.90	2.0	65.46	770.14	148.60	1.0	32.73	385.07	74.30
13		4.0	78.12	997.20	210.16	3.0	58.59	747.90	157.62	2.0	39.06	498.60	105.08
sp		4.61	29.18	390.28	87.36	3.61	22.85	305.62	68.41	2.61	16.52	220.96	49.46
			342.00√	3959.58√	758.64√		188.84√	2275.14√	453.49√		88.31√	1104.63√	228.84√

Division	x	m	⑫ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	⑬ $m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
13		1.0	19.53	249.30	52.54	0	0	0	0
sp		1.61	10.19	136.30	30.51	.61	3.86	51.64	11.56
			29.72√	385.60√	83.05√		3.86√	51.64√	11.56√

CALCULATIONS FOR 3

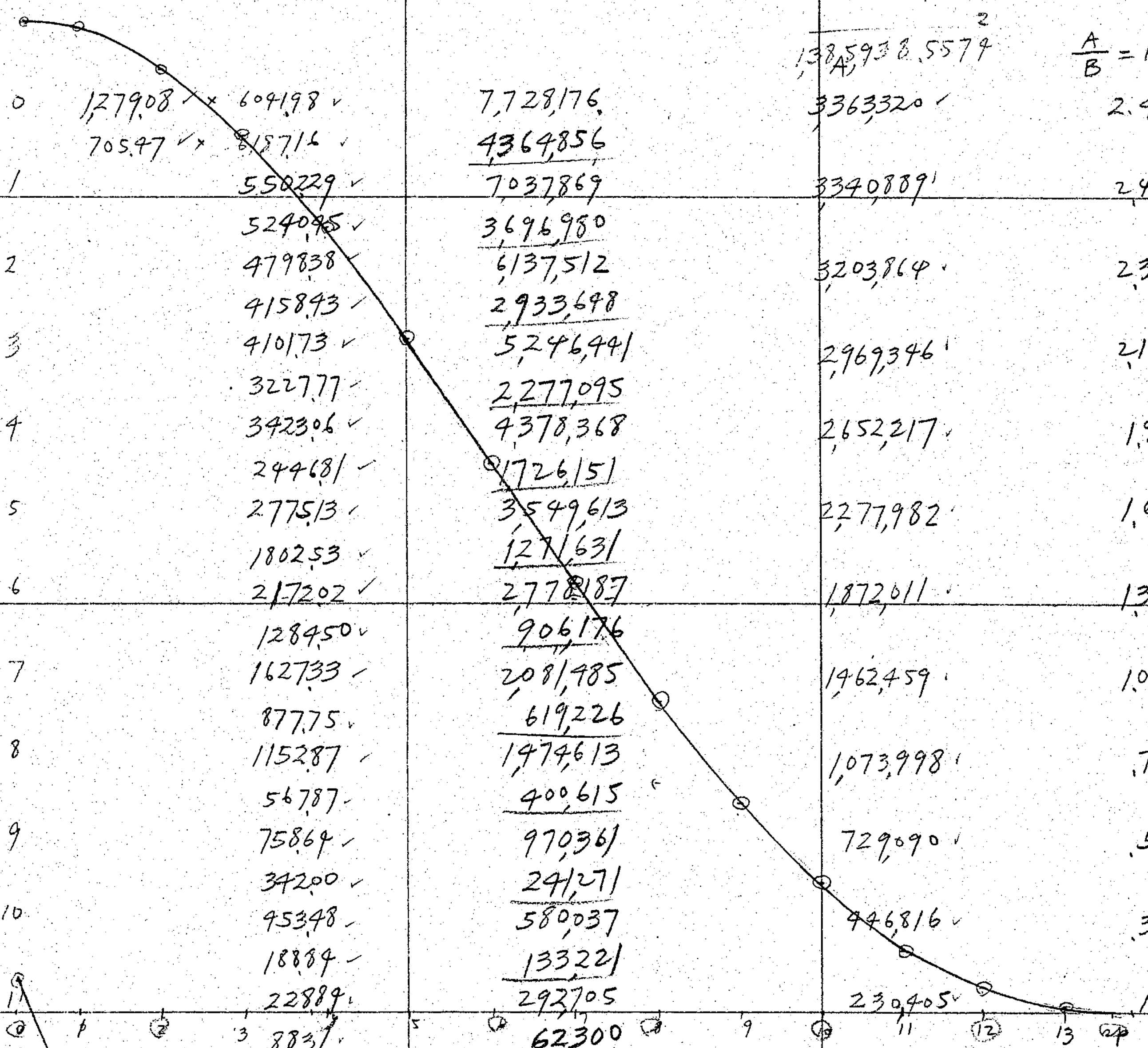
Shinoku-Bashi Span no. 3 ③

$$H_0 = \frac{\int\frac{ds}{I}\int my\frac{ds}{I} - \int m\frac{ds}{I}\int y\frac{ds}{I}}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = \frac{A}{B}$$

$B = 2\left[127908 \times 93087 - (70547)^2\right] = 1385939$

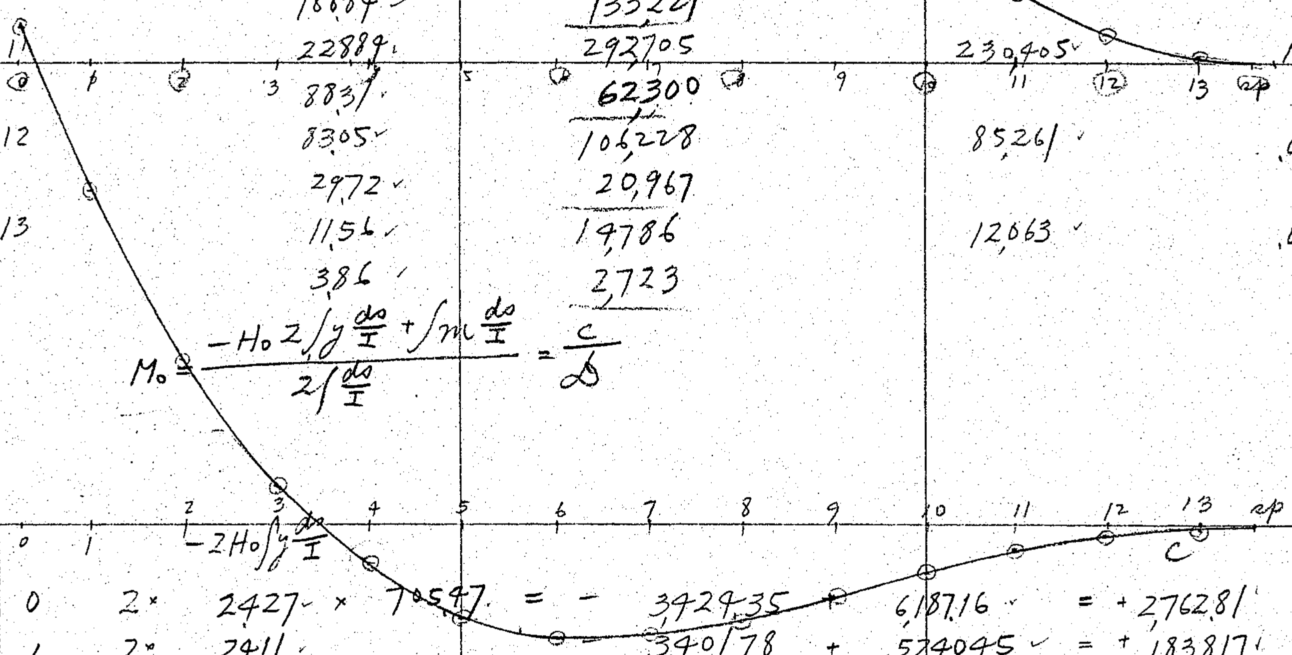
1,190,6571996
497,6879209
692969,2787
2
1385938,5574

$\frac{A}{B} = H_0$



			(A)	
0	127908 × 604198	7,728,176	3363320	2.427
	705.47 × 818716	4364856		
1	550229	7037869	3340889	2411
	524095	3696980		
2	479838	6137512	3203864	2312
	415843	2933698		
3	410173	5246441	2969346	2142
	322777	2277095		
4	342306	4378368	2652217	1914
	244681	1726151		
5	277513	3549613	2277982	1644
	180253	1271631		
6	217202	2778187	1872011	1351
	128450	906176		
7	162733	2081985	1462459	1055
	87775	619226		
8	115287	1474613	1073998	.775
	56787	400615		
9	75864	970361	729090	.526
	34200	241271		
10	45348	580037	446816	.322
	18884	133221		
11	22889	292705	230405	.166
	8831	62300		
12	8305	106228	85261	.062
	2972	20967		
13	1156	14786	12063	.009
	386	2723		

$$M_0 = \frac{-H_0 2\int y\frac{ds}{I} + \int m\frac{ds}{I}}{2\int\frac{ds}{I}} = \frac{C}{D}$$



	$-2H_0\int y\frac{ds}{I}$					C	$2\int\frac{ds}{I}$ D	M_0
0	2 × 2427 × 70547	= − 342435	+	618716	=	+ 276281	÷ 255816	= + 1.0800
1	2 × 2411	− 340178	+	524095	=	+ 183817	〃	= + .7186
2	2 × 2312	− 326209	+	415843	=	+ 89634	〃	= + .3504
3	2 × 2142	− 302223	+	322777	=	+ 20554	〃	= + .0835
4	2 × 1914	− 270054	+	244681	=	− 25373	〃	= − .0992
5	2 × 1644	− 231959	+	180253	=	− 51706	〃	= − .2021
6	2 × 1351	− 190618	+	128450	=	− 62168	〃	= − .2430
7	2 × 1055	− 148854	+	87775	=	− 61079	〃	= − .2388
8	2 × .775	− 109348	+	56787	=	− 52561	〃	= − .2055
9	2 × .526	− 74215	+	34200	=	− 40015	〃	= − .1564
10	2 × .322	− 45432	+	18884	=	− 26548	〃	= − .1038
11	2 × .166	− 23422	+	8831	=	− 14591	〃	= − .0570
12	2 × .062	− 8748	+	2972	=	− 5776	〃	= − .0226
13	2 × .009	− 1270	+	386	=	− 884	〃	= − .0035
sp	0							= 0

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CALCULATIONS FOR 3

Shinobu-Bashi span no. 3 ④

$$V_0 = \frac{\int m x \frac{ds}{I}}{2\int x^2 \frac{ds}{I}} = \frac{E}{F}$$

0	44017.63	÷	88035.26	=	.5000
1	39284.62			=	.4462
2	33396.47			=	.3794
3	27415.39			=	.3114
4	22028.27			=	.2502
5	~~11655.75~~ 17155.75			=	~~.1892~~ .1949
6	12884.81			=	.1464
7	9255.40			=	.1051
8	6281.32			=	.0714
9	3959.58			=	.0450
10	2275.14			=	.0258
11	1104.63			=	.0125
12	385.60			=	.0044
13	51.69			=	.0006
sp	0			=	0

d' lever arm of unit load about center of section origin at crown
left hand

$M_L = M_0 + H_0 y + V_0 x - d'$

$M_R = M_0 + H_0 y - V_0 x$

Point SP

$x = 13.375$ $y = 2.994$

	M_0	$H_0 y$	$V_0 x$	d'
0	+1.0800	7.2664	6.6875	13.375
1	+.7186	7.2185	5.9679	12.61
2	+.3504	6.9221	5.0745	11.61
3	+.0835	6.4131	4.1650	10.61
4	−.0992	5.7305	3.3464	9.61
5	−.2021	4.9221	2.6068	8.61
6	−.2430	4.0449	1.9581	7.61
7	−.2388	3.1587	1.4057	6.61
8	−.2055	2.3204	.9550	5.61
9	−.1564	1.5748	.6019	4.61
10	−.1038	.9641	.3451	3.61
11	−.0570	.4970	.1672	2.61
12	−.0226	.1856	.0589	1.61
13	−.0035	.0269	.0080	.61
sp	0	0	0	0

12

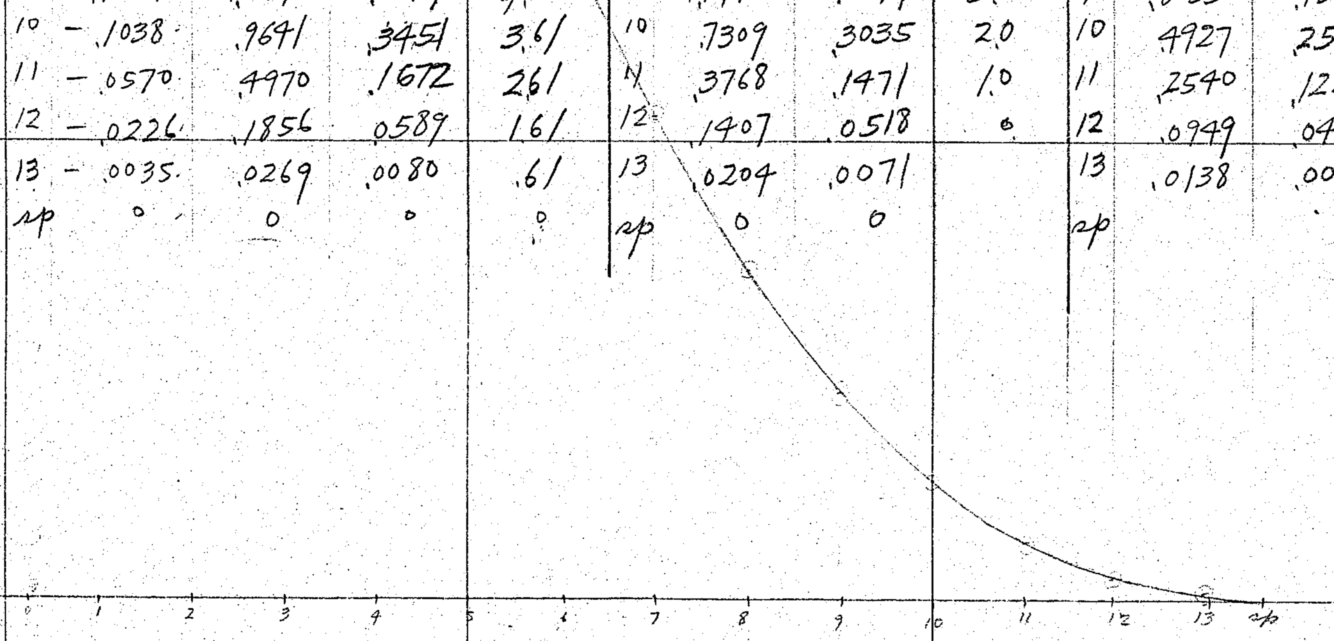
$x = 11.765$ $y = 2.270$

	$H_0 y$	$V_0 x$	d'
0	5.5093	5.8825	11.765
1	5.4730	5.2495	11.0
2	5.2482	4.4636	10.0
3	4.8623	3.6636	9.0
4	4.3448	2.9436	8.0
5	3.7319	2.2930	7.0
6	3.0668	1.7224	6.0
7	2.3949	1.2365	5.0
8	1.7593	.8400	4.0
9	1.1940	.5294	3.0
10	.7309	.3035	2.0
11	.3768	.1471	1.0
12	.1407	.0518	0
13	.0204	.0071	
sp	0	0	

10

$x = 9.765$ $y = 1.530$

	$H_0 y$	$V_0 x$	d'
0	3.7133	4.8825	9.765
1	3.6888	4.3571	9.0
2	3.5374	3.7048	8.0
3	3.2773	3.0408	7.0
4	2.9284	2.4432	6.0
5	2.5153	1.9032	5.0
6	2.0670	1.4296	4.0
7	1.6142	1.0263	3.0
8	1.1858	.6972	2.0
9	.8033	.4394	1.0
10	.4927	.2519	0
11	.2540	.1221	
12	.0949	.0430	
13	.0138	.0059	
sp			



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CALCULATIONS FOR 3

Shinobu-Bashi span no. 3

5

Point 8: $x = 7.765'$ $y = 0.955'$

	M_0	$H_0 y$	$V_0 x$	d'
0	+1.0880	2.3178	3.8825	7.765
1	+.7186	2.3025	3.4647	7.0
2	+.3504	2.2080	2.9460	6.0
3	+.0835	2.0456	2.4180	5.0
4	−.0992	1.8279	1.9428	4.0
5	−.2021	1.5700	1.5134	3.0
6	−.2430	1.2902	1.1368	2.0
7	−.2388	1.0075	.8161	1.0
8	−.2055	.7401	.5544	0
9	−.1564	.5023	.3494	
10	−.1038	.3075	.2003	
11	−.0570	.1585	.0971	
12	−.0226	.0592	.0342	
13	−.0035	.0086	.0047	
sp	0	0		

Point 6: $x = 5.765'$ $y = .525'$

	$H_0 y$	$V_0 x$	d'
0	1.2742	2.8825	5.765
1	1.2658	2.5723	5.0
2	1.2138	2.1872	4.0
3	1.1246	1.7952	3.0
4	1.0049	1.4424	2.0
5	.8631	1.1236	1.0
6	.7093	.8440	0
7	.5539	.6059	
8	.4069	.4116	
9	.2762	.2594	
10	.1691	.1487	
11	.0872	.0721	
12	.0326	.0254	
13	.0047	.0035	
sp	0		

Point 4: $x = 3.765'$ $y = .225'$

	$H_0 y$	$V_0 x$	d'
0	.5461	1.8825	3.765
1	.5425	1.6799	3.0
2	.5202	1.4284	2.0
3	.4820	1.1724	1.0
4	.4307	.9420	0
5	.3699	.7338	
6	.3040	.5512	
7	.2374	.3957	
8	.1744	.2688	
9	.1184	.1694	
10	.0725	.0971	
11	.0374	.0471	
12	.0140	.0166	
13	.0020	.0023	
sp	0	0	

Point 2: $x = 1.765'$ $y = .048'$

	M_0	$H_0 y$	$V_0 x$	d'
0	+1.0800	.1165	.8825	1.765
1	+.7186	.1157	.7875	1.0
2	+.3504	.1110	.6696	0
3	+.0835	.1028	.5496	
4	−.0992	.0919	.4416	
5	−.2021	.0789	.3440	
6	−.2430	.0648	.2584	
7	−.2388	.0526	.1855	
8	−.2055	.0372	.1260	
9	−.1564	.0252	.0794	
10	−.1038	.0155	.0455	
11	−.0570	.0056	.0221	
12	−.0226	.0030	.0078	
13	−.0035	.0004	.0011	
sp	− 0	0	0	

Point 0: $x = 0$ $y = 0$

	$H_0 y$	$V_0 x$	d'
0	0	0	0
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
sp			

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR 3

Shinobu-Bashi span no.3

6

Group		0	1	2	3	4	5	6	7	8	9	10	11	12	13
5F	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	7.2669	7.2185	6.9221	6.9131	5.7305	4.9221	4.0449	3.1587	2.3209	1.5748	.9691	.4970	.1856	.0269
	Tox	+8.3464	+7.9371	+7.2725	+6.4966	+5.6313	+4.7200	+3.8019	+2.9199	+2.1149	+1.4184	+.8603	+.4400	+.1630	+.0239
		+6.6875	+5.9679	+5.0745	+4.1650	+3.3469	+2.6068	+1.9581	+1.4057	+.9550	+.6019	+.3451	+.1672	+.0589	+.0080
	d'	+15.0339	+13.9050	+12.3470	+10.6616	+8.9777	+7.3268	+5.7600	+4.3256	+3.0699	+2.0203	+1.2054	+.6072	+.2219	+.0314
		13.375	12.61	11.61	10.61	9.61	8.61	7.61	6.61	5.61	4.61	3.61	2.61	1.61	.61
	ML	+1.6589	+1.2950	+0.7370	.0516	-.6323	-1.2832	-1.8500	-2.2849	-2.5401	-2.5897	-2.4046	-2.0028	-1.3881	-.5786
	MR	+1.6589	+1.9692	+2.1980	+2.3316	+2.2848	+2.1132	+1.8438	+1.5142	+1.1599	+.8161	+.5152	+.2728	+.1041	+.0154
12	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	5.5093	5.4730	5.2482	4.8623	4.3448	3.7319	3.0668	2.3949	1.7593	1.1940	.7309	.3768	.1407	.0204
	Tox	+6.5893	+6.1916	+5.5986	+4.9458	+4.2456	+3.5298	+2.8238	+2.1561	+1.5548	+1.0376	+.6271	+.3198	+.1181	+.0169
		5.8825	5.2495	4.4636	3.6636	2.9434	2.2930	1.7224	1.2365	.8400	.5294	.3035	.1471	.0518	.0071
	d'	+12.4718	+11.4411	+10.0622	+8.6094	+7.1892	+5.8228	+4.5462	+3.3925	+2.3948	+1.5670	+.9306	+.4669	+.1699	+.0240
		11.765	11.0	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0		
	ML	+.7068	+.4411	+.0622	-.3906	-.8108	-1.1772	-1.4538	-1.6075	-1.6052	-1.4330	-1.0694	-.5331	+.1699	+.0240
	MR	+.7068	+.9421	+1.1350	+1.2822	+1.3020	+1.2368	+1.1014	+.9196	+.7148	+.5082	+.3231	+.1727	+.0663	+.0098
10	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	3.7133	3.6888	3.5374	3.2773	2.9289	2.5153	2.0670	1.6142	1.1858	.8033	.4927	.2540	.0949	.0138
	Tox	+4.7933	+4.4079	+3.8878	+3.3608	+2.8292	+2.3132	+1.8240	+1.3754	+.9803	+.6469	+.3889	+.1970	+.0723	+.0103
		4.8825	4.3571	3.7048	3.0408	2.4932	1.9032	1.4296	1.0263	.6972	.4394	.2519	.1221	.0430	.0059
	d'	+9.6758	+8.7645	+7.5926	+6.4016	+5.2724	+4.2164	+3.2536	+2.4017	+1.6775	+1.0863	+.6408	+.3191	+.1153	+.0162
		9.765	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0				
	ML	-.0892	-.2355	-.4074	-.5989	-.7276	-.7836	-.7469	-.5983	-.3225	+.0863	+.6408	+.3191	+.1153	+.0162
	MR	-.0892	+.0503	+.1830	+.3200	+.3860	+.4100	+.3944	+.3491	+.2831	+.2075	+.1370	+.0749	+.0293	+.0044
8	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	2.3178	2.3025	2.2080	2.0456	1.8279	1.5700	1.2902	1.0075	.7401	.5023	.3075	.1585	.0592	.0086
	Tox	+3.3978	+3.0211	+2.5584	+2.1291	+1.7287	+1.3679	+1.0472	+.7687	+.5346	+.3459	+.2037	+.1015	+.0366	+.0051
		3.8825	3.4647	2.9460	2.4180	1.9428	1.5134	1.1368	.8161	.5549	.3499	.2003	.0971	.0342	.0047
	d'	+7.2803	+6.4858	+5.5044	+4.5471	+3.6715	+2.8813	+2.1840	+1.5848	+1.0890	+.6953	+.4040	+.1986	+.0708	+.0098
		7.765	7.0	6.0	5.0	4.0	3.0	2.0	1.0						
	ML	-.4847	-.5142	-.4951	-.4529	-.3285	-.1187	+.1840	+.5848	+1.0890	+.6953	+.4040	+.1986	+.0708	+.0098
	MR	-.4847	-.4936	-.3876	-.2889	-.2141	-.1455	-.0896	-.0474	-.0198	-.0035	+.0034	+.0044	+.0029	+.0004
6	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1564	-.1038	-.0570	-.0226	-.0035
	Hoy	1.2742	1.2658	1.2138	1.1246	1.0049	.8631	.7093	.5539	.4069	.2762	.1691	.0872	.0326	.0047
	Tox	+2.3592	+1.9849	+1.5642	+1.2081	+.9057	+.6610	+.4663	+.3151	+.2014	+.1198	+.0653	+.0302	+.0100	+.0012
		2.8825	2.5723	2.1872	1.7952	1.4424	1.1236	.8440	.6059	.4116	.2599	.1487	.0721	.0254	.0035
	d'	+5.2367	+4.5567	+3.7514	+3.0033	+2.3481	+1.7846	+1.3103	+.9210	+.6130	+.3792	+.2140	+.1023	+.0354	+.0047
		5.765	5.0	4.0	3.0	2.0	1.0								
	ML	-.5283	-.4433	-.2486	+.0033	+.3481	+.7846	+1.3103	+.9210	+.6130	+.3792	+.2140	+.1023	+.0354	+.0047
	MR	-.5283	-.5879	-.6230	-.5871	-.5367	-.4626	-.3777	-.2908	-.2102	-.1396	-.0834	-.0419	-.0154	-.0023

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CALCULATIONS FOR 3

Shinobu-Bashi span no. 3

		0	1	2	3	4	5	6	7	8	9	10	11	12	13
7	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	.5461	.5425	.5202	.4820	.4307	.3699	.3040	.2374	.1749	.1184	.0725	.0374	.0140	.0020
	Tox	+.1626 .18825	+.1261 .16799	+.8706 .14284	+.5655 .11724	+.3315 .9420	+.1678 .7338	+.0610 .5512	-.0014 .3957	-.0311 .2688	-.0380 .1699	-.0313 .0971	-.0196 .0471	-.0086 .0166	-.0015 .0023
	d'	+.35086 3.765	+.29410 3.0	+.22990 2.0	+.17379 1.0	+.12735	+.9016	+.6122	+.3943	+.2377	+.1314	+.0658	+.0275	+.0080	+.0008
	ML	-.2564	-.0590	+.2990	+.7379	+.12735	+.9016	+.6122	+.3943	+.2377	+.1314	+.0658	+.0275	+.0080	+.0008
	MR	-.2564	-.4188	-.5578	-.6069	-.6105	-.5660	-.4902	-.3971	-.2999	-.2074	-.1289	-.0667	-.0252	-.0038
2	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy	.1165	.1157	.1110	.1028	.0919	.0789	.0648	.0526	.0372	.0252	.0155	.0056	.0030	.0004
	Tox	+.1965 .8825	+.8343 .7875	+.4614 .6696	+.1863 .5496	-.0073 .4416	-.1232 .3440	-.1782 .2584	-.1862 .1855	-.1683 .1260	-.1312 .0794	-.0883 .0455	-.0514 .0221	-.0196 .0078	-.0031 .0011
	d'	+.20790 .1765	+.16218 1.0	+.1310	+.7358	+.4393	+.2208	+.0802	-.0007	-.0423	-.0518	-.0428	-.0293	-.0118	-.0020
	ML	+.3140	+.6218	+.1310	+.7358	+.4393	+.2208	+.0802	-.0007	-.0423	-.0518	-.0428	-.0293	-.0118	-.0020
	MR	+.3140	+.0468	-.2082	-.3633	-.4489	-.4672	-.4366	-.3717	-.2993	-.2106	-.1338	-.0735	-.0279	-.0042
0	Mo	+1.0800	+.7186	+.3504	+.0835	-.0992	-.2021	-.2430	-.2388	-.2055	-.1569	-.1038	-.0570	-.0226	-.0035
	Hoy														
	Tox														
	d'														
	ML														
	MR														

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CALCULATIONS FOR

sp 6,650

			3							8	
			SP		12		10		8		6
	Load	M (unit)	M	M (unit)	M	M (unit)	M	M (unit)	M	M (unit)	M
13	12,000	-.5786	-6,948	+.0240	+288	+.0162	+194	+.0098	+118	+.0047	+56
12	39,140	-1.3881	-54,350	+.1699	+6,646	+.1153	+4,515	+.0708	+2,767	+.0354	+1,385
11	13,250	-2.0028	-26,530	-.5331	-7,062	+.3191	+4,238	+.1986	+2,631	+.1023	+1,356
10	33,980	-2.4046	-81,700	-1.0694	-36,320	+.6408	+21,770	+.4040	+13,730	+.2140	+7,270
9	11,200	-2.5897	-29,000	-1.4330	-16,060	+.0863	+967	+.6953	+7,788	+.3792	+4,250
8	32,040	-2.5401	-81,400	-1.6052	-51,420	-.3225	-10,325	+1.0890	+34,890	+.6130	+19,640
7	9,900	-2.2844	-22,610	-1.6075	-15,910	-.5983	-5,925	+.5848	+5,790	+.9210	+9,120
6	28,410	-1.8500	-52,550	-1.4538	-41,300	-.7464	-21,200	+.1840	+5,226	+1.3103	+37,220
5	9,440	-1.2832	-12,110	-1.1772	-11,110	-.7836	-7,390	-.1187	-1,120	+.7846	+7,410
4	23,600	-.6323	-14,920	-.8108	-19,130	-.7276	-17,160	-.3285	-7,750	+.3481	+8,215
3	18,860	+.0516	+973	-.3906	-7,362	-.5984	-11,280	-.4529	-8,540	+.0033	+62
2	17,680	+.7370	+13,040	+.0622	+1,100	-.4074	-7,205	-.4956	-8,765	-.2486	-4,395
1	16,860	+1.2950	+21,820	+.4411	+7,438	-.2355	-3,968	-.5142	-8,670	-.4433	-7,472
0	8,780	+1.6589	+14,560	+.7068	+6,202	-.0892	-783	-.4847	-4,252	-.5283	-4,640
1	16,860	+1.9692	+33,180	+.9421	+15,880	+.0503	+848	-.4436	-7,475	-.5879	-9,900
2	17,680	+2.1980	38,860 + ~~38,750~~	+1.1350	+20,080	+.1830	+3,235	-.3876	-6,855	-.6230	-11,025
3	18,860	+2.3316	+43,950	+1.2822	+24,170	+.3200	+6,030	-.2889	-5,442	-.5871	-11,070
4	23,600	+2.2848	+53,900	+1.3020	+30,720	+.3860	+9,110	-.2141	-5,053	-.5367	-12,660
5	9,440	+2.1132	+19,930	+1.2368	+11,670	+.4100	+3,868	-.1455	-1,372	-.4626	-4,365
6	28,410	+1.8438	+52,370	+1.1014	+31,300	+.3944	+11,200	-.0896	-2,545	-.3777	-10,720
7	9,900	+1.5142	+14,980	+.9196	+9,100	+.3491	+3,455	-.0474	-469	-.2908	-2,878
8	32,040	+1.1599	+37,170	+.7148	+22,900	+.2831	+9,070	-.0198	-634	-.2102	-6,728
9	11,200	+.8161	+9,145	+.5082	+5,695	+.2075	+2,325	-.0035	-39	-.1396	-1,564
10	33,980	+.5152	+17,500	+.3236	+10,980	+.1370	4,655 + ~~4,552~~	+.0034	+115	-.0834	-2,833
11	13,250	+.2728	+3,615	+.1727	+2,288	+.0749	+993	+.0044	+58	-.0419	-555
12	39,140	+.1041	+4,075	+.0663	+2,595	+.0293	+1,146	+.0024	+94	-.0154	-602
13	12,000	+.0159	+185	+.0098	+118	+.0044	+53	+.0004	+5	-.0023	-28
			-382,118		+209,170		~~+87,569~~		+73,212		+95,984
			~~+379,143~~		-205,674		-85,236	+87,672	68,981		-91,435
13			- ~~2,975~~	379253	+3,496		+ ~~2,333~~		+4,231		+4,549
12			-2,865				+2,436				
11											
10											
9											
8											
7											
6											
5											
4											
3											
2											
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JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

③ ⑨

	Load	M (unit)	④ M	M (unit)	② M	M (unit)	M
13	12,000	+ .0008	+ 10	- .0020	- 24		
12	39,140	+ .0080	+ 313	- .0118	- 469		
11	13,250	+ .0275	+ 364	- .0293	- 388		
10	33,980	+ .0658	+ 2,235	- .0428	- 1,459		
9	11,200	+ .1314	+ 1,472	- .0518	- 581		
8	32,040	+ .2377	+ ~~6,610~~ 7616	- .0423	- 1,355		
7	9,900	+ .3943	+ 3,905	- .0007	- 7		
6	28,410	+ .6122	+ 17,380	+ .0802	+ 2,277		
5	9,440	+ .9016	+ 8,510	+ .2208	+ 2,083		
4	23,600	+ 1.2735	+ 30,050	+ .4343	+ 10,250		
3	18,860	+ .7379	+ 13,910	+ .7358	+ 13,870		
2	17,680	+ .2990	+ 5,285	+ 1.1310	+ 20,000		
1	16,860	- .0590	- 994	+ .6218	+ 10,475		
0	8,780	- .2569	- 2,250	+ .3140	+ 2,756		
1	16,860	- .4188	- 7,060	+ .0468	+ 789		
2	17,680	- .5578	- 9,860	- .2082	- 3,683		
3	18,860	- .6069	- 11,450	- .3633	- 6,850		
4	23,600	- .6105	- 14,410	- .4489	- 10,590		
5	9,440	- .5660	- 5,341	- .4672	- 4,410		
6	28,410	- .4902	- 13,920	- .4366	- 12,400		
7	9,900	- .3971	- 3,932	- .3717	- 3,678		
8	32,040	- .2999	- 9,605	- .2943	- 9,430		
9	11,200	- .2074	- 2,323	- .2106	- 2,358		
10	33,980	- .1284	- 4,362	- .1338	- 4,546		
11	13,250	- .0667	- 884	- .0735	- 974		
12	39,140	- .0252	- 986	- .0274	- 1,072		
13	12,000	- .0038	- 46	- .0042	- 50		

+91,050 ~~+90,044~~
- 87,423
+ ~~2,621~~
+ 3.627

- 64,314
+ 62,500
- 1,814

⓪

	load	M (unit)	M
13	12,000	-.0035	- 42
12	39,140	-.0226	- 885
11	13,250	-.0570	- 757
10	33,980	-.1038	- 3,527
9	11,200	-.1564	- 1,755
8	32,040	-.2055	- 6,583
7	9,900	-.2388	- 2,363
6	28,410	-.2430	- 6,902
5	9,440	-.2021	- 1,908
4	23,600	-.0992	- ~~2,240~~ 2340
3	18,860	+.0835	+ 1,575
2	17,680	+.3504	+ 6,200
1	16,860	+.7186	+ 12,110
0	4,390	+1.0800	+ 4,740

-27,062 ~~- 26,962~~ × 2 = ~~-53,924~~ 54,124
+ 24,625 × 2 = + 49,250
~~4,674~~ -4,874

増田淳氏関係資料（独立行政法人 土木研究所蔵）

CALCULATIONS FOR

3

10

Dead load thrust

Point	Load	H unit load	H_0			normal thrust	vertical shear		normal thrust
0	4,390	2427	10,650	576,988	× 1.000 =	576,988	0	× 0 =	0
1	16,860	2411	40,650				12,820		
2	17,680	2312	40,900	〃	× .999 =	576,100	30,090	× .050 =	1,504
3	18,860	2,142	40,400				48,360		
4	23,600	1,914	45,150	〃	× .992 =	572,200	59,590	× .118 =	7,033
5	9,440	1,644	15,510				86,110		
6	28,410	1351	38,700	〃	× .985 =	568,200	105,030	× .180 =	18,900
7	9,900	1,055	10,440				124,190		
8	32,040	.775	24,830	〃	× .975 =	562,500	145,210	× .245 =	35,600
9	11,200	.526	5,890				166,780		
10	33,980	.322	10,940	〃	× .950 =	548,000	189,370	× .320 =	60,600
11	13,250	.166	2,200				212,985		
12	39,140	.062	2,426	〃	× .925 =	533,900	239,185	× .385 =	92,100
13	12,000	.009	108				264,750		
sp	6,650	0	0	〃	× .900 =	519,400	~~277,075~~	× .425 =	~~116,500~~
	277,400		288,494				277 400		117,800
			× 2						
			576,988						

Summary of Dead load normal thrust ~~and moments~~

	0	2	4	6	8	10	12	sp
Due to vertical shear	0	1,504	7033	18,900	35,600	60,600	92,100	~~116,500~~ 117,800
Due to Horizontal thrust	576,988	576,100	572,220	568,200	562,500	548,000	533,900	519,400
	576,988	577,604	579,253	587,100	598,100	608,600	626,000	~~635,900~~ 63,720

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CALCULATIONS FOR (3)

Temperature stress

$$H_0 = \frac{E\omega t l \int \frac{ds}{I}}{2\left[\int \frac{ds}{I} \int y^2 \frac{ds}{I} - \left(\int y \frac{ds}{I}\right)^2\right]} = \frac{1400,000,000 \times .000012 \times 15 \times 2675 \times 127908}{1385939} = 6221$$

252,000 6,741,000

$6221 \times 85 = 528785$ Kgm

$$M_0 = \frac{-528785 \times 70547}{127908} = -29,165 \text{ Kgm}$$ — crown

D.L. 4674

springing $29165 - 528785 \times 2994 = -76592$ Kgm

105,757 D.L. -2,975

158320
29165
129155

2	2,578
4	11,898
6	27,761
8	50,499
10	80,904
12	130,034
sp	158318

Temperature stress

crown section

$$H_0 = \frac{1400000000 \times .000012 \times 15 \times 2675 \times 127908}{1385939} = 6,221$$ per 1 meter strip For 85 meters wide $6221 \times 85 = 528785$ Kgm

$$M_0 = \frac{-528785 \times 70547}{127908} = +29165 \text{ Kgm}$$

Panel point

	moment		normal thrust
2	M = 29165 − 528785 × 0.048 = +26587	52,8785 × .999 =	52826
4	" − " × .225 = +17267	" × .992 =	52455
6	" − " × .525 = +1404	.985 =	52085
8	" − " × .955 = −21334	.975 =	51557
10	" − " × 1530 = −51739	.950 =	50235
12	" − " × 2270 = −90869	.925 =	48913
sp	" − " × 2994 = −129154	.900 =	47591

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CALCULATIONS FOR

参5書類 A1

Shinobu-Bashi

Erection stresses Horizontal thrust due to weight of arch ring only

Span no. 4

point	load	Ho vert. load	Ho
0	4610	2411	11,110
1	8150	2365	19,275
2	8350	2254	18,820
3	8550	2078	17,750
4	8560	1847	15,800
5	8980	1580	14,180
6	9370	1292	12,110
7	9,800	1,009	9,885
8	10,400	0.734	7,635
9	11,200	.495	5,545
10	11,820	.301	3,555
11	13,050	.153	1,996
12	14,500	.058	841
13	12,000	.008	96
sp	6600	0	0
	145,940 Kgo		138,598

× 2

277,196 Kgo

Span no. 3

point	load	Ho vert. load	Ho
0	2165	2.427	5,250
1	8,150	2.411	19,650
2	8,350	2.312	19,320
3	8,450	2.142	18,100
4	8,560	1.914	16,370
5	8,980	1.644	14,760
6	9,400	1.351	12,700
7	9,900	1.055	10,440
8	10,600	.775	8210
9	11,200	.526	5,890
10	12,050	.322	3,880
11	13,250	.166	2,200
12	14,900	.062	924
13	12,000	.009	108
sp	6,650	0	0
	144,605 Kgo		137,802

× 2

275,604 Kgo

Span no. 2

point	load	Ho vert. load	Ho
0	3390	2425	8,220
1	8,150	2390	19,470
2	8,350	2265	18,910
3	8,560	2,064	17,660
4	8,780	1,804	15,730
5	9,180	1,505	13,810
6	9,800	1,191	11,670
7	10,200	.884	9,020
8	10,800	.605	6,535
9	11,820	.373	4,410
10	13,100	.193	2,530
11	14,700	.071	1,043
12	12,000	.010	120
sp	6,650	0	0
	135,480 Kgo		129,128

× 2

258,256 Kgo

Span no. 1

point	load	Ho vert. load	Ho
0	1350	2.462	3,325
1	8,150	2.450	19,950
2	8,350	2.318	19,350
3	8,570	2.091	17,920
4	8,770	1.788	15,670
5	9,200	1.442	13,260
6	9,780	1.086	10,620
7	10,400	.752	7,820
8	11,400	.466	5,310
9	12,750	.242	3,085
10	14,500	.091	1,319
11	12,000	.013	156
sp	6,650	0	0
	121,870 Kgo		117,785 Kgo

× 2

235,570 Kgo

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CALCULATIONS FOR

Shinobu-Bashi A2

Deflection of arch ring due to moment,
Span no. 4
Crown deflection due to dead load $\int x \frac{ds}{I} = 6893.35$ (13,786.70) $\int xy \frac{ds}{I} = 6984.10$ (13,968.2)

point	M_o	H_o	$2M_o \int x \frac{ds}{I}$	$2H_o \int xy \frac{ds}{I}$	$-\int mx \frac{ds}{I}$	sum	Load	Product	
0	+1.1155	2411	+15379	33677	−50,656	−1,600	9,440	−15,100,000	−15,104.00
1	+.6460	2365	+8,906	33,035	−43293	−1,352	16,860	−22,800,000	−22,794.72
2	+.2980	2254	+4,108	31,484	−36565	−973	17,970	−17,470,000	−17,484.81
3	+.0447	2078	+616	29,026	−30,148	−506	19,550	−9,900,000	−9,892.30
4	−.1232	1847	−1,699	25,799	−24,180	−80	24,100	−1,928,000	−1,928.00
5	−.2180	1,580	−3,006	22,070	−18,793	+271	9,490	+2,572,000	+2,571.79
6	−.2525	1292	−3,481	18,047	−14,072	+494	28,700	+14,180,000	+14,177.80
7	−.2470	1.009	−3,405	14,094	−10,061	+628	9,800	+6,160,000	+6,154.40
8	−.2084	.734	−2,873	10,253	−6,780	+600	32,200	+19,300,000	+19,320.0
9	−.1573	.495	−2,169	6,914	−4,243	+502	11,200	+5,625,000	+5,622.4
10	−.1036	.301	−1,428	4,204	−2,413	+363	34,000	+12,330,000	+12,342.0
11	−.0552	.153	−761	2,137	−1,157	+219	13,050	+2,860,000	+2,857.95
12	−.0224	.058	−309	810	−414	+87	39,020	+3,400,000	+3,394.74
13	−.0032	.008	−44	112	−54	+14	12,000	+168,000	+168.00
								+66,595,000	+66,609.08
								−67,198,000	−67,203.83
								−603,000	−594.75

$$\text{Deflection} = \frac{-603000 \times 100}{140,000 \times 850} = .507^{cm} \text{ fall}$$

29328
13364
42692

44018
42692
1326

Span no. 3
Crown deflection due to dead load $\int x \frac{ds}{I} = 6187.16$ (12,374.32) $\int xy \frac{ds}{I} = 6041.98$ (12,083.96)

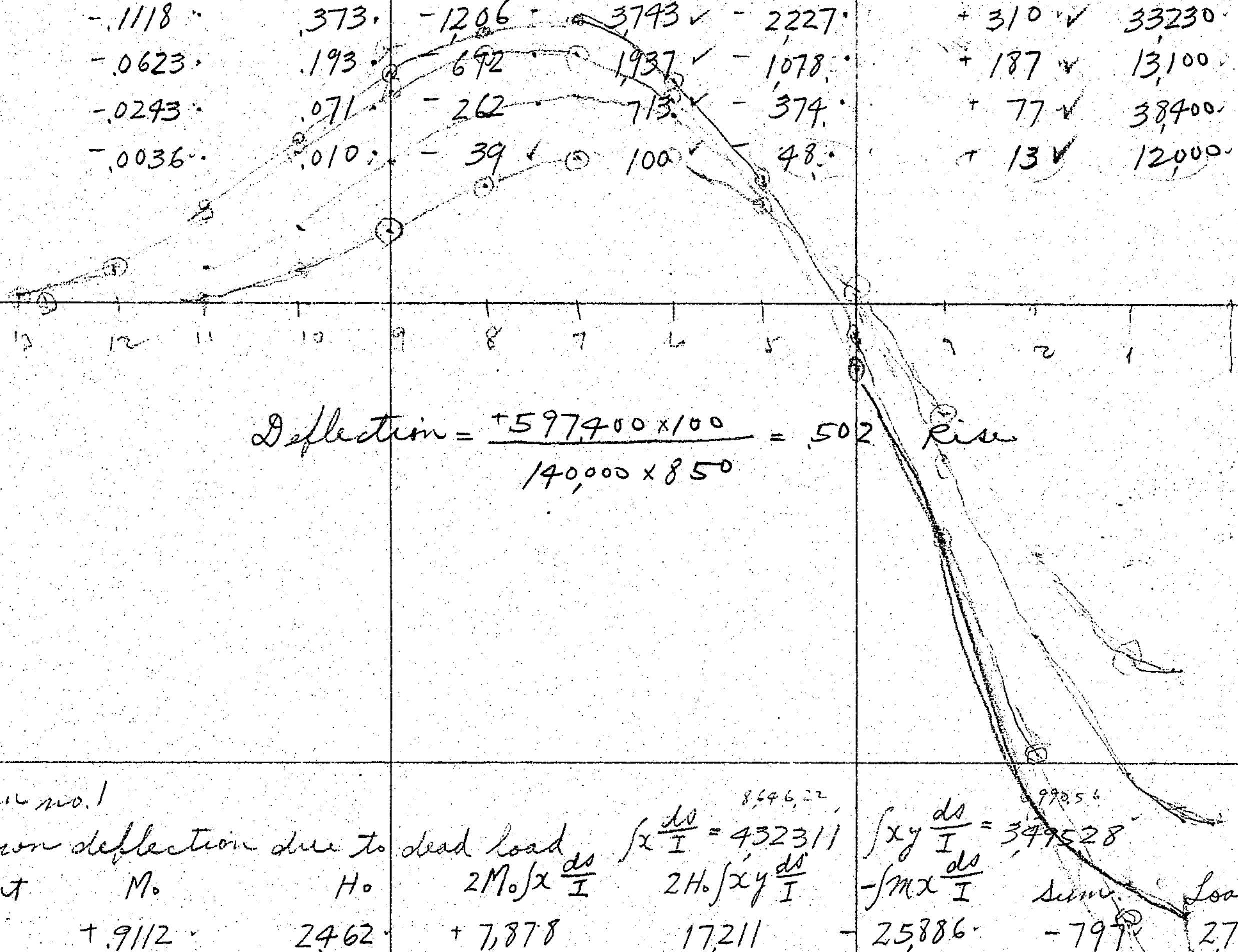
point	M_o	H_o	$2M_o \int x \frac{ds}{I}$	$2H_o \int xy \frac{ds}{I}$	$-\int mx \frac{ds}{I}$	Sum	Load	Product	
0	+1.0800	2427	+13364	29,328	−44,018	−1326	4390	−5,821,000	−5,821.140
1	+.7186	2411	+8,892	29,134	−39,285	−1259	16,860	−21,227,000	−21,226.740
2	+.3509	2312	+4336	27,938	−33,396	−1,122	17,680	−19,800,000	−19,836.96
3	+.0835	2142	+1,033	25,884	−27,415	−498	18860	−9,400,000	−9,392.28
4	−.0992	1,914	−1,228	23,129	−22,028	−127	23600	−3,000,000	−2,997.21
5	−.2021	1,644	−2,501	19,866	−17,156	+209	9,440	+1,974,000	+1,972.96
6	−.2430	1351	−3,007	16,325	−12,885	+433	28410	+12,320,000	+12,301.53
7	−.2388	1,055	−2,955	12,749	−9,255	+539	9,900	+5,330,000	+5,336.1
8	−.2055	.775	−2,543	9,365	−6281	+541	32,040	+17,330,000	+17,333.64
9	−.1564	.526	−1,935	6,356	−3,960	+461	11,200	+5,160,000	+5,163.2
10	−.1038	.322	−1,284	3,891	−2,275	+332	33,980	+11,280,000	+11,281.36
11	−.0570	.166	−,705	2,006	−1,105	+196	13,250	+2,598,000	+2,597.00
12	−.0226	.062	−,280	749	−386	+83	39,140	+3,250,000	+3,248.62
13	−.0035	.009	−43	109	−52	+14	12,000	+168,000	+168.00
								−59,248,000	−59,274.32
								+59,410,000	+59,402.41
								+162,000	+128.09

$$\text{Deflection} = \frac{+162000 \times 100}{140,000 \times 850} = +.136^{cm} \text{ Rise}$$

A3

Deflection of arch ring due to moment
Span no 2
Crown deflection due to dead load $\int x\frac{ds}{I} = 539517$ (0,790.38) $\int xy\frac{ds}{I} = 501801$ (1003602)

point	M_o	H_o	$2M_o\int x\frac{ds}{I}$	$2H_o\int xy\frac{ds}{I}$	$-\int m x\frac{ds}{I}$	sum	Load	Product	
0	+1.0059	2425	+10,854	24337 ✓	−36330	−1,139 ✓	6,940	−7,910,000 ✓	−7,904.66
1	+.5919	2390	+6387	23986 ✓	−31,394	−1,021 ✓	16,860	−17,220,000 ✓	−17,214.06
2	+.2503	2265	+2,701	22,732 ✓	−26,140	−707 ✓	17,820	−12,600,000 ✓	−12,598.74
3	+.0111	2064	+.120	20,714 ✓	−21,169	−335 ✓	22850	−7,670,000 ✓	−7,654.75
4	−.1380	1804	−1,489	18,105 ✓	−16,606	+10 ✓	9140	+91,400 ✓	+91.40
5	−.2127	1505	−2,295	15,104 ✓	−12,542	+267 ✓	27,550	+7,350,000 ✓	+7,355.85
6	−.2308	1191	−2,490	11,953 ✓	−9,045	+418 ✓	9,800	+4,100,000 ✓	+4,096.00
7	−.2095	884	−2261	8,872 ✓	−6,152	+459 ✓	30,800	+14,120,000 ✓	+14,137.20
8	−.1647	605	−1,777	6,072 ✓	−3,882	+413 ✓	10,800	+4,460,000 ✓	+4,460.4
9	−.1118	373	−1,206	3,743 ✓	−2,227	+310 ✓	33230	+10,310,000 ✓	+10,301.3
10	−.0623	.193	−692	1,937 ✓	−1,078	+187 ✓	13,100	+2450,000 ✓	+2,449.7
11	−.0243	.071	−262	713 ✓	−374	+77 ✓	38,400	+2,960,000 ✓	+2,956.8
12	−.0036	.010	−39 ✓	100 ✓	−48	+13 ✓	12,000	+156,000 ✓	+156.0
								−45,400,000 ✓	−45,372.21
								+45,997,400 ✓	+46,004.65
								+597,400 ✓	+632.44



$$\text{Deflection} = \frac{+597400 \times 100}{140,000 \times 850} = .502 \text{ Rise}$$

Span no. 1
Crown deflection due to dead load $\int x\frac{ds}{I} = 432311$ (8,646.22) $\int xy\frac{ds}{I} = 349528$ (99056)

point	M_o	H_o	$2M_o\int x\frac{ds}{I}$	$2H_o\int xy\frac{ds}{I}$	$-\int m x\frac{ds}{I}$	sum	Load	Product
0	+.9112	2462	+7,878	17,211	−25,886	−797	2,760	−2,200,000
1	+.5923	2450	+5,121	17,127	−23,011	−763	16,860	−12,870,000
2	+.2379	2318	+2,057	16,204	−18,791	−530	17,680	−9,370,000
3	−.0034	2091	−29	14,617	−14,818	−230	19,000	−4,370,000
4	−.1432	1788	−1,238	12,499	−11,223	+38	24,230	+921,000
5	−.2030	1442	−1,755	10,080	−8,098	+227	9200	+2,088,000
6	−.2045	1086	−1,768	7,592	−5,505	+319	29,180	+9,310,000
7	−.1706	.752	−1,475	5,257	−3,459	+323	10,400	+3,360,000
8	−.1190	.466	−1,029	3,258	−1,976	+253	31,900	+8,075,000
9	−.0674	.242	−583	1,692	−951	+158	12,750	+2,016,000
10	−.0272	.091	−235	636	−331	+70	37,150	+2,600,000
11	−.0041	.013	−35	91	−44	+12	12,000	+144,000
								−28,810,000
								+28,514,000
								−296,000

$$\text{Deflection} = \frac{-296,000 \times 100}{140,000 \times 850} = -.249 \text{ fall.}$$

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CALCULATIONS FOR

A4

Deflection at crown due to temperature

For fall of temperature $\Delta y = -\dfrac{2wtl\left(\int\frac{ds}{I}\int xy\frac{ds}{I} - \int x\frac{ds}{I}\int y\frac{ds}{I}\right)}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = -\dfrac{2wtl \times A}{B}$

Span no. 4

A = 4,066,000

B = 1,685,308

A : B = 2.411

Deflection for crown for 15° fall of temperature

$\Delta y = -2 \times .000012 \times 15 \times 2735 \times 2.411 \times 100 = -2.37^{cm}$ fall

Deflection of crown due to rib shortening

average stresses due to dead load = 140,500

Rib shortening − 5,300 = 49.5%

Temperature 15° fall − 10,700

124,500

Ratio 124,500 ÷ 252,000 = 0.495 − 2370 × .495 = 1.17^cm^ fall

140,500 − 10,700 − 5,300 = 124,500 ; 49.5% ; 124,500 / 252,000 = 495

Dead load moment deflection − .507

Temperature 15° fall −2.370

Rib shortening −1.170

−4.047^cm^ fall

average stresses due to dead load = 140,500

Rib shortening = − 5,720 = 53.5 %

134,780

140,500 − 5,720 = 134,780 ; 53.5 ; 134,780 / 252,000 = 535

Ratio 134780 ÷ 252,000 = 53.5% − 2370 × .535 = −1.27^cm^ fall

Span no. 3

A = 7,728,176

B = 1,385,939

A : B = 2.427

Dead load moment deflection − .507

Rib shortening −1.27

−1.777 fall

Deflection for crown for 15° fall of temperature

$\Delta y = -2 \times .000012 \times 15 \times 2675 \times 2.427 \times 100 = -2.34^{cm}$ fall

Deflection of crown due to rib shortening

average stresses due to dead load = 138,000

Rib shortening − 5,680 = 47.8%

Temperature 15° fall − 11,900

120,420

138,000 − 11,900 − 5,680 = 120,420 ; 47.8 ; 120,420 / 252,000 = 478

Ratio 120,420 ÷ 252,000 = 0.478 − 2.340 × 0.478 = −1.118

Dead load moment deflection + .136

Temperature 15° fall −2.340

Rib shortening −1.118

−3.322^cm^ fall

average stresses due to dead load = 138,000

Rib shortening = − 6,220 = 52.3%

131,780

138,000 − 6,220 = 131,780 ; 52.3 ; 131,780 / 252,000 = 523

Ratio 131,780 ÷ 252,000 = 52.3% − 2.340 × 0.523 = −1.224

Dead load moment deflection + .136

Rib shortening −1.224

−1.088 fall

増田淳氏関係資料（独立行政法人 土木研究所蔵）

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CALCULATIONS FOR

A5

Span no. 2

A = 2583306

B = 1065206

A ÷ B = 2425

Deflection for crown for 15° fall of temperature

$\Delta y = -2 \times .000012 \times 15 \times 2505 \times 2425 \times 100 = -2.18$ cm fall

Deflection of crown due to rib shortening

average stresses due to dead load = 127,000

Rib shortening − 5730 = 42.8 %

Temperature 15° fall − 13,400

107,870

127,000
−13,400
42.8 −5730
107,870

107870 / 252000 = .428

ratio 107,870 ÷ 252,000 = 0.428 — −2.180 × 0.428 = −.933

Dead load moment deflection + .502

Temperature 15° fall − 2.180

Rib shortening − .933

−2.611 cm fall

127,000
479 −6420
120,580

120580 / 252000 = 479

average stresses due to dead load = 127,000

Rib shortening = −6,420 479

120,580

ratio 120,580 ÷ 252,000 = 47.9 % — −2.180 × .479 = −1.044

Dead load moment deflection +.502

Rib shortening = −1.044

−.542 fall

Span no. 1

A = 1616479

B = 656210

A ÷ B = 2462

Deflection for crown for 15° fall of temperature

$\Delta y = -2 \times .000012 \times 15 \times 2255 \times 2462 \times 100 = -2.000$ cm fall

Deflection of crown due to rib shortening

average stresses due to dead = 118,000

Rib shortening − 6560 = 37.3 %

Temperature 15° fall − 17,600

93,840

118,000
−17,600
37.3 −6560
93,840

ratio 93,840 ÷ 252,000 = .373 — −2.000 × .373 = −.746

Dead load moment deflection = −.249

Temperature 15° fall −2.000

Rib shortening −.746

−2.995 fall

118,000
43.8 −7,700
110,300

average stresses due to dead load = 118,000

Rib shortening = −7,700 = 43.8 %

110,300

ratio 110,300 ÷ 252,000 = 43.8 % — −2.000 × .438 = −.876

Dead load moment deflection = −.249

Rib shortening = −.876

−1.125 fall

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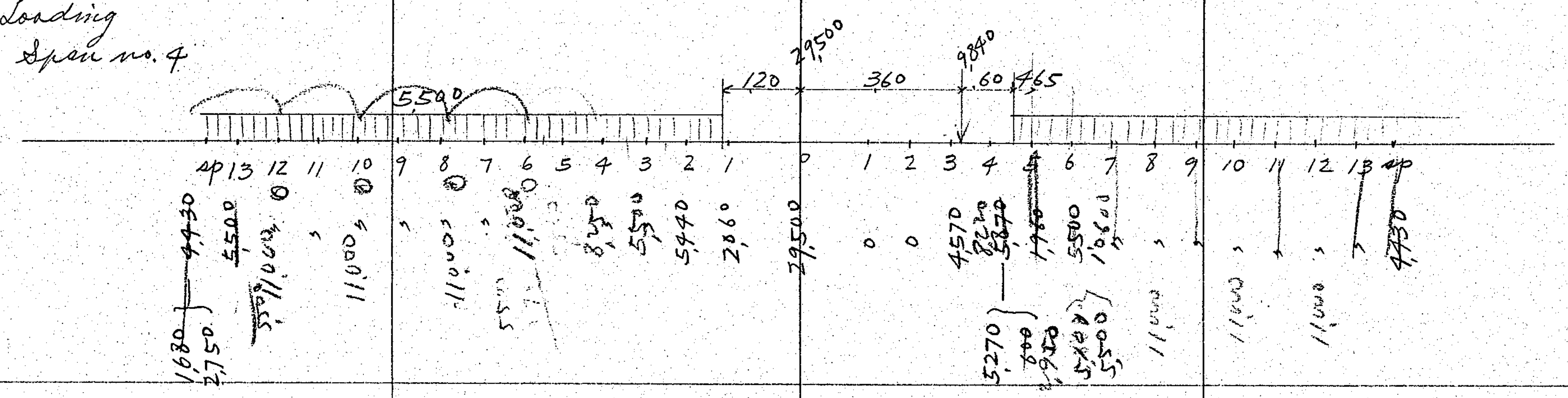
CALCULATIONS FOR

Loading
Span no. 4



Live load thrust

point	load	Ho		thrust	
~~13~~	~~4430~~	~~.008~~	−M	~~35~~	
12	~~5500~~ 11000	.058		~~319~~	638
~~11~~	~~"~~	~~.153~~		~~842~~	
10	" 11000	.301		~~1655~~	3310
~~9~~	~~"~~	~~.495~~		~~2722~~	
8	" 11000	.734		~~4037~~	8080
~~7~~	~~"~~	~~1.009~~		~~5545~~	
6	" 11000	1.292		~~7104~~	14,210
~~5~~	~~"~~	~~1.580~~		~~8690~~	
4	" 8250	1.847		~~10150~~	15,230
3	" 5500	2.078	+M	11,420	
2	5440	2.254		12,260	
1	2060	2.365		4,873	
0	29,500	2.411		71,130	
1	0	2.365		0	
2	0	2.254		0	
3	4570	2.078		9,500	
4	~~5870~~ 8,220	1.847	−M	~~10,840~~	15,180
~~5~~	~~1960~~	~~1.580~~		~~3095~~	
6	~~5500~~ 10,600	1.292		~~7104~~	13,700
~~7~~	~~"~~	~~1.009~~		~~5545~~	
8	" 11000	.734		~~4037~~	8080
~~9~~	~~"~~	~~.495~~		~~2722~~	
10	" 11000	.301		~~1655~~	3310
~~11~~	~~"~~	~~.153~~		~~842~~	
~~12~~	" 11000	.058		~~319~~	638
~~13~~	~~4430~~	~~.008~~		~~35~~	

+M = 109,183 ÷ 3.77 = 29,000 e .89 = 25,800
−M = ~~77,293~~ 83,376 ÷ 3.77 = ~~20,500~~ 21,850 e .91 = ~~18,650~~ 19,880
average thrust for live load ~~44,450~~ 45,680 kg.

average stresses due to live load = ~~44,650~~ 45,680
Rib shortening = −1,860
~~42,830~~ 43,820

Ratio ~~42,830~~ 43,820 ÷ 252,000 = ~~0.179~~ .174

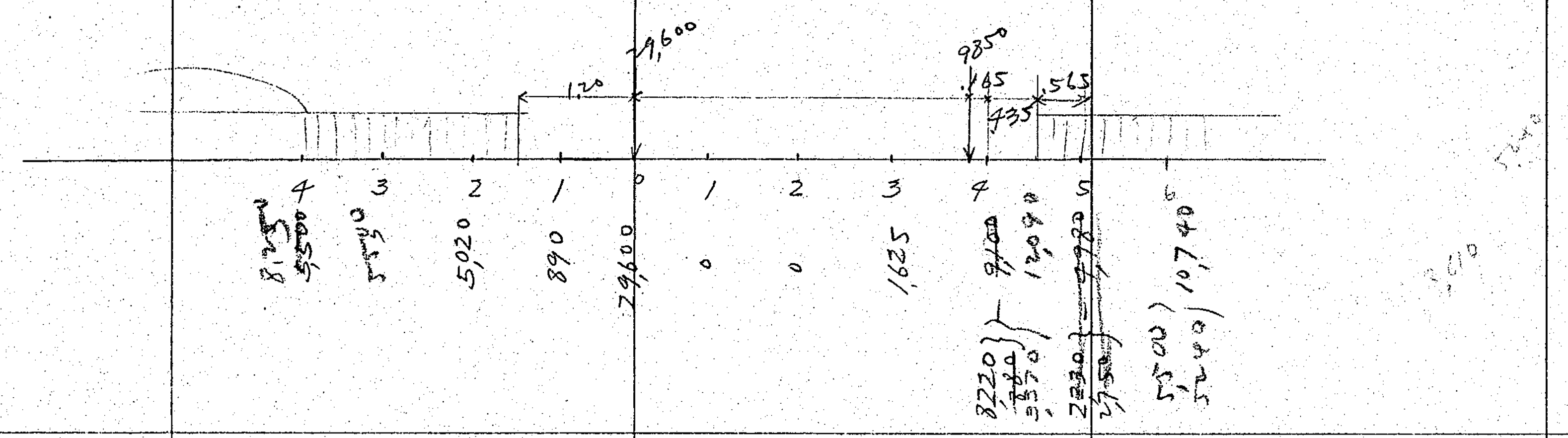
− 2370 × ~~.169~~ ~~.170~~ .174 = ~~0.401~~ ~~.403~~ .413 cm fall

174

45,680
1,860
43,820

CALCULATIONS FOR

Loading
Span no. 3



Line load thrust

point	load		Ho		thrust	
~~13~~	~~4430~~		~~.009~~	−M	~~40~~	
12	~~5500~~	11,000	.062		~~341~~	682
~~11~~	~~〃~~		~~.166~~		~~916~~	
10	~~〃~~	11,000	.322		~~1,770~~	3,540
~~9~~	~~〃~~		~~.526~~		~~2,892~~	
8	〃	11,000	.775		~~4,263~~	8,530
~~7~~	~~〃~~		~~1,055~~		~~5,810~~	
6	〃	11,000	1,351		~~7,430~~	14,860
~~5~~	~~〃~~		~~1,644~~		~~9,040~~	
4	〃	8,250	1,914		~~10,520~~	15,780
3	〃		2,142	+M	11,780	
2	5,020		2,312		11,600	
1	890		2,411		2,150	
0	29,600		2,427		71,820	
1	0		2,411		0	
2	0		2,312		0	
3	1,625		2,142		3480	
4	~~9,100~~	12,090	1,914	−M	~~17,400~~	23,120
5	~~4,980~~		~~1,644~~		~~8,180~~	
6	~~5500~~	10,740	1,351		~~7,430~~	14,520
~~7~~	~~〃~~		~~1,055~~		~~5,810~~	
8	〃	11,000	.775		~~4,263~~	8,530
~~9~~	~~〃~~	~~11,000~~	~~.526~~		~~2,892~~	
10	〃	11,000	.322		1,770	3,540
~~11~~	~~〃~~		~~.166~~		~~916~~	
12	〃	11,000	.062		341	682
~~13~~	~~4430~~		~~.009~~		~~40~~	

+M = 100,830 ÷ 3.77 = 26,750 c c .89 = 23,800

−M = ~~92,063~~ 93,789 ÷ 3.77 = ~~24,430~~ 24,890 c c .91 = ~~22,400~~ 22,630

average thrust for line load = ~~46,200~~ 46430 Kgs

11900

average stresses due to line load = ~~46,200~~ 46430
Rib shortening − 2080 −2090
= 44,020 44340

46200
17.5 − 2080
44,020

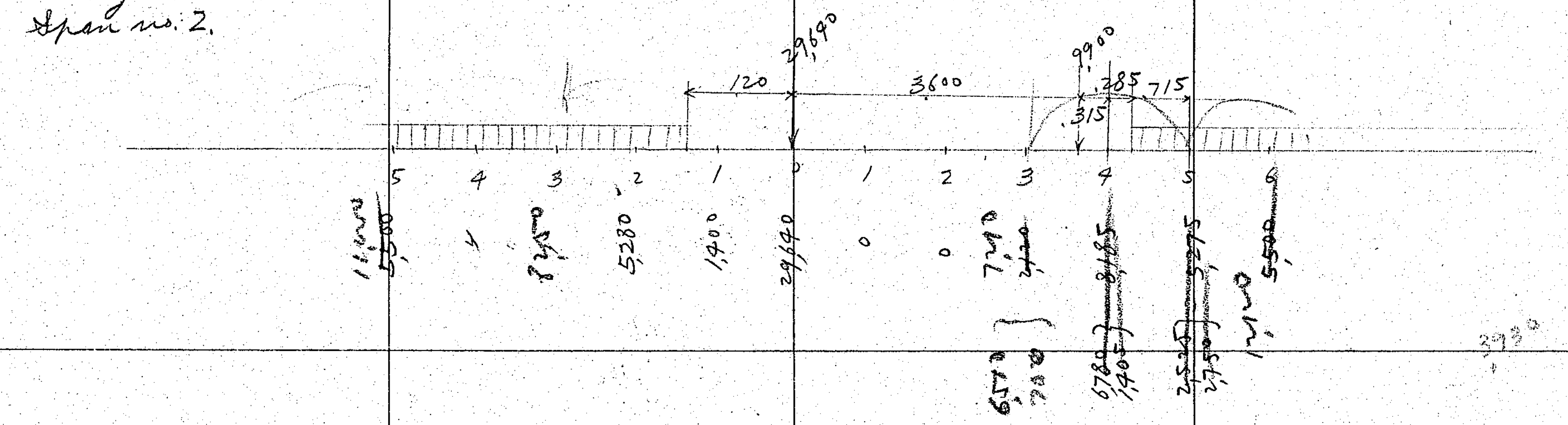
17.6 46430
2090
44,340

ratio ~~44,020~~ 44340 ÷ 252,000 = .176 −.234 × .176 = −.409 cm fall

.412

CALCULATIONS FOR

Loading
Span no. 2.



Line load thrust

point	load	H.		thrust	
~~12~~	~~4430~~	~~.070~~	−M	~~44~~	
11	~~5500~~ 11,000	.071		~~390~~	781
~~10~~		~~.193~~		~~1,061~~	
9	11,000	.373		~~2050~~	4100
~~8~~		~~.605~~		~~3355~~	
7	11,000	.884		~~4860~~	
~~6~~		~~1.191~~		~~6550~~	9,280
5	11,000	1,505		~~8280~~	~~1155~~ 16,550
~~4~~		~~1,809~~		~~9,920~~	
3	8,250	2,064	+M	~~11,350~~	16,770
2	5280	2,265		11,960	
1	1,400	2,390		3,345	
0	29,640	2,425		71,860	
1	0	2,390		0	
2	0	2,265		0	
3	~~6120~~ 7,210	2,064		~~4,375~~	14,970
~~4~~	~~8,185~~	~~1,809~~	−M	~~14,750~~	
5	~~5275~~ 12,120	1505		~~7930~~	18,250
~~6~~	~~5,500~~	~~1.191~~		~~6,550~~	
7	11,000	.884		~~4860~~	9280
~~8~~		~~.605~~		~~3355~~	
9	11,000	.373		~~2050~~	4100
~~10~~		~~.193~~		~~1061~~	
11	11,000	.071		~~390~~	781
~~12~~	~~4430~~	~~.070~~		~~44~~	

+M = ~~102,890~~ 118,905 ÷ 3.77 = ~~27,300~~ 31,550 @ .89 = ~~24,300~~ 28,080

−M = ~~77,500~~ 63,122 ÷ 3.77 = ~~20,570~~ 16,780 @ .91 = ~~18,700~~ 15,260

Average thrust for line load = ~~43,000~~ 43,340 kgs

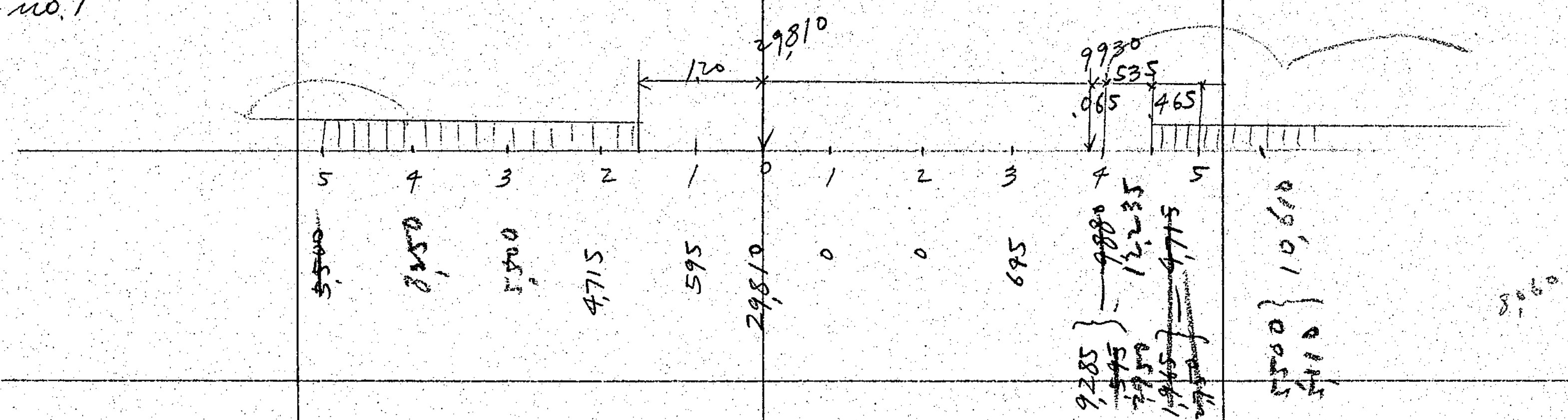
average stresses due to line load = ~~43,000~~ 43,340
Rib shortening = − ~~2170~~ −2180
~~40,830~~ 41,160

43000 −2180 40,836 .162
43340 −2180 41,160 .163

ratio ~~40,830~~ 41,160 ÷ 252,000 = .163   −218 @ .163 = −.355 cm fall

CALCULATIONS FOR

Loading
Span no. 1



Live load thrust

point	load	Ho		thrust	
~~11~~	~~4430~~	~~.013~~	-M	~~58~~	
10	~~5500~~ 11,000	.091		500	1,002
~~9~~	~~〃~~	~~.242~~		~~1331~~	
8	〃 11,000	.466		~~2562~~	5,125
~~7~~	~~〃~~	~~.752~~		~~4135~~	
6	〃 11,000	1,086		~~5,970~~	11,950
~~5~~	~~〃~~	~~1442~~		~~7930~~	
4	〃 8250	1,788		~~9830~~	14750
3	〃 5500	2091		11,500	
2	4,715	2318	+M	10,930	
1	595	2450		1,457	
0	29,810	2462		73,400	
1	0	2450		0	
2	0	2318		0	
3	645	2091	-M	1,350	
4	~~4880~~ 12,235	1,788		~~18650~~	21880
~~5~~	~~4715~~	~~1442~~		~~6800~~	
6	5,500 / 10,610	1,086		~~5,970~~	11,950
~~7~~	~~〃~~	~~.752~~		~~4135~~	
8	〃 11,000	.466		~~2562~~	5,125
~~9~~	~~〃~~	~~.242~~		~~1331~~	
10	〃 11,000	.091		~~500~~	1,002
~~4~~	~~4430~~	~~.013~~		~~58~~	

+M = 85,787 ÷ 377 = 22,750 @ .89 = 20,250

−M = ~~85172~~ 85634 ÷ 377 = ~~22600~~ 22720 @ .91 = ~~20570~~ 21,350

average thrust for live load = ~~40820~~ 41,600 kgs

average stresses due to live load = ~~40820~~ 41,600
Rib shortening = − 2660 ~~17,200~~ 2720
= 38,160 38880

17,600

40,820
151 − 2660
38,160

ratio ~~38,160~~ 38880 ÷ 252,000 = ~~.151~~ .154 − 2.00 × ~~.151~~ .154 = −.308 cm fall

.154
.155
41,600
− 2720
38,880

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CALCULATIONS FOR

Preliminary Design of Shin kawa Bashi for Fukushima ken.

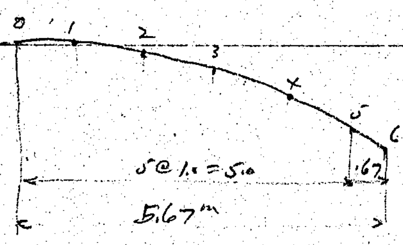
Filled spandrel arch. span length 11.00 meter clear Effective span = 11.34 m about. width of roadway = 13.0m clear, arch ring 13.70 m wide. rise 1.65m rise ratio $\frac{l}{r} = \frac{11.34}{1.65} = 6.9$

Let us design the arch ring of one meter strip along center line of bridge. (r = 1.6 m rise ratio)

Dead Load.

gravel pavement	0.1 @ 1700	=	170
Earth fill	0.4 @ 1600	=	640
Arch ring	0.3 @ 2400	=	720

1530 × 0.5 = 770 at 0.



0.1 @ 1700 = 170
0.43 @ 1600 = 688
.32 @ 2400 = 768
1626 = 1630 at 1.

170
.56 @ 1600 = 896
.34 @ 2400 = 816
1882 = 1880 at 2

170
0.78 @ 1600 = 1250
.4 @ 2400 = 960
2380 = 2380 at 3.

170
1.10 @ 1600 = 1760
.48 @ 2400 = 1150
3080 — 4

170
1.5 @ 1600 = 2400
.58 @ 2400 = 1390
3960 — 5

170
1.8 @ 1600 = 2880
.7 @ 2400 = 1680
4730 × .17 = 750 — 6'

moment about spring

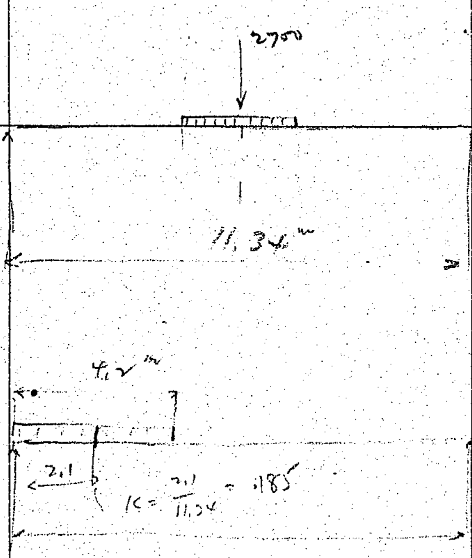
14450	6'	750 × .09	=	70	63
13700	5	3960 × .167	=	2650	2650
9740	4	3080 × 1.67	=	5140	5140
6660	3	2380 × 2.67	=	6350	6350
4280	2	1880 × 3.67	=	6900	
2400	1	1630 × 4.67	=	7610	
770	0	770 × 5.67	=	4360	4365
		14450		33080 kgm/m strip at center	

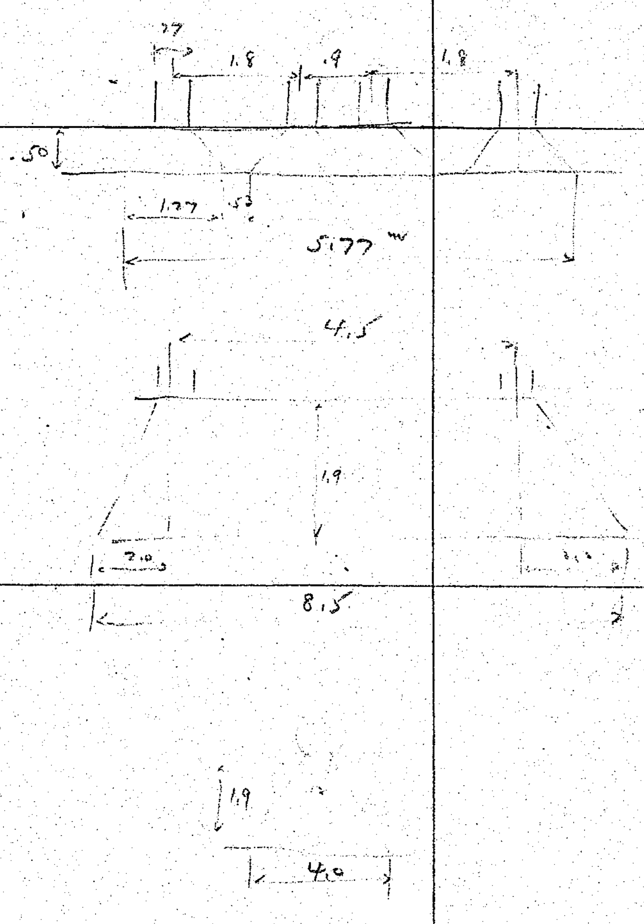
approx $H = \frac{33080}{1.65} = 20400$ kg

Live Load 8 ton motor truck

rear wheels 4 @ 3900 = 15600 kg

$\frac{15600}{5.77} = 2700$ kg/m strip





Live load at crown

$M_c = .105 \times 11.34 \times 2700 = 1530$ kgm

$H = 1.75 \times 2700 = 4730$ kg

$\frac{15600}{8.5} = 1840$ kg/m strip

$\frac{1840}{4} = 460$ kg/0m

460 × 4.2 = 1930

$T_S = 1.33 \times 1930 = 2580$ kg

$M_S = + .10 \times 11.34 \times 1930 = +2190$ kgm

Preliminary Design of Shinkawa Bashi for Fukushima ken

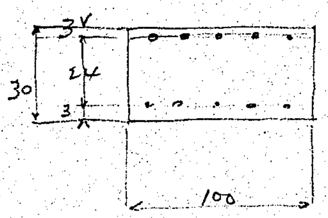
Dead load + moment at crown by diagram 682

$T_c = H_c = 1.18\ wc\ l = 1.18 \times 1540 \times 11.34 = \underline{20580}$ kg ✓ Ecc say 5 cm $m_c = 20600 \times .05 = 1030$ kgm

$T_s = 1.6 \times \text{〃} = 1.6 \times 1540 \times 1134 = \underline{27950}$ kg Ecc say 10 $m_s = 27950 \times .1 = 2795$

	Crown N_c	M_c	Spring N_s	M_s
D L	20600	1030	27950	2795
L L	4730	1530	2580	2190
	25330 kg	2560 kgm	30500 kg	4985 kgm

Crown section



steel req'd for moment only $= \frac{2560 \times 100}{1200 \times \frac{7}{8} \times 27} = 9.05$ cm² ✓

$Ecc = \frac{2560}{25330} = 0.10$ $e/h = \frac{.10}{.30} = .333$ $d'/h = \frac{3}{30} = .10$

Try steel 22φ bars at 30 cm c to c = 12.7 cm² ✓

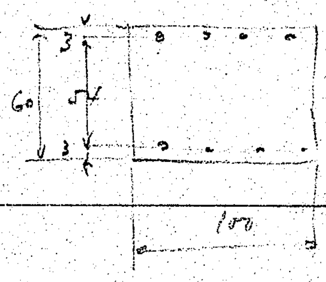
$p_c = \frac{12.7 \times 2}{100 \times 30} = .0085$

$k = .68$ $L = .123$

$f_c = \frac{2560 \times 100}{.123 \times 100 \times 30^2} = 23.1$ kg/cm² ok

$f_s = 15 \times 23.1 \left(\frac{27}{.68 \times 30} - 1\right) = 115$ kg/cm² ok

Springing



$Ecc = \frac{4985}{30500} = .164$ $e/h = \frac{.164}{.60} = .273$ $d'/h = 3/60 = .05$

Try steel 22φ at 30 cm c to c = 12.7 cm²

$p_c = \frac{25.4}{100 \times 60} = .0043$

$k = .765$ $L = .111$

$f_c = \frac{4985 \times 100}{.111 \times 100 \times 60^2} = 11.25$ kg/cm² ok

$f_s = 15 \times 11.25 \left(\frac{57}{.765 \times 60} - 1\right) = 41$ kg/cm² ok

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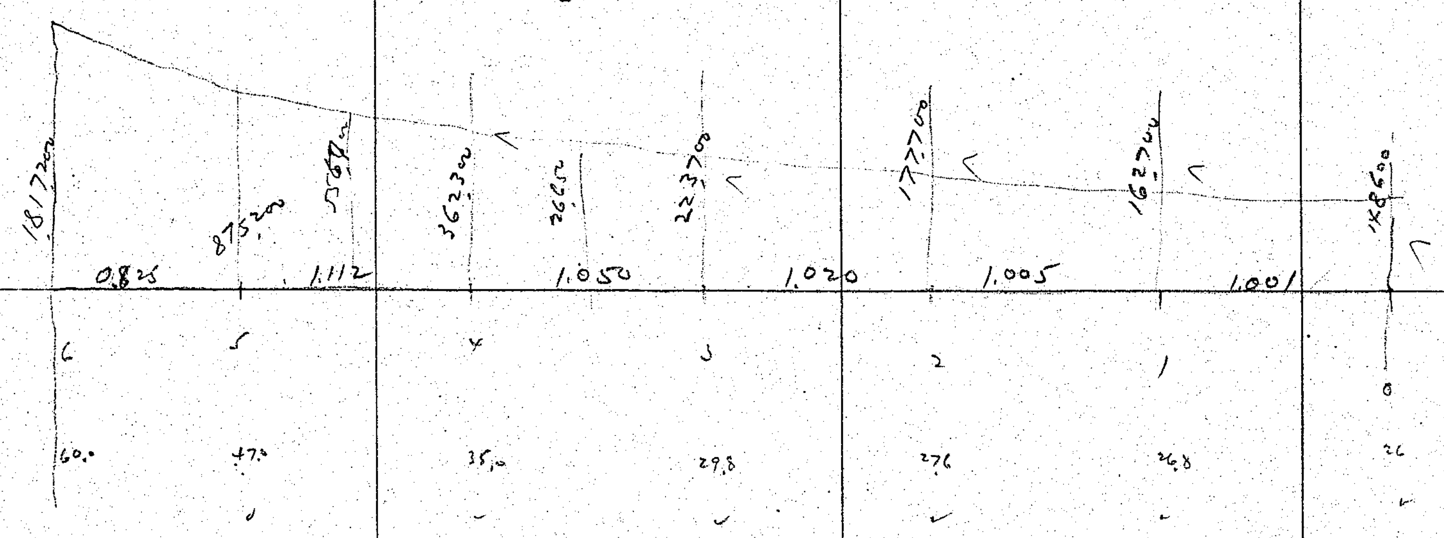
CALCULATIONS FOR

Shinkawa Bashi for Fukushima Ken.

Division of arch ring for constant $\frac{s}{I}$

Length of arch axis



Moment of inertia at panel points

0 $\quad I_0 \quad \frac{100 \times 26^3}{12} = 146,500$

$25.4 \times 9^2 = 2100$ → 148,600

1 $\quad I_1 \quad \frac{100 \times 26.8^3}{12} = 160,500$

$25.4 \times 9.4^2 = 2,200$ → 162,700

2 $\quad \frac{100 \times 27.6^3}{12} = 175,250$

$25.4 \times 9.8^2 = 2,450$ → 177,700

3 $\quad \frac{100 \times 29.8^3}{12} = 220,700$

$25.4 \times 10.9^2 = 3000$ → 223,700

4 $\quad \frac{100 \times 35^3}{12} = 357,700$

$25.4 \times 13.5^2 = 4600$ → 362,300

5 $\quad \frac{100 \times 47^3}{12} = 865,500$

$25.4 \times 19.5^2 = 9700$ → 875,200

6 $\quad \frac{100 \times 60^3}{12} = 1,800,000$

$25.4 \times 26^2 = 17,200$ → 1,817,200

$\frac{100 \times 31.6^3}{12} = 263,000$

$25.4 \times 11.8^2 = 3500$ → 266,500

$\frac{100 \times 40.4^3}{12} = 550,000$

$25.4 \times 16.2^2 = 6700$ → 556,700

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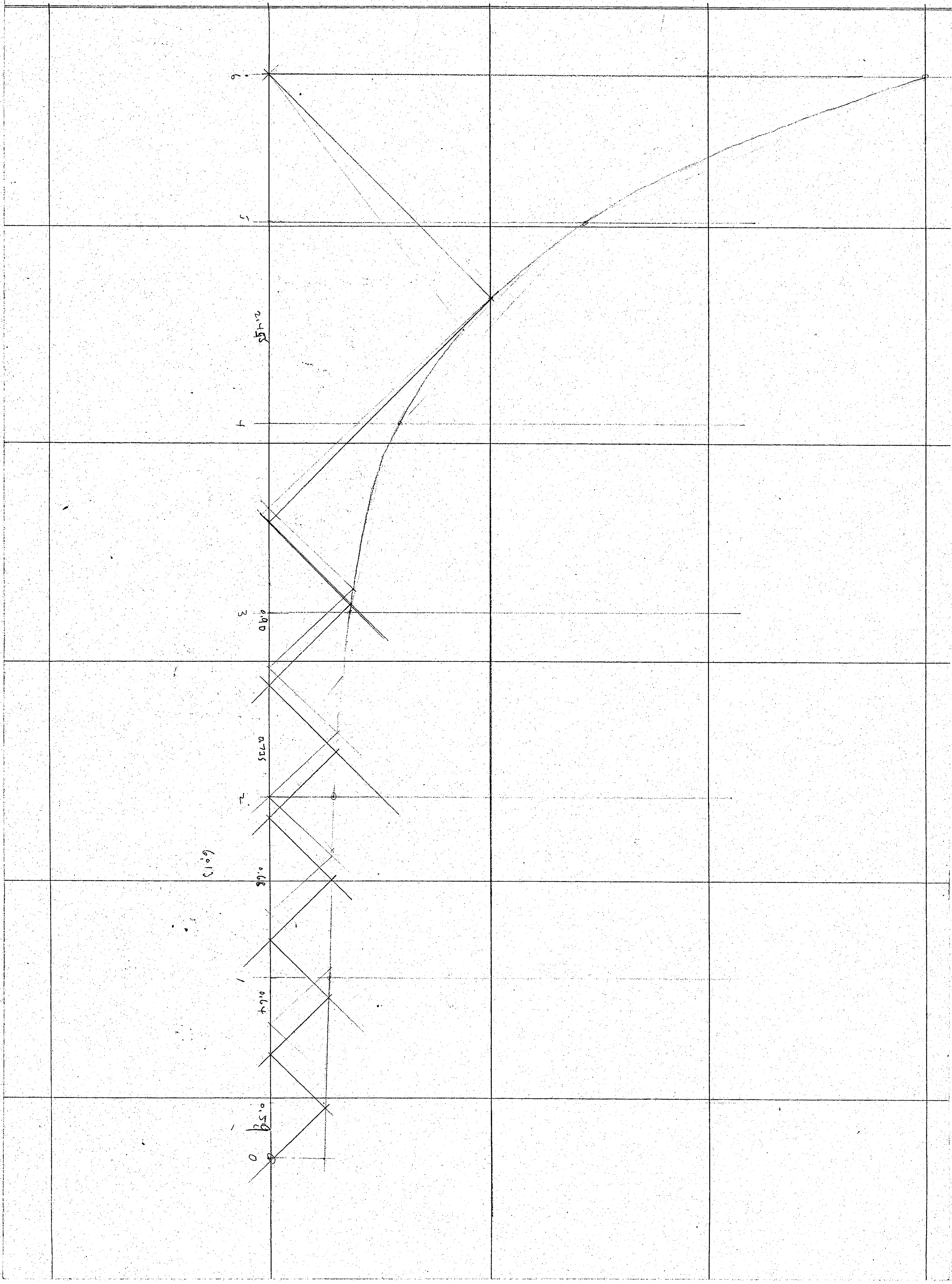
CALCULATIONS FOR



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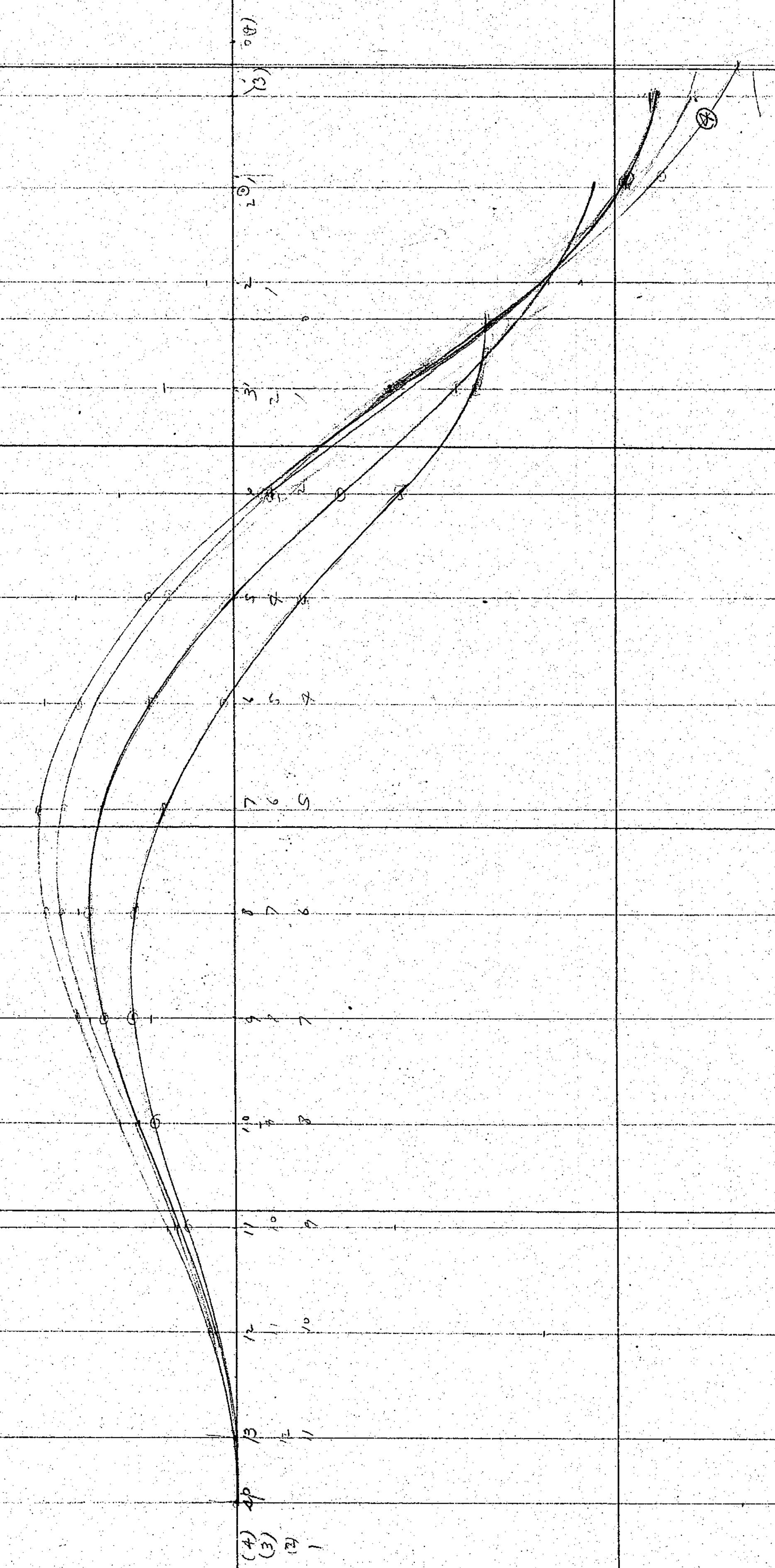
CALCULATIONS FOR



増田淳氏関係資料
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CALCULATIONS FOR 信夫橋材料概算

Materials of Shinobu Bashi for Fukushima ken.

Handrails.

Total length of Bridge = 184.81 meters
less 2@.315 = - .63
6@.70 = - 4.20
Concrete 1:2:4 179.98 m × 2 = 359.96 m

Cross section of Handrail.
top rail .13 × .23 = .0299
.13 × .55 = .0715
.17 × .27 = .0459
0.1473 × 359.96 = 53.0 cub. meters.

Light pedestals on piers. 12 @ .75 × .75 × 1.0 = 6.8
59.8 cub. meter · Handrail concrete.

Forms.
359.96 m @ 1.90 = 684 sq m
12 @ .75 × 4 × 1 = 36
720. sq. meter · Handrail form.

Reinforcements 59.8 m³ @ 0.15 tons = 9.0 kg tons. · reinforcements

人造仕上. 359.96 @ 2.15 774 / 42 816 sq. m · 人造仕上

Pedestal. 12 @ 3.5

Cast iron grate 42 @ 50 kg = 2.10 kg tons. · cast iron grate

Roadway. pavement.
Asphalt block. 369 (185) m × 8 = 2950 (1475) sq. meter pavements.
granolithic pavement. 369 (185) × 3 = 1108 (554)
Expansion joints. 7 @ 4 = 28 sq. Exp. jts.

Floor slab

Concrete 1:2:4 mix
Slab. .165 × 11.0 = 1.815
coping .365 × .3 × 2 = 0.219
2.034 sq m × 369 (185) = 750 (375) cub. meter. Concrete

Forms. bottom 11.00
coping 2 × .72 = 1.44
curb. 2 × .22 = .44
12.88
less - .75
12.13 m × 369 (185) = 4480 (2240) sq meter form. 全部分 (crown fill 下ヲ見込ム)

Reinforcements, plain bars. 750 (375) cub m @ 0.13 = 98. (49.) kg tons. reinforcements

人造 .03 + .18 + .05 + .365 + .23 = .86 × 2 = 1.72 × 369 (185) = 635 (318) sq. m 人造

Crown fill 7 @ 6.9 × 3.65 × 2 (.22) = 202 (77.3) cub. meter (average figure) crown fill

Longitudinal beams. concrete
0.25 × .20 × 2 × 178.2 = 17.8 m³
0.25 × .12 × 2 × 162 = 16.2
34.0 cub. meter. beam incl. conc.

forms. 0.65 × 2 × 178.2 = 232 sq. m. form

reinforcements 34. @ .17 = 5.8 kg tons. steel bars.

人造 0.5 × 2 × 178.2 178. sq. m 人造
~~0.5~~

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CALCULATIONS FOR

Materials for Shinobu Bashi for Fukushima Ken.

Cross beams and walls.

Concrete 0.6×0.3×4.15×2×28 = 41.9
.3×.5×1.75×28 = 7.4
1.8×.3×4.8×28 = 72.5
.3×.5×1.75×84 = 22.1
on pier 0.8×5.6×3.1×6 = 74.3
218.2 cub m.

Reinforcements 218.2 @ .08 = 17.5 kg tons.

Forms. 8.9×22.6×28 = 299.0
1.75×1.3×28 = 63.7
1.8×12.0×28 = 605.0
1.75×1.3×84 = 191.0
3.1×4.0×4×6 = 297.8
1456.5 sq. m.

人造 0.9×0.5×2×28 = 25.2
0.9×1.7×2×28 = 85.8
0.8×3.1×2×6 = 29.8
140.8 sq. m.

Arch Ring
Concrete. 1:2:4 mix
no1 0.6×23.3×2×4.25×2 = 237.5 | 104×2 = 208
no2 0.6×25.95×2×8.5 = 264.5 | 115×2 = 230
no3 0.6×27.75×2×8.5 = 283.0 | 123×2 = 246
no4 0.6×28.30×8.5 = 144.3 | 125×1 = 125
929.3 cub. m. 809

Stress calculation ヨリ精算ス

Centering 10.25×22.2×2 = 455
×24.7×2 = 507
×26.4×2 = 541
×27.0×1 = 277
1780. sq. m @15円 = 26700円

Reinforcements. Plain Bars.
237.5 @ 88 kg = 20.9
264.5 @ = 23.3
283.0 @ = 24.9
144.3 @ = 12.7
81.8 kg tons.

人造. .3+.3+.43 = 1.03 m ×2 = 2.06 m
2.06×23.3×2 = 96.0
×25.95×2 = 107.0
×27.75×2 = 104.3
×28.3×1 = 58.3
365.6 sq. m.

Form. 0.4×4 × 23.3×2 = 74.5
0.16 × 25.95×2 = 83.0
0.16 × 27.75×2 = 88.8
0.16 × 28.3×1 = 45.3
291.6 sq. m.

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CALCULATIONS FOR

Materials for Shinobu Bashi for Fukushima Ken.

Materials for Pier.

Concrete caisson

Concrete 1:2:4 mix.

12.0 × 7.5 = 90.0
11.2 × 6.7 = 75.0
15.0 × 6.0 = 90.0 cub.m
Struts .5 × .6 × 6.7 × 4 = 8.1
98.1

Form. outside 39.0
inside 35.8
74.8 × 6.0 = 449
Struts 1.7 × 4 × 6.7 = 46
495 sq.m.

Reinforcements 98.1 @ 0.050 = 4.9
beams + diagonals 1.1
6.0 kg tons.

Excavation. 12.0 × 7.5 × 7.5 = 675. cub.m.

Concrete fill 1:3:4.
75.0 × 4.0 = 300 cub.m

Rubble fill 1.8 × 2 × 2 × 11.2 = 81. "

rubble fill

Shaft

Concrete 1:2:4
2.2 × 6.0 × 10.15 = 134
1.5 × 5.0 × 1.5 × 2 = 22.5
1.2 × .8 × 10.15 = 9.8
.5 × 1.3 × 1.3 × 2 = 1.7
168 cub.m.

Form.
11.2 × 2 × 2 = 44.8
10.15 × 2 × 4 = 81.2
.8 × 2 × 10.15 = 16.3
say 1.6 × 1.3 × 1.5 × 2 = 6.2
1.2 × .8 × 2 = 1.9
misc. 4.6
155 sq.m

Reinforcements
168 @ .025 = 42 kg tons.

人造 say 6.2 sq.m.

Stone facing 3.6 × 2 × 4.0 × 0.3 = 8.65 cub.m

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CALCULATIONS FOR

Materials of Shinobu Bashi for Fukushima Ken.

Materials for Abutment 福島市側（左岸）

-Concrete 1:2:4 mix.			
frontwall.	0.4×3.0×11.0 = 13.2	26.3	
wing	2×.4×3.5×14.0 = 11.2		
〃 〃 coping	2×.6×.4×4.0 = 1.9		
Body	4.7×4×12.8 = 240.6		
〃	.14×4×10.15 = 16.3		
base	13.0×8.0×1.5 = 156.0		
	439.2 cub.m.		
Reinforcements	26.3 @ .070 = 1.85		
	2.45		
	4.30		
	.20		
	4.5 kg tons.		
Forms.	3×11.0×2 = 66.0		
	3.5×4.0×2×2 = 56.0		
	7.0×1×2 = 14.0		
	.4×4×2 = 3.2		
	.4×4×2 = 3.2		
	4.0×11.8 = 47.2		
	4.7×4.0×2 = 37.6		
	4.0×13.0 = 52.0	1.5×13 = 20	
	1.5×13.0 = 19.5	1.5×16 = 24	
	299.+44 = 343 sq.m.	44	
捨矢板.	13.0×8×2 =	29.0m 厚 6cm 長 5.0m.	
	29+4+15 =	48.0m 厚 6cm 長 3.5m	
Piles	8×13 =	104. 本 @ 末口 18cm × 5.5m	
人造			
	4×5÷2×2 = 20.0		
	.9×5.5×2 = 9.9		
	1×4×2 = 8.0		
	2.2×2×.3 = 1.3		
	.7×4×2 = 5.6		
	44.8 sq.m.		
親柱		2.	
袖高欄		2.	
Excavation.	9.0×15.0×1.5 = 203 cub.m. 水中掘削		
	7.0×16×6 = 672 〃 水上 〃		
蹴込石	0.3×0.25×11 = 0.825 cub.m. 花崗石		
土留石垣.			

.5
.25

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CALCULATIONS FOR

Materials of Shinobu Bashi for Fukushima ken.

materials of Abutment 1右岸.

Concrete 1:2:4 mix

front wall	.4×.3×11.0 = 13.2 ✓	26.3	
wing	2×.4×3.5×4.0 = 11.2 ✓		
〃 coping	2×.6×.4×4.0 = 1.9 ✓		
Body.	4.2×2.6×12.8 = 139.8 ✓		
〃	.4×3.3×10.15 = 13.4 ✓		
base.	6.5×13.0×1.2 = 101.5 ✓		
		281. cub m. ✓ ✓	
Reinforcements	26.3@.070 = 1.85 ✓		
	2×.5×6.5/8. = 2.00 ✓		
	.15 ✓		
		4.00 ✓ kg tons. ✓	
Forms.	3×11.×2 = 66.0 ✓		
	4×4.0×4 = 64.0 ✓		
	7×1×2 = 14.0 ✓		
	.4×4.×2 = 3.2 ✓		
	.4×6×2 = 4.8 ✓		
	3.5×11.8 = 41.3 ✓		
	3.6×3×2 = 21.6 ✓		
	1.5×13.0 = 19.5 ✓		
	1.2×39.0 = 46.8 ✓		
		281. ✓ sq.m. ✓	
Piles	6×13 = 78本 ✓	末口 18cm × 4.5m ✓	
人造.	say	35 ✓ sq.m. ✓	
親柱		2 ✓ 基	
袖高欄		2. ✓	
Excavation.	6.5×13×1.2 =	102. ✓ cub m	水中掘削 ✓
	9×15.5×2.5 = 349. ✓		
	say 6×7×6 = 252 ✓		
		601. ✓ 〃	水上ノ掘削 ✓
路じ石	0.3×0.25×11 =	0.825 ✓ cub m	花崗石. ✓
土留石垣			
電燈 12本.			
Electric wiring	186 metres ×2 = 372 m.		

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CALCULATIONS FOR

Materials of Shinobu Bashi for Fukushima Ken.

Arch Bridge on the Right approach. 11.0 m clear span.

Handrail 15 m long

Concrete. 30 m @ 0.1473 = 4.4
·6
5.0 cub m.

Cast iron grates 6 @ 50 = 0.30 kg ton

form. 30 × 1.9 = 57.0
5.0
62.0 sq. m.

人造石 30 @ 2.15 = 64.5
5.5
70.0 sq m

Reinforcements 5.0 @ 0.15 = 0.75 kg ton.

Road way 砂利敷 13.0 × 11.6 = 151 sq. m.

Earth fill 151 @ 1.1 = 166 cub. m

Spandrel wall
concrete 1.1 × 11 × ·3 × 2 = 7.3 cub m
Reinforcement 7.3 @ ·075 = 0.55 kg tons.
form. 1.2 × 4 × 11 = 53 sq. m
人造 1.6 × 2 × 11 = 35.2 "

Arch Ring
Concrete 0.5 × 13.5 × 12.0 = 81.0 cub m
Reinforcements 81 @ ·085 = 6.9 kg tons
Centering 13.5 × 11 = 148.5 sq m
form. 0.5 × 12 × 2 = 12.0
人造 0.8 × 12 × 2 = 19.2

Abutment.
Concrete. ·3 × 13 × 2.0 = 7.8
3 × 2 × ·4 × 2 = 4.8
3.5 × 3 × 13.8 = 145.0
157.6 × 2 = 315.2 cub m. for 2 abutments

Reinforcements 2 @ 1.8 = 3.6 kg tons. "

forms 2.0 × 13 × 2 = 52.0
3 × 2 × 4 = 24.0
4 × .4 × 2 = 3.2
·3 × 3.5 × 2 = 21.0
3.0 × 13.8 = 41.4
6.0 × 13.8 = 82.8
224.4 × 2 = 448.8 sq m for 2 abutments

人造.
2 × 2 × 2 = 8.0
·3 × 2 × 4 = 2.4
·6 × 2 × 2 = 2.4
12.8 × 2 = 25.6 sq. m for 2 abutments

Piles 4 × 13 = 52 × 2 = 104 本 " "
末口 15 cm, 3.5 m

Excavation 5.5 × 16 × 3 = 264 × 2 = 528 cub m. for 2 abutments.

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CALCULATIONS FOR

Materials of Shinobu Bashi for Fukushima Ken.

混凝土一立方米代價表 一三、〇

セメント	二、〇〇樽	五、五〇	一一、〇〇
砂	〇、五立坪	一、五〇	〇、七五
砂利	一、〇	二、七〇	二、七〇
練混手間	一、七人	一、五〇	二、五五
			一七、〇〇