昭和五年四月

福島縣信夫橋設計々算書

及材料調書

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY J. Masuda DATE 4-12-15 FILE NO ____
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CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

The new bridge will be located on line of present wooden truss bridge which span over Arakawa which neccesitate to build temporary bridge on upstream for general traffic during construction and also the spanning of new bridge will be restricted to clear the present piers. On preliminary estimates we get min. construction cost adapting reinforced concrete arch span comparing to any other types of bridge. On account of bridge camber to be given to bridge and also of too flat arch for this site we finally adopted the arch spans of varying span length and rise keeping the springing line of arch to flood level.
The following is the approximate spanning of bridge layout for this crossing.

1st span	21.8 meters	rise	2.685 m
2nd "	24.6 meters	"	2.995 "
3rd "	26.4 "	"	3.195 "
4th "	27.0 "	"	3.265 "

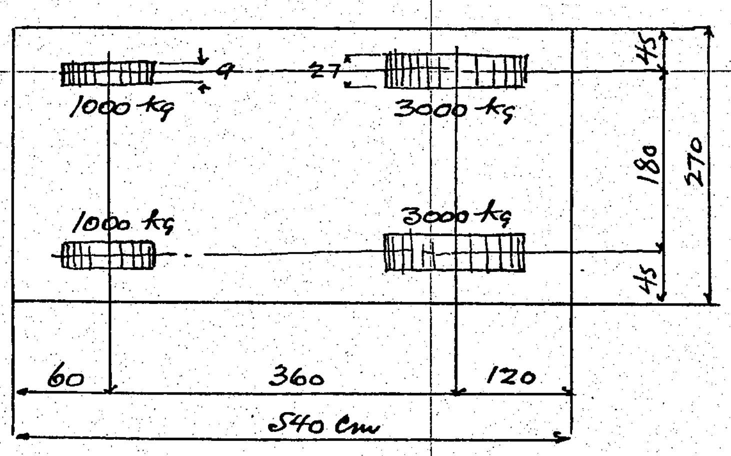
Giving ratio rise to span length = .121 about throughout width of pier at springing 1.6 meters about ; the bridge symmetrical about 4th span making 7 spans in all. At abutment 0.8 meter each Total length of bridge 183.8 meters about between faces of parapet walls of abutments.
Clear roadway 11.0 meters clear between curb lines. the pavement will be asphalt block pavement 8. meters wide at center and 2 - 1.5 meters on both sides granolithic pavement using crushed granite for aggregate.

Assumed loadings

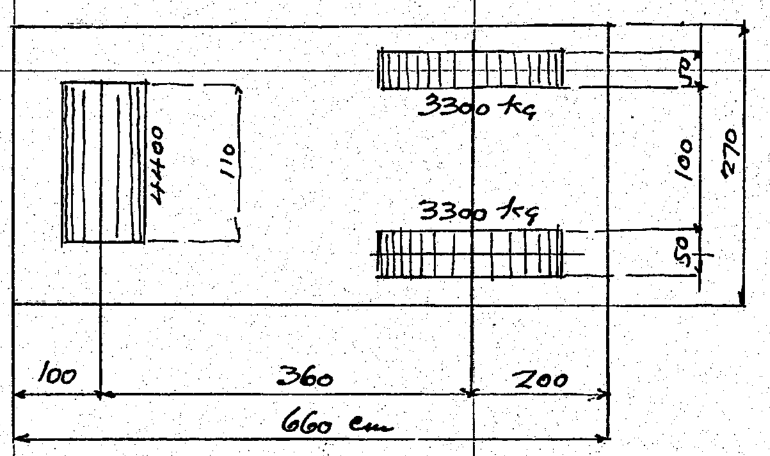
Uniform load on Roadway $w = \frac{100.000}{170+l} \leq 500$ kg/m²

where w = uniform load in kg per sq. meters
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 Coef $= \frac{20}{60+l}$ where l = loaded length in meter
max impact 30%

no impact considered for roadroller and uniform load.

Allowable Working Strength
Concrete 1:2:4 mixture

Direct compression		35 kg/cm²
Fibre stress due to bending		45 "
Combined stresses direct and bending	compression member	35 "
	Arch ring.	45 "
Punching shear of Concrete		9
Shear of plain Concrete		4
Bearing value		45

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CONSULTIEG ENGINEER
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CALCULATIONS FOR

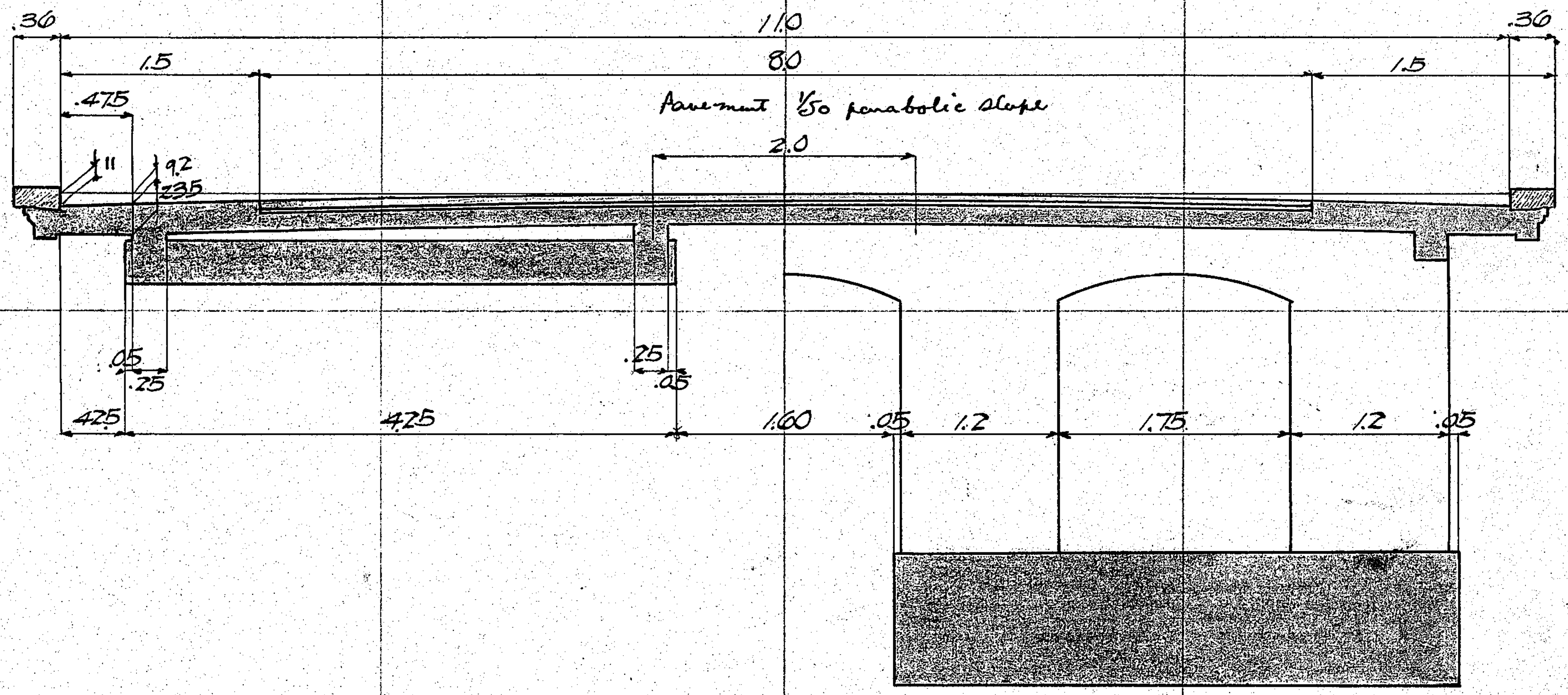
Shinobu-Bashi for Fukushima-Ken

Bond stress for plain bar	6 kg/cm²
" " " deformed bar	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 stress shall be increased 60%

Seismic accelleration 2000 mm/sec² or say $k = 0.2$

Cross section of bridge assumed as shown below:-



Design of Floor Slab. max. span length 2.0 meter between ℄ Floor Beam

Dead Load

5 cm Asphalt Block Pavement	@ 21 kg	=	105
2 cm mortar Cushion	@ 17 "	=	34
16.5 cm Concrete Slab	@ 24 "	=	396
misc concrete say			5
			540 kg per sq meter.
7 cm Concrete pavement	@ 22	=	154.0
16.5 cm Concrete slab	@ 24	=	396.0
			550
misc say variation.			5
			555 kg. per sq meter.

Average weight

540 · 8 = 4320

555 · 3 = 1665

5985 ÷ 11.0 = 544 kg per sq meter.

Assume wt of flooring 540 kg per sq meter

Dead Load moment = $\frac{1}{10}$ · 540 · 2.0² = 216 kgm

Dead Load Shear = $\frac{1}{2}$ · 540 · 2.0 = 540 kg

Live Load motor truck loading

Rear wheel Concentration	3000	Front wheel Concentration
30% impact	900	3900 ÷ 3 = 1300 kg.
	3900 kg	

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CONSULTIEG ENGINEER
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CALCULATIONS FOR

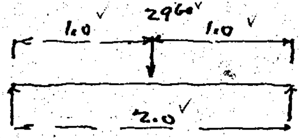
Shinobu-Bashi for Fukushima-Ken

Distribution of wheel Concentration on slab.
Thickness of pavement + mortar cushion = 7. cm
Longitudinal distribution a Contact between wheel and pavement 20
Distribution 2 × 7 14
34 cm

Transverse distribution b = 27 + 14 = 41.0 cm

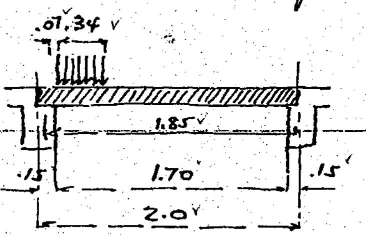
Longitudinal slab on transverse cross beam Effective width = 2/3 × 2.0 + .41 = 1.74 meters
Load per meter strip 3900 ÷ 1.74 = 2240 kg per lin. meter.
Incase of 2 wheels side by side .90 meter apart
Effective width = 2/3 × 2 + .41 + .90 = 2.64 meters

Load per meter strip 7800 ÷ 2.64 = 2960 kg per lin. meter. use this loading.



moment as concentration $\frac{2960}{2}$ × 1.0 = 1480 kg m
For continuity of slab 1480 × 0.8 = 1183 " "

max End shear of slab. Span length assumed 1.85 meters
2960 × $\frac{1.64}{1.85}$ = 2630 kg.



Summary for moments and shears

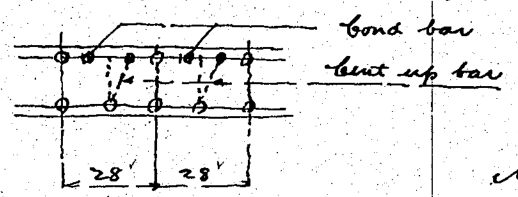
	moment	shear
Dead Load	216.0	540
Live Load	1183.0	2630
	1399.0 kgm	3170 kg

Effective depth required for slab fs = 1200 kg/cm² fc = 45 kg/cm²
$R = \frac{M}{bd^2}$ $d = \sqrt{\frac{M}{bR}}$ where R = 7.18

$d = \sqrt{\frac{1399.}{7.18}}$ = 14.0 cm make depth of slab 16.5 cm with 2.5 cm insulation at bottom

Steel area required = $\frac{139900}{7/8 \times 14.0 \times 1200}$ = 9.53 □cm per meter strip

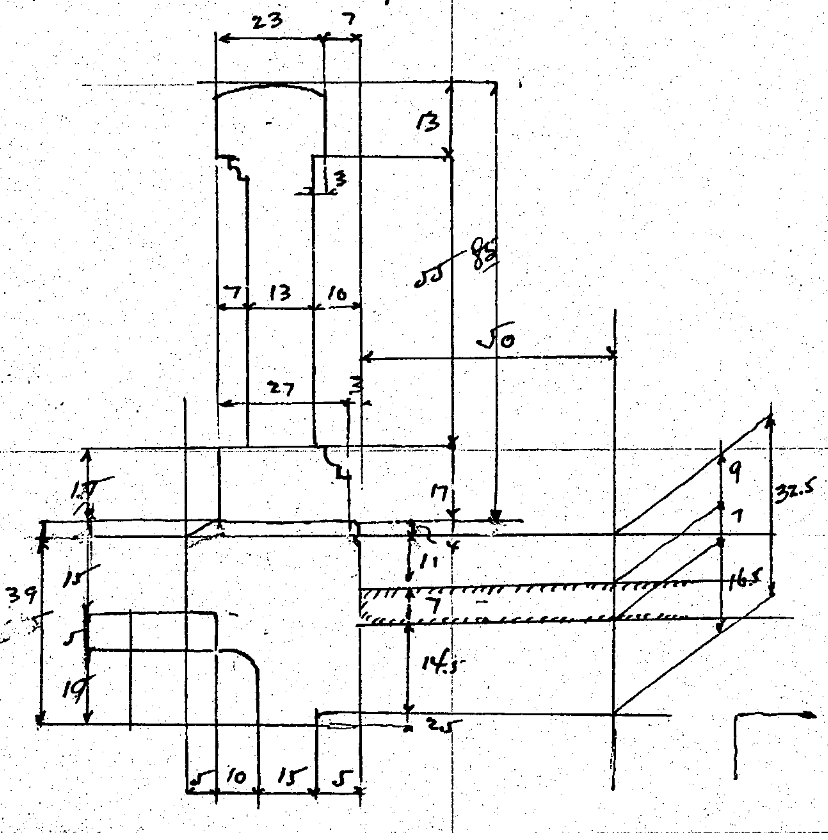
13mm bars area = 1.33 □cm spacing of bar = $\frac{133}{9.53}$ = 14.0 cm.



13mm circumference 4.08 spacing $\frac{100}{\frac{28}{3}}$ = 10.74 = 43.6

Unit bond = $\frac{3170}{7/8 \times 14 \times 43.6}$ = 5.93 kg/cm²

Overhanging slab at Edge of roadway
Approximate details of Handrails and coping.



weight of Handrail
Cap. .13 × .23 = 0.03
panel .55 × .13 = 0.071
base .17 × .27 = 0.046
0.147 @ 2400 = 353 kg.

Call this 350 kg per lin. meter

weight of Coping
0.35 × 0.39 = 0.136
0.05 × .29 = 0.014
0.10 × .19 = 0.019
0.05 × 0.025 = 0.001
0.034

0.136
− 0.034
~~0.096~~ 0.102 @ 2400 = ~~246~~ 245 kg.

weight of slab 555 × 0.5 = 278 kg

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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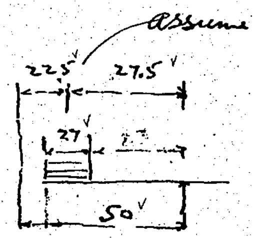
CALCULATIONS FOR

Shinobu - Bashi for Fukushima - Ken

Approximate Cantilever moment projection 50. cm

	weight		arm		moment
Handrail	350	×	.68	=	238
Coping	245	×	.66	=	162
Slab.	278	×	.25	=	70
	873 kg.				470 kgm

Live Load motor truck loading rear wheel with impact 3900 kg
distribution assumed .50 × 2 = 1.00
.34
1.34 meter



Load per meter strip 3900 ÷ 1.34 = 2910 kg.
moment = 2910 × .275 = 800 kgm
Shear say ~~3900~~ 2910 kg

Summary for moments and shears

	moment	shear
Dead Load	470	873
Live Load	800	2910
	1270 kgm	3783 kg.

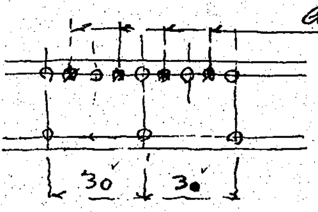
Effective depth reqd = $\sqrt{\frac{1270}{7.18}}$ = 13.3 cm

Steel area = $\frac{127000}{7/8 \times 14.0 \times 1200}$ = 8.7 cm² per meter

using 13 mm bar $\frac{133}{8.7}$ = 15.3 cm

Use 15 cm spacing.

add for bond. 13 mm dia.

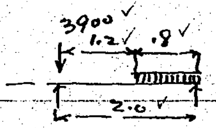


13 mm bar circum. 4.08 no = 13.3 per meter
Total area = 4.08 × 13.3 = 54.2 sq cm

Unit bond = $\frac{3783}{7/8 \times 14 \times 54.2}$ = 5.7 kg/cm²

Design of Fascia Girder. Span length 2.0 meters
Dead Load beyond face 873
Slab say 555 × 1.00 assumed 555
beam assumed 300
1728 call this 1750 kg per lin. meter
Dead Load Moment = $\frac{1}{10} \times 1750 \times 2.0^2$ = 700.0 kgm
Dead Load shear = $\frac{1}{2} \times 1750 \times 2.0$ = 1750 kg.

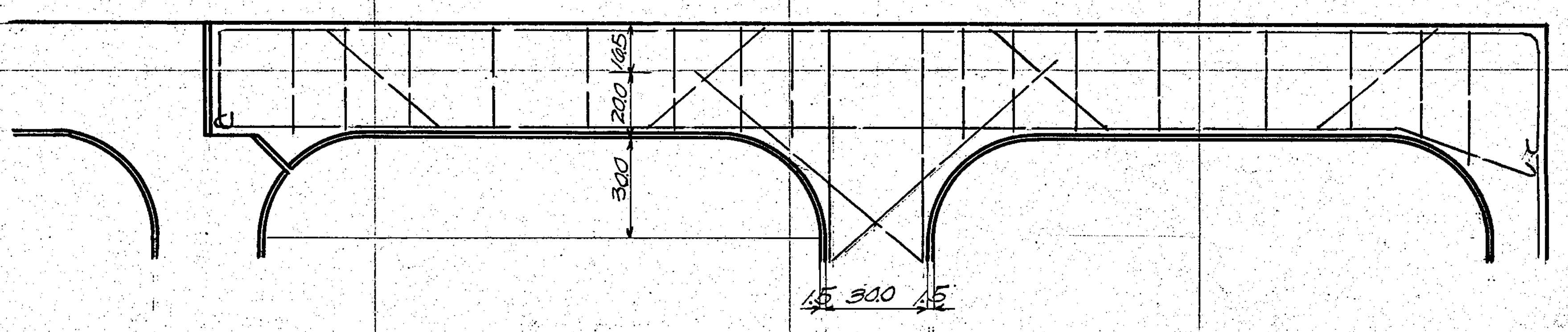
Live Load motor truck loading rear wheel with impact 3900 kg.
Live load moment = $\frac{3900}{2} \times 1.0$ = 1950 kgm @ 80% = 1560 kgm
End shear say motor truck = 3900
Unif. load $0.8 \times 750 \times \frac{.4}{2.0}$ = 120
4020 kg



500 × 1.5 = 750 assumed

Summary for moments and shears

	moment	shear
Dead Load	700.	1750
Live Load	1560	4020
	2260 kgm	5770 kg.



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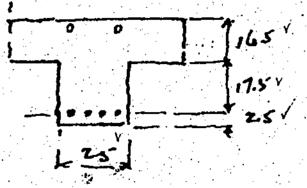
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken



$t/d = \frac{16.5}{34} = .485$ neutral axis in flange. width of flange $= \frac{2.0}{4} = 0.5$ assumed.

Reinforcing Bars 4-16mm bars $4 \times 2.01 = 8.04\ cm^2$

Steel % $\frac{8.04}{50 \times 34} = 0.473\%$ $k = 0.311$ $j = 0.896$ $kj = .278$

Stress in Concrete $f_c = \frac{226000 \times 2}{.278 \times 50 \times 34^2} = 28\ kg/cm^2$

Steel Stress $f_s = \frac{226000}{0.00473 \times .896 \times 50 \times 34^2} = 920\ kg/cm^2$

For negative moment $d = 64\ cm$ width $= 25\ cm$

~~Steel area~~ $= \frac{8.04}{64 \times 25} = .502\%$ $k = 0.32$ $j = .891$ $kj = 285$

Stress in Concrete $f_c = \frac{226000 \times 2}{.285 \times 25 \times 64^2} = 15.5\ kg/cm^2$

Stress in Steel $f_s = \frac{226000}{0.00502 \times .891 \times 25 \times 64^2} = 485\ kg/cm^2$

max End Shear $\frac{5770}{25 \times 64 \times .891} = 4.05\ kg/cm^2$ use 9mm Stirrups as shown on Sketch

at free end $\frac{5770}{25 \times 34 \times .891} = $ about $7.6\ kg/cm^2$

$\underline{4.0}$

$3.6\ kg/cm^2$ to be taken care of Stirrups.

9mm bars shearing strength $= .63 \times 900 = 570\ kg$

spacing of Stirrups $= \frac{570 \times 2}{3.6 \times 25} = 12.7\ cm$ at end

Bond stress $= \frac{5770}{.891 \times 64 \times 20.08} = 5.05\ kg/cm^2$ using 4-16mm bars

Transverse Beam carrying 2.0 meter floor slab span length 2.0 meter clear opening 1.75 meters.

Dead Load floor load $540 \times 2 = 1080$

stem assumed $\underline{385}$

1465 kg.

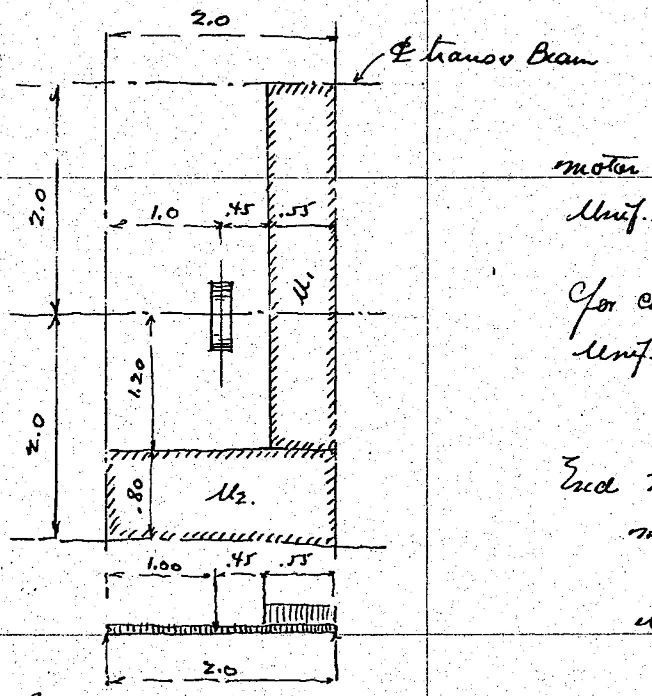
Dead Load moment $= \frac{1}{10} \times 1465 \times 2.0^2 = 585\ kgm$

Dead Load shear $= \frac{1}{2} \times 1465 \times 2.0 = 1465\ kg.$

Live Load motor truck loading rear wheel with impact 3900 kg.

Uniform live load $500\ kg/m^2$

M_2 Reaction $\frac{500 \times .8^2}{2 \times 2.0} = 80$ kg per meter.



M_1 Reaction $500 \times 2 = 1000$

$\underline{-80}$

920 kg per meter. $R = \frac{920 \times .55^2}{2 \times 2.0} = 70.2\ kg$

motor truck $\frac{3900}{2} \times 1.0 = 1950$

Unif. load as simple beam $70.2 \times 1.0 = \underline{70}$

2020

For continuity of beam $2020 \times 0.8 = 1616$.

Unif. load M_2 $\frac{1}{10} \times 80 \times 2.0^2 = \underline{32}$

1648 kgm

End Shear 2 rear wheels on span

motor truck $3900 \times \frac{1.1}{2.0} = 2140$

3900

Unif. load M_2 $\frac{1}{2} \times 80 \times 2.0$ $\underline{80}$

6120 kg.

Summary for moments and shears

	moment	shear
Dead Load	585	1465
Live Load	1648	6120
	2233 kgm	7585 kg

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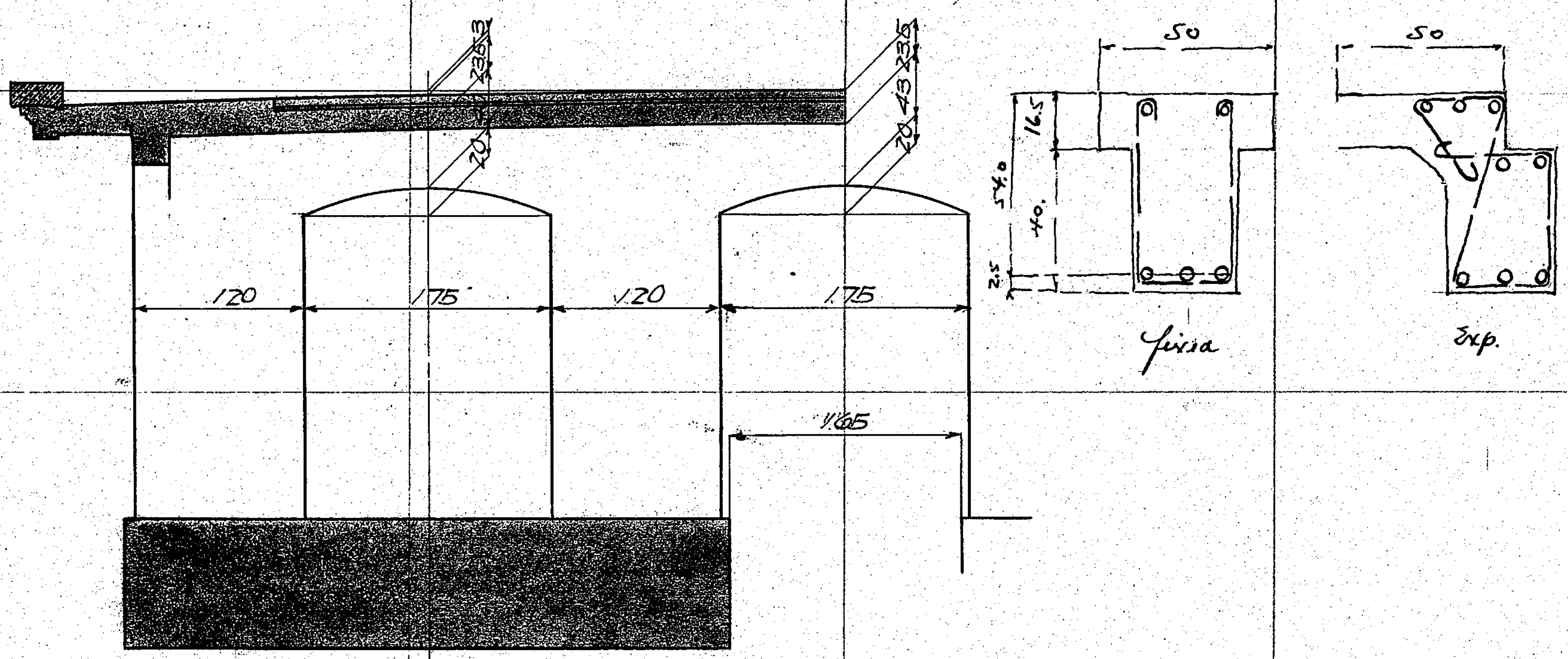
CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken



Effective width assumed $\frac{2.0}{4}$ = 0.50 meter   Reinforcing Bars 3- 16 mm @ 2.01 = 6.03 bottom
2- " @ 2.01 = 4.02 top

$t/d = \frac{16.5}{54} = .306$ neutral axis in flange
Steel ratio at center of beam $\frac{6.03}{50 \times 54}$ = 0.223 %   k = 0.225 j = .924 kj = .208

Stress in concrete $f_c = \frac{223300 \times 2}{.208 \times 50 \times 54^2}$ = 14.7 kg/cm²

Stress in Steel $f_s = \frac{223300}{0.00223 \times .924 \times 50 \times 54^2}$ = 743 kg/cm²

Beam stress for negative moment d = 74 cm   Steel ratio = $\frac{4.02}{30 \times 74}$ = 0.181 %

k = 0.205 j = .93 kj = 0.191

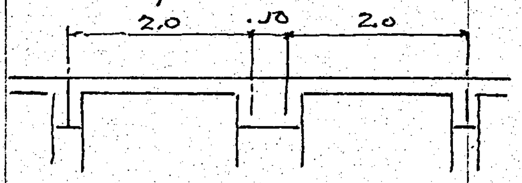
Stress in Concrete $f_c = \frac{223300 \times 2}{0.191 \times 30 \times 74^2}$ = 14.2 kg/cm²

Stress in Steel $f_s = \frac{223300}{0.00181 \times 0.93 \times 30 \times 74^2}$ = 812 kg/cm²

Unit shear at end = $\frac{7585}{.93 \times 74 \times 30}$ = 3.67 kg/cm²

Add 2 more bars at end for bond
4- 16 mm bars circumference 5.02 × 4 = 20.08
Unit bond = $\frac{7585}{.93 \times 74 \times 20.08}$ = 5.5 kg/cm²

Cross Beam over Piers. span length 2.0 meter clear opening 1.75 meters
width of beam .80 meter



Dead Load Floor load 540 × 2.50 = 1350
beam say 960
2310 kg.

Dead Load moment = $\frac{1}{10} \times 2310 \times 2.0^2$ = 924 kgm
Dead Load shear = $\frac{1}{2} \times 2310 \times 2.0$ = 2310 kg.

Live Load same as for typical transverse beam
manner of loading assumed as shown on sketch

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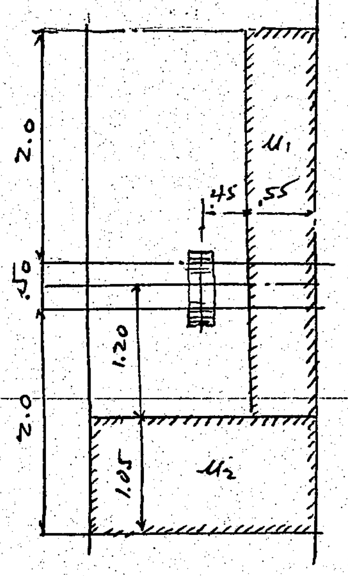
CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken



U2 Uniform load $\frac{500 \times 1.05}{2 \times 2.0}$ = 131 kg. Unif.

U1 Unif. load 500 × 2.5 = 1250
− 131
1119 kg.

Reaction = $\frac{1119 \times .55^2}{2 \times 2.0}$ = 84.5

motor truck loading. $\frac{3900}{2} \times 1.0$ = 1950
Unif. load U1 84.5 × 1.0 = 84
2034

for continuity of beam 2034 × 0.8 = 1630
U2 $\frac{1}{10} \times 131 \times 2.0^2$ = 52
1682 kgm

End shear two wheels side by side.
motor truck rear wheel $3900 \times \frac{1.1}{2.0}$ = 2140
do 3900
Uniform load U2 $\frac{1}{2} \times 131 \times 2.0$ = 131
6171 kg

Summary for moments and shears

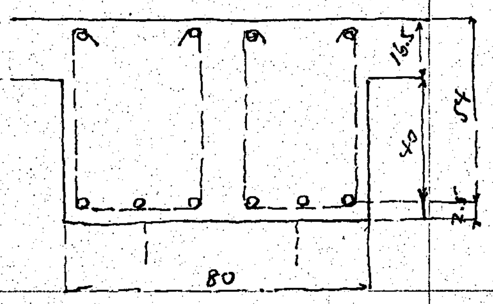
	moment	shear
Dead Load	924	2310
Live Load	1682	6171
	2606 kgm	8481 kg.

As square beam of .80 meter wide.
depth at center line say 54 cm

Reinforcing Bars 6-16mm bars @ 2.01 = 12.06

Steel ratio = $\frac{12.06}{80 \times 54}$ = 0.279 %. k = 0.25 j = .914

kj = .228



Stress in Concrete $f_c = \frac{260600 \times 2}{0.228 \times 80 \times 54^2}$ = 9.8 ~~4.9~~ kg/cm²

Stress in Steel $f_s = \frac{260600}{.002790 \times .914 \times 80 \times 54^2}$ = 438 kg/cm²

Stresses at end of beam for negative moment
d = 74 b = 80 Reinforcing bars same as middle of span 6-16mm bars
Steel ratio = $\frac{12.06}{80 \times 74}$ = .204 % k = .22 j = .928 kj = .204

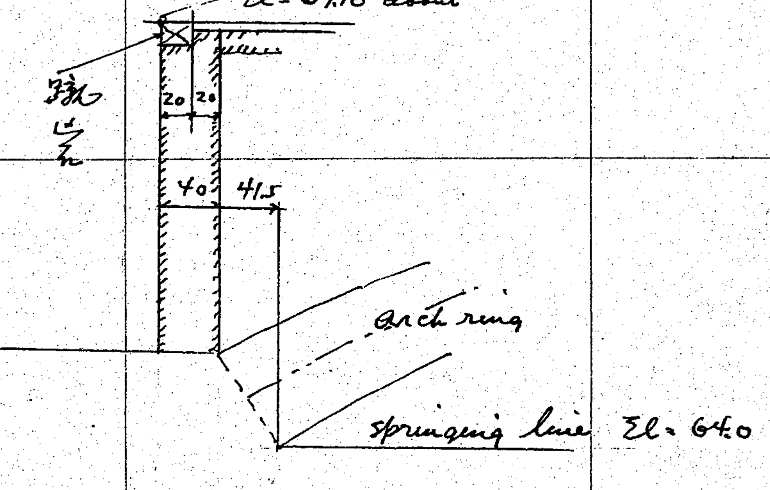
Stress in Concrete $f_c = \frac{260600 \times 2}{0.204 \times 80 \times 74^2}$ = 5.85 kg/cm²

Stress in Steel $f_s = \frac{260600}{.00204 \times .928 \times 80 \times 74^2}$ = 314 kg/cm²

Unit shear at end = $\frac{8481}{.928 \times 80 \times 74}$ = 1.55 kg/cm²

5.02 × 6 = 30.12 Bond Stress = $\frac{8481}{.928 \times 74 \times 30.12}$ = 4.1 kg/cm²

Retaining wall at end of span over abutment
Details as shown on sketch calculation shall be made with design of abutment



Shinobu-Bashi for Fukushima-Ken

Assumed Dead Load of Arch Spans.

weight of Handrail.

Top rail	0.13 × .23	=	0.0299
Bottom rail	0.17 × .27	=	0.0459
Panel	.13 × .55	=	0.0715

0.1473 @ 2400 = 353 kg per lin. meter

weight of Coping

.35 × .365 0.1280
.050 × 0.215 = − 0.0107
.08 × 0.15 = − 0.0120
0.1053
.15
0.1065 @ 2400 = 256 kg per lin. meter

Concrete Pavement .07 × 1.50 @ 2400 = 252. 2@252 = 504 kg.

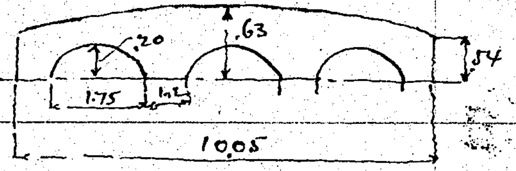
Asphalt Pavement 5cm Asphalt block @ 21 = 105
2cm mortar @ 17 = 34
139 × 8.0 m = 1110
1614 kg.

Slab. .165 × 11.0 @ 2400 = 4350 kg.

Summary

Handrails	2@ 353	=	706
Copings	2@ 256	=	512
Pavement			1614
Concrete Slab.			4350
			7182 kg per lin. meter.

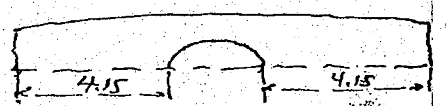
Transverse Cross Beam average area 10.05 × .61 = 6.12
less opening 3 × .236 = − .71
5.41 × .30 = 1.62 cubic meter



weight = 1.62 @ 2400 = 3890 kg

Column 4.80 × 3.0 @ 2400 = 3460 kg. per meter of height.

Transverse Cross Beam with one opening. 6.12
− .24
5.88 @ .30 @ 2400 = 4220 kg.



Solid wall 8.30 × .30 @ 2400 = 5980 kg per lin. meter of height of wall.

Center cross beam .63 × 1.75 = 1.10
less opening .24
.86 × .30 @ 2400 = 620 kg

Wall on Arch ring. 5980 kg per lin. meter of height

Longitudinal Fascia girder under slab.
.20 × 1.70 = .340
filler 2@ .019 = .038
.378 × .25 = 0.0943 @ 2400 = 227 kg.
for both sides 2 × 227 = 454 kg.

Longitudinal wall 25 cm wide
for 2 walls .25 × 2 @ 2400 = 1200 kg for square meter

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

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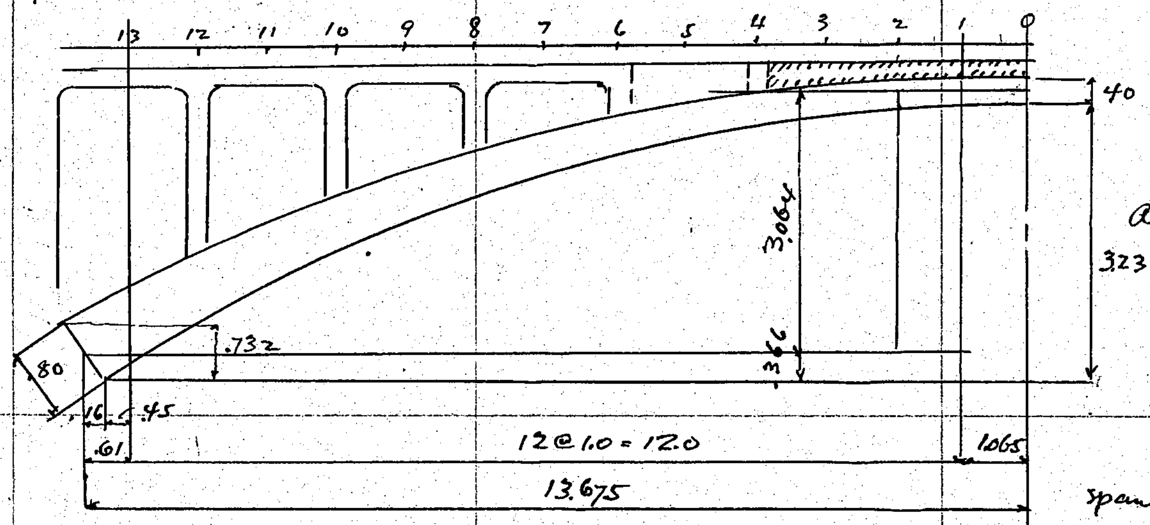
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Span no 4



Springing
Arch ring .38 × .86 × 8.50 @2400 = 6650

at ⑬ Arch ring $\frac{.45}{2}$ × 0.5 = .72
.72 × .82 × 8.5 × 2400 = 12000 kg
assumed.

Span length 27.35 m

at ⑫	flooring	7182 × 2 =	14364.
	cross beam		3890.
	Fascia girder		454
	Column	3460 × 1.68 =	5810
			24518
	Arch ring	.71 × 8.50 @ 2400 =	14500
			39018
at ⑪	Arch ring	.64 × 8.50 @ 2400 =	13050
at ⑩	flooring	7182 × 2 =	14364
	Cross beam		3890
	Fascia girder		454
	Col.	3460 × 1.00 =	3460
			22168
	Arch ring	.58 × 8.50 @ 2400 =	11820
			33988
at ⑨	Arch ring	.55 × 8.50 @ 2400 =	11200
at ⑧	flooring	7182 × 2 =	14364
	Cross beam		4220
	fascia girder		454
	wall	5980 × .46 =	2750
			21788
	Arch ring	.51 × 8.5 @ 2400 =	10400
			32188
at ⑦	Arch ring	.48 × 8.5 @ 2400 =	9800
at ⑥	flooring	7182 × 2.0 =	143644
	Cross beam		4220
	fascia girder (outside)		227
	longl wall	.35 × .55 @ 1200 =	231
	Transverse wall	5980 × .05 =	300
			19342
	Arch ring	~~.40~~ .46 × 8.50 @ 2400 =	9370
			28712
at ⑤	longl wall	1.0 × .42 @ 1200 =	505
	Arch ring	.44 × 8.50 @ 2400 =	8980
			9485

at ④	flooring	7182 × 1.50 =	10780
	cross beam (center)		620
	cross wall	5980 × .35 =	2060
	longl wall (outside)	.28 × 1.00 × 1200 =	336
	" " (inside)	.35 × .35 × 1200 =	147
	Sand fill	.35 × .35 × 7.3 × 1800 =	1610
			15553
	Arch ring	.42 × 8.5 × 2400 =	8560
			24113
at ③	flooring	7182 × 1.0 =	7182
	longl wall (out)	.19 × 1.00 × 1200 =	230
	" " (ins)	.26 × 1.00 × 1200 =	310
	Sand fill	.25 × 1.00 × 7.3 × 1800 =	3280
			11002
	Arch ring	.42 × 8.5 × 2400 =	8550
			19552
at ②	flooring	7182 × 1.0 =	7182
	outside wall	.11 × 1.00 × 1200 =	132
	inside wall	.17 × 1.00 × 1200 =	204
	Sand fill	.15 × 1.00 × 7.3 × 1800 =	2100
			9618
	Arch ring	.41 × 8.5 @ 2400 =	8350
			17968
at ①	flooring	7182 × 1.0 =	7182
	outside wall	.06 × 1.00 × 1200 =	70
	inside wall	.12 × 1.00 × 1200 =	144
	Sand fill	.10 × 1.00 × 7.3 × 1800 =	1315
			8711
	Arch ring	.40 × 8.50 × 2400 =	8150
			16861
at ⓪	flooring	7182 × .565 =	4050
	outside wall	.565 × .05 × 1200 =	34
	inside wall	.565 × .11 × 1200 =	75
	Sand fill	.565 × 0.09 × 7.3 × 1800 =	668
			4827
	Arch ring	.40 × 8.50 × 2400 =	4610
			9437

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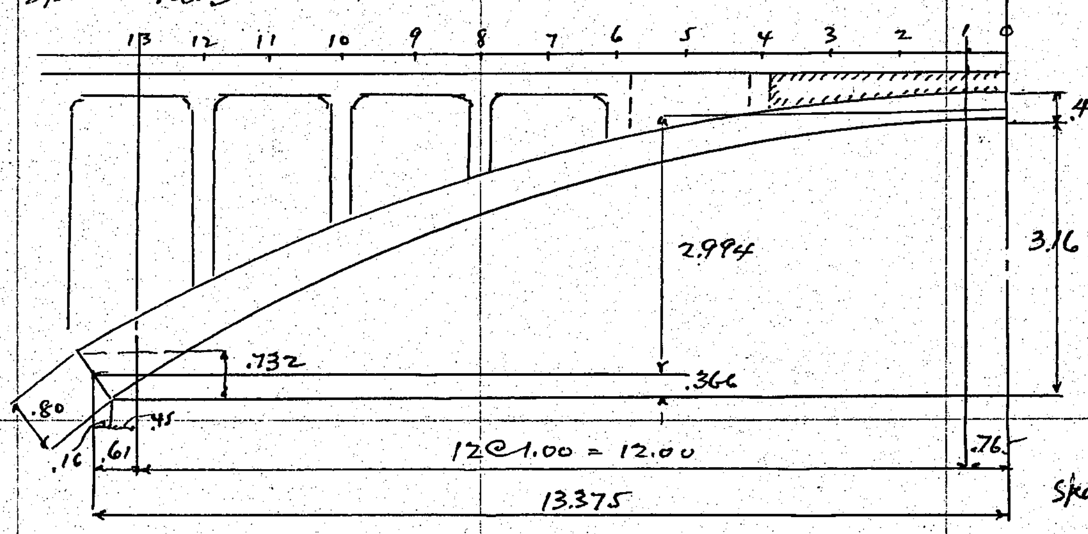
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Span No. 3



at Springing
arch ring .38 × .86 × 8.50@2400 = 6650

at ⑬ Arch ring $\frac{.45}{2}$ + 0.5 = .72

.72 × .82 × 8.5 × 2400 = 12000 kg
assumed

Span length = 26.75 m

at ⑫ flooring 7182 × 2.0 = 14364
Cross beam 3890
Fascia girder 454
Column 3460 × 1.60 = 5530
24238
Arch ring .73 × 8.5 × 2400 = 14900
39138

at ⑪ Arch ring .65 × 8.5 × 2400 = 13250

at ⑩ flooring 7182 × 2.0 = 14364
Cross beam 454
Fascia girder 3890
Col. 3460 × .93 = 3220
21928
Arch ring .59 × 8.50 × 2400 = 12050
33978

at ⑨ Arch ring .55 × 8.50 × 2400 = 11200

at ⑧ flooring 7182 × 2.0 = 14364
Cross beam 4220
fascia girder 454
Col. 5980 × .40 = 2400
21438
Arch ring .52 × 8.5 × 2400 = 10600
32038

at ⑦ Arch ring .485 × 8.5 × 2400 = 9900

at ⑥ flooring 7182 × 2.0 = 14364
Cross beam 4220
fascia girder 227
longl wall .35 × .48 × 1200 = 202
19013
Arch ring .46 × 8.5 × 2400 = 9400
28413

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

at ④ flooring 7182 × 1.5 = 10780
Cross beam center 620
Cross wall 5980 × 0.32 = 1920
Outside wall .25 × 1.00 × 1200 = 300
inside wall .35 × .30 × 1200 = 126
Sand fill .35 × .28 × 7.3 × 1800 = 1290
15036
Arch ring .42 × 8.5 × 2400 = 8560
23596

at ③ flooring 7182 × 1.0 = 7182
outside wall .17 × 1.00 × 1200 = 204
inside wall .23 × 1.00 × 1200 = 390
Sand fill .20 × 1.00 × 7.3 × 1800 = 2630
10406
Arch ring .415 × 8.50 × 2400 = 8450
18856

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

at ① flooring 7182 × 1.0 = 7182
outside wall .06 × 1.00 × 1200 = 70
inside wall .12 × 1.00 × 1200 = 144
Sand fill .10 × 1.0 × 7.3 × 1800 = 1315
8711
Arch ring .40 × 8.50 × 2400 = 8150
16861

at 0 flooring 7182 × .265 = 1900
outside wall .265 × .05 × 1.00 × 1200 = 16
inside wall .265 × .11 × 1.00 × 1200 = 35
Sand fill .265 × 0.08 × 1.0 × 7.3 × 1800 = 278
2229
Arch ring .40 × .265 × 8.5 × 2400 = 2165
4394

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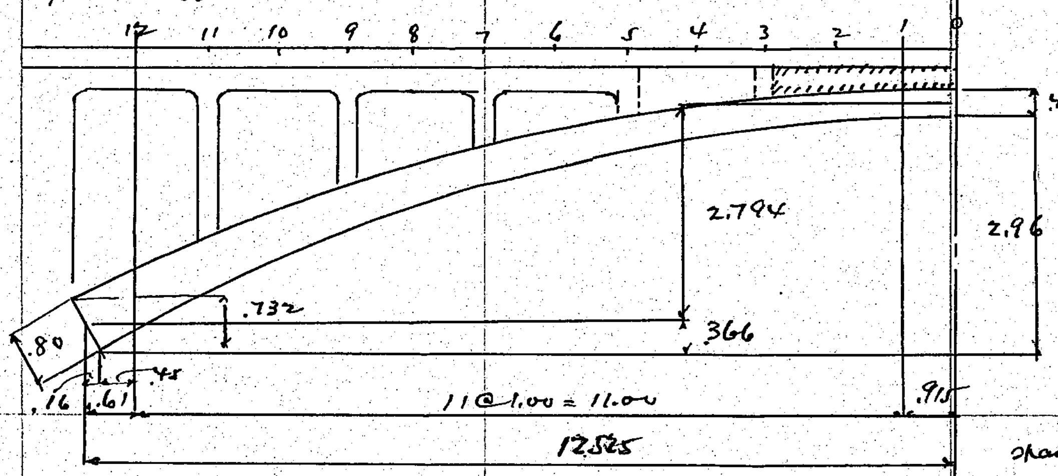
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

Span no 2.



at Springing 6650 kg. arch ring
at ⑫ arch ring 12000 assumed

span length 25.05 meters

at ⑪	flooring	7182 × 2.0	=	64 14344
	Cross Beam			3890
	Fascia girder			454
	Column	3460 × 1.43	=	4950
				23658
	Arch ring	.72 × 8.5 × 2400	=	14700 4950
				38358
at ⑩	Arch ring	.64 × 8.5 × 2400	=	13100
at 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
at ⑧	Arch ring	.53 × 8.5 × 2400	=	10800
at 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
at ⑥	arch ring	.48 × 8.5 × 2400	=	9800
at ⑤	flooring	7182 × 2.0	=	14364
	Center cross beam		=	620
	cross wall	5980 × 0.50	=	2990
	fascia girder			227
	longl wall	.35 × .39 × 1200	=	164
				18365
	Arch ring	.45 × 8.5 × 2400	=	9180
				27545
at ④	longl wall	1.00 × .30 × 1200	=	360
	Arch ring	.43 × 8.5 × 2400	=	8780
				9140

at ③	flooring	7182 × 1.5	=	10780
	Center wall			620
	Cross wall	5980 × .25	=	1500
	Outside wall	.19 × 1.00 × 1200		230
	inside wall	.23 × .35 × 1200	say	100
	Sand fill	.23 × .35 × 7.3 × 1800	=	1060
				14290
	Arch ring	.42 × 8.5 × 2400	=	8560
				22850
at ②	flooring	7182 × 1.0	=	7182
	Outside wall	.11 × 1.00 × 1200	=	132
	inside wall	.17 × 1.00 × 1200	=	187
	Sand fill	.15 × 1.00 × 7.3 × 1800	=	1970
				9471
	Arch ring	.41 × 8.5 × 2400	=	8350
				17821
at ①	flooring	7182 × 1.0	=	7182
	outside wall	.06 × 1.00 × 1200	=	70
	inside wall	.12 × 1.00 × 1200	=	144
	Sand fill	.10 × 1.0 × 7.3 × 1800	=	1315
				8711
	Arch ring	.40 × 8.5 × 2400	=	8150
				16861
at ⓪	flooring	7182 × .415	=	2980
	outside wall	.415 × .05 × 1200	=	25
	inside wall	.415 .10 × 1200	=	50
	Sand fill	.415 × .09 × 7.3 × 1200	=	490
				3545
	Arch ring	.415 × .40 × 8.5 × 2400	=	3390
				6935

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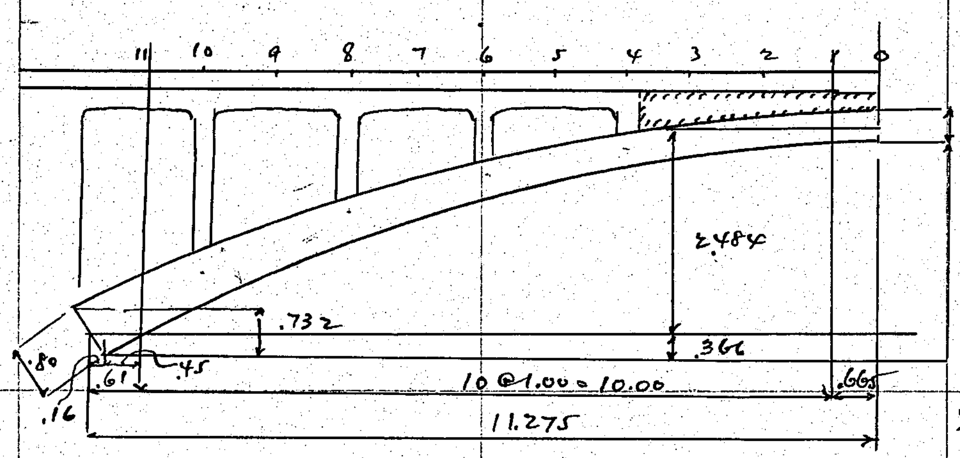
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

Span no 1.



springing arch ring 6650 kg
at ⑪ arch ring 12000 " assumed
Span length 22.55 meters

at ⑩	flooring	7182 × 2.0	=	14364
	cross beam			3890
	fascia girder			454
	Col.	3460 × 1.14	=	3940
				22648
	Arch ring	.71 × 8.5 × 2400	=	14500
				37148
at ⑨	Arch ring	.625 × 8.5 × 2400	=	12750
at 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
at ⑦	Arch ring	.51 × 8.5 × 2400	=	10400
at ⑥	flooring	7182 × 2.0	=	14364
	Cross beam			4220
	fascia girder			454
	wall	5980 × 0.06	=	360
				19398
	Arch ring	.48 × 8.50 × 2400	=	9780
				29178
at ⑤	Arch ring	.45 × 8.50 × 2400	=	9200
at ④	flooring	7182 × 1.5	=	10780
	Center cross beam			620
	wall	5980 × .35	=	2100
	fascia girder			227
	Outside wall	.28 × .35 × 1200	=	118
	inside wall	.34 × .35 × 1200	=	143
	Sand fill	.32 × .35 × 7.3 × 1800	=	1470
				15458
	Arch ring	.43 × 8.5 × 2400	=	8770
				24228

at ③	flooring	7182 × 1.0	=	7182
	Outside wall	.17 × 1.00 × 1200	=	204
	inside wall	.23 × 1.00 × 1200	=	276
	Sand fill	.21 × 1.0 × 7.3 × 1800	=	2760
				10422
	Arch ring	.42 × 8.5 × 2400	=	8570
				18992
at ②	flooring	7182 × 1.0	=	7182
	Outside wall	.10 × 1.00 × 1200	=	120
	inside wall	.16 × 1.00 × 1200	=	192
	Sand fill	.14 × 1.0 × 7.3 × 1800	=	1840
				9334
	Arch ring	.41 × 8.5 × 2400	=	8350
				17684
at ①	flooring	7182 × 1.0	=	7182
	outside wall	.06 × 1.00 × 1200	=	70
	inside wall	.12 × 1.00 × 1200	=	144
	Sand fill	.10 × 1.0 × 7.3 × 1800	=	1315
				8711
	arch ring	.40 × 8.5 × 2400	=	8150
				16861
at ⓪	flooring	7182 × .165	=	1185
	outside wall	.165 × .05 × ~~1.0~~ × 1200	=	10
	inside wall	.165 .11 × ~~1.0~~ × 1200	=	22
	Sand fill	.165 × .09 × 7.3 × 1800	=	196
				1413
	Arch ring	.165 × .40 × 8.5 × 2400	=	1350
				2763

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

Approximate Dead Load Reactions and Horizontal thrusts assuming zero moment at crown and springing.

Span no 4

Panel Point	Load	Arm	moment
0	9440	13.675	129.000
1	16860	12.610	212 500
2	17970	11.610	208.500
3	19550	10.610	207500
4	24100	9.610	232 000
5	9490	8.610	81 700
6	28700	7.610	218 500
7	9800	6.610	64 800
8	32200	5.610	180 800
9	11200	4.610	51 600
10	34000	3.610	119 000
11	13050	2.610	34 ~~340~~.000
12	39020	1.610	62800
13	12000	.610	7300
sp	6650	0	0
	284030 kg.		1810000

Hor. Thrust 1810.000 ÷ 3.064 = 590.000 kg

Span no 3.

Panel Point	Load	arm	moment.
0	4390	13.375	58700
1	16860	12.610	212500
2	17680	11.610	205500
3	18860	10.610	200000
4	23600	9.610	226500
5	9440	8.610	81300
6	28410	7.610	216500
7	9900	6.610	65500
8	32040	5.610	179800
9	11200	4.610	51600
10	33980	3.610	122500
11	13250	2.610	34600
12	39140	1.610	63000
13	12000	0.61	7300
sp.	6650	0	0
	277400 kg.		1725300

Hor. Thrust = 1725300 ÷ 2.994 = 576.000 kg

Span no 2.

Panel Point	Load	Arm	moment
0	6940	12.525	81400
1	16860	11.61	196000
2	17820	10.61	189 000
3	22850	9.61	220 000
4	9140	8.61	78700
5	27550	7.61	209500
6	9800	6.61	64800
7	30800	5.61	173000
8	10800	4.61	49800
9	33230	3.61	120000
10	13100	2.61	34200
11	38400	1.61	61800
12	12000	0.61	7300
Sp.	6650	0	0
	255940		1485500

Hor. Thrust = 1485500 ÷ 2.794 = 531.000 kg.

Span no 1.

Panel Point	Load	arm	moment
0	2760	11.275	31200
1	16860	10.61	179000
2	17680	9.61	170000
3	19000	8.61	163500
4	24230	7.61	185000
5	9200	6.61	60900
6	29180	5.61	164000
7	10400	4.61	48000
8	31900	3.61	115000
9	12750	2.61	33200
10	37150	1.61	59800
11	12000	0.61	7300
Sp.	6650	0	0
	229760 kg.		1216900

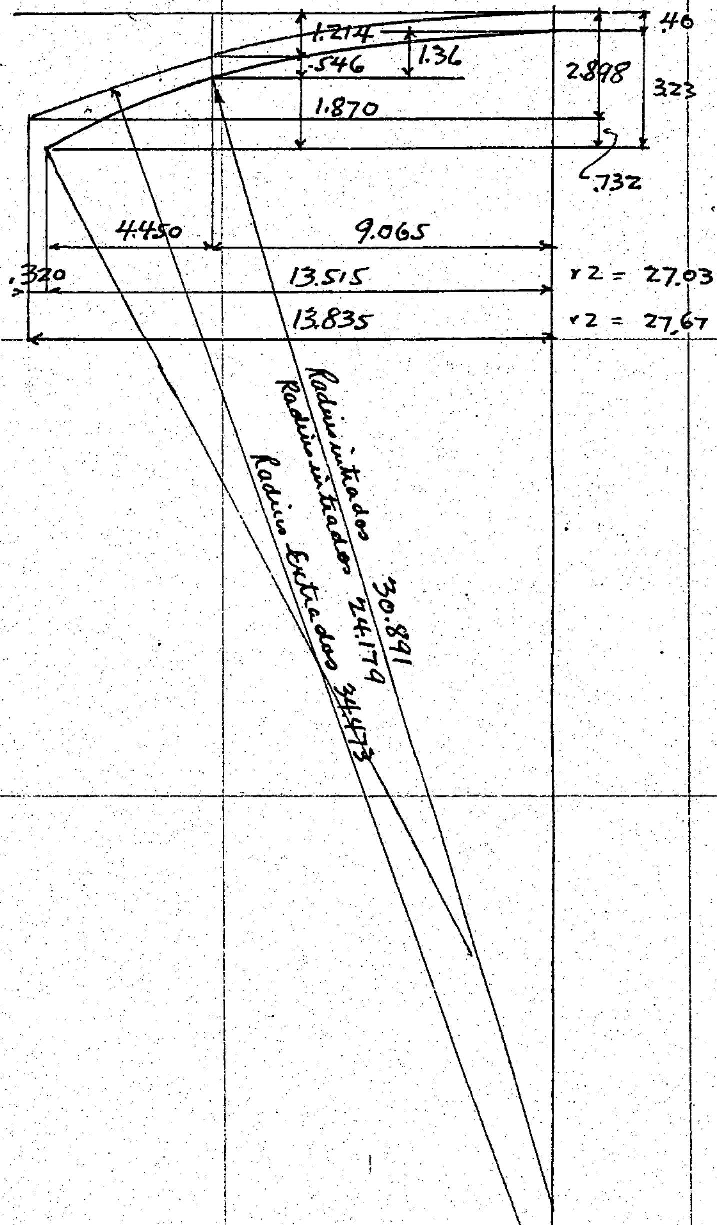
Hor. Thrust = 1216900 ÷ 2.484 = 489000 kg

増田淳氏関係資料
（独立行政法人 土木研究所蔵）

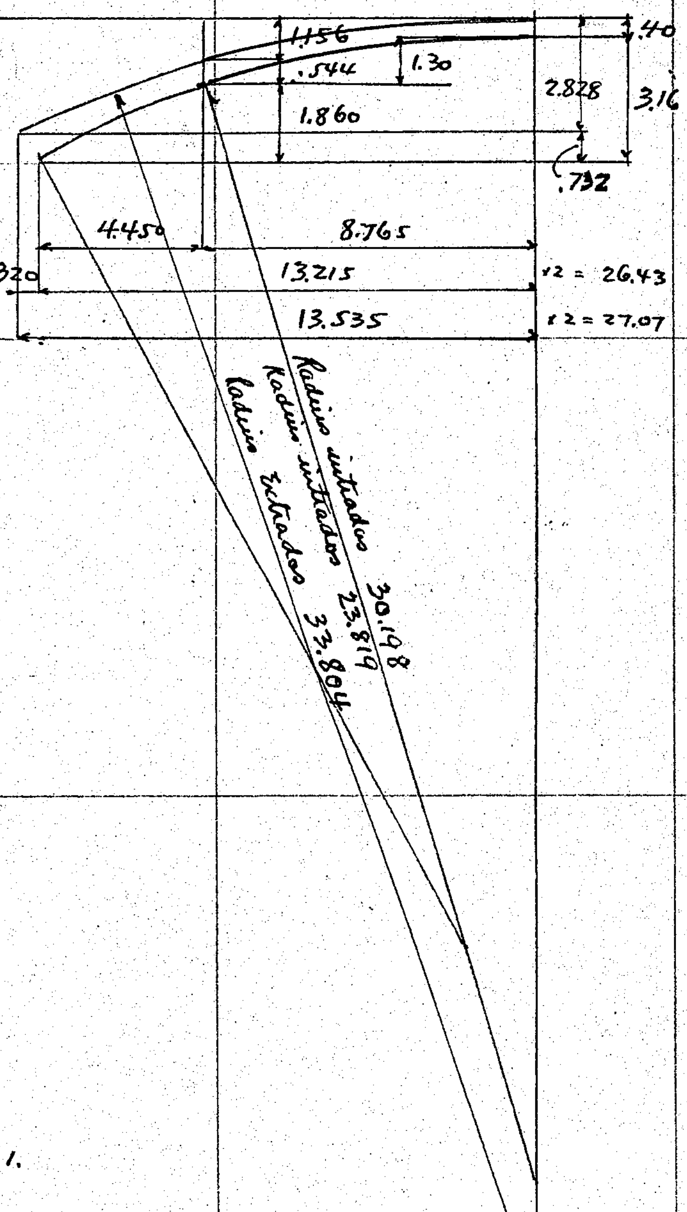
Shinobu-Bashi for Fukushima-Ken.

Dimensions of Arch ring.

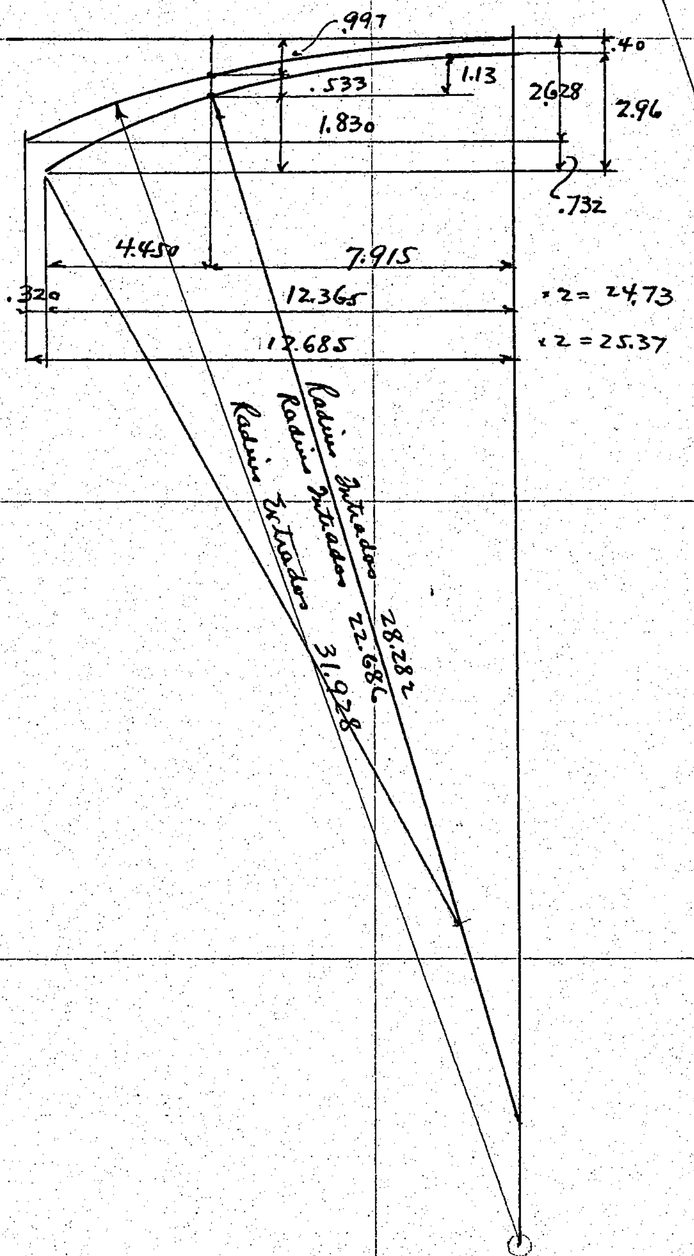
Span No 4



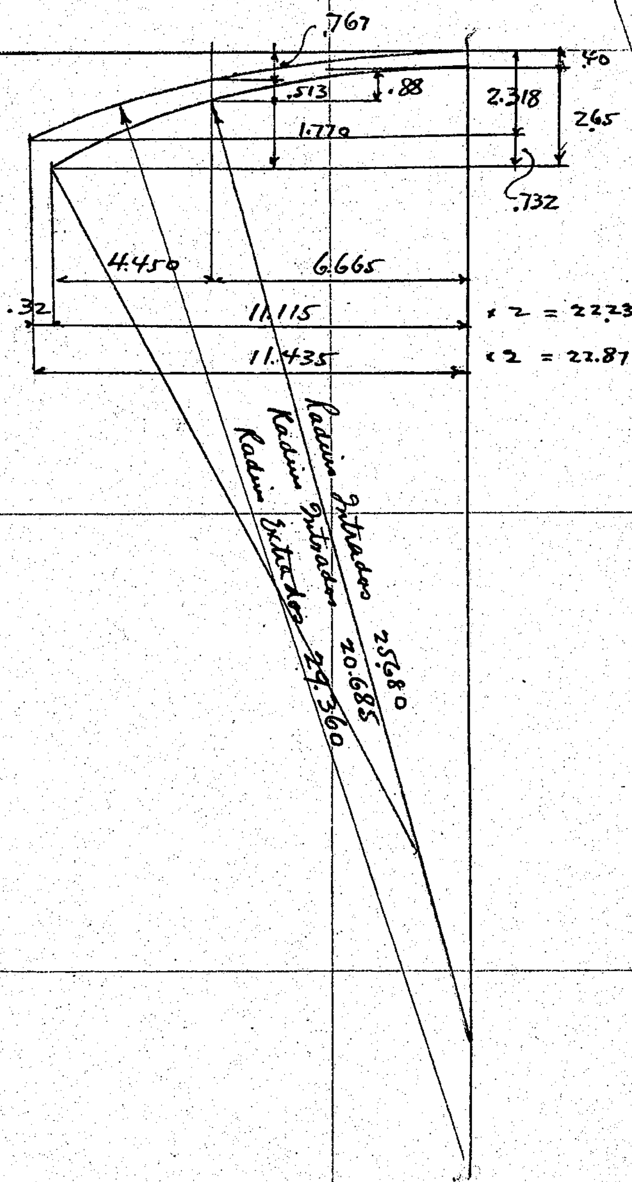
Span No 3.



Span No 2.



Span No 1.



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CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

Span No 4 Arch Ring

The arch ring will consist of 2- 4.25 meter rings separated at center line of bridge.
reinforcing bars 22 mm bars = 3.80 square cm at top and bottom of ring, spaced 26 cm at crown and 13 cm for springing.

$\therefore$ at crown 1 meter strip $3.80 \cdot \frac{1.00}{.26} = 14.6$ cm²

$2 @ 14.6 = 29.2$ cm²

moment of inertia of concrete for 1 meter strip $= \frac{1}{12} d^3$ where $d =$ depth of arch ring.

moment of inertia of steel for 1 meter strip $= \frac{29.2 \cdot 15}{10000} \left(\frac{d}{2} - 0.045 \right)^2$

$= 0.0438 \left(\frac{d}{2} - 0.045 \right)^2$

From panel point No 10 to Springing line. the above reinforcement will be doubled.

Division	Depth d	d^3	$I_c = \frac{1}{12} d^3$	$\left(\frac{d}{2} - 0.045\right)^2$			I_s	$I_c + I_s$	Concrete area 1 meter strip
Crown 0	.400	0.0640	0.00533	0.0240	× 0.0438	=	0.00105	0.00638	.400
1	.402	0.0649	0.00540	0.0244	"	=	0.00107	0.00647	.402
2	.405	0.0664	0.00553	0.0248	"	=	0.00109	0.00662	.405
3	.410	0.0689	0.00574	0.0256	"	=	0.00112	0.00686	.410
4	.414	0.0709	0.00591	0.0262	"	=	0.00115	0.00706	.414
5	.427	0.0778	0.00648	0.0284	"	=	0.00124	0.00772	.427
6	.445	0.0881	0.00734	0.0315	"	=	0.00138	0.00872	.445
7	.465	0.1005	0.00838	0.0352	"	=	0.00154	0.00992	.465
8	.485	0.1141	0.00952	0.0390	"	=	0.00171	0.01123	.485
9	.515	0.1366	0.01138	0.0452	"	=	0.00198	0.01336	.515
10	.550	0.1664	0.01385	0.0530	0.0876	=	0.00464	0.01849	.550
11	.600	0.2160	0.01733	0.0650	"	=	0.00570	0.02303	.600
12	.660	0.2875	0.02690	0.0813	"	=	0.00712	0.03402	.660
13	.735	0.3971	0.03310	0.1040	"	=	0.00910	0.04220	.735
Sp.	.800	0.5120	0.04265	0.1260	"	=	0.01102	0.05367	.800

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	.565	0.00638	88.60	0	0	0	0
1	1.065	1.134	0.015	0.002?	1.000	0.00647	154.50	164.50	175.20	2.32	.31
2	2.065	4.264	0.060	0.004	1.000	0.00662	151.20	312.00	644.00	9.07	.61
3	3.065	9.394	0.140	0.020	1.005	0.00686	146.50	449.00	1375.00	20.50	2.93
4	4.065	16.524	0.260	0.068	1.010	0.00706	143.00	581.00	2361.00	37.20	9.72
5	5.065	25.654	0.395	0.156	1.015	0.00772	131.50	666.00	3370.00	51.90	20.51
6	6.065	36.784	0.570	0.325	1.020	0.00872	117.00	709.50	4300.00	66.70	38.00
7	7.065	49.914	0.780	0.608	1.025	0.00992	103.40	730.50	5160.00	80.65	62.90
8	8.065	65.044	1.015	1.030	1.035	0.01123	92.20	744.00	6000.00	93.60	95.00
9	9.065	82.174	1.290	1.664	1.042	0.01336	78.00	706.50	6405.00	100.60	129.70
10	10.065	101.303	1.600	2.560	1.055	0.01849	57.10	574.20	5780.00	91.30	146.20
11	11.065	122.434	1.955	3.822	1.068	0.02303	46.40	513.50	5680.00	90.65	177.40
12	12.065	145.564	2.350	5.523	1.080	0.03402	31.76	383.00	4625.00	74.60	175.50
13	13.065	170.694	2.775	7.701	0.875	0.04220	20.70	270.50	3562.00	57.40	159.40
Sp.	13.675	187.006	3.064	9.388	0.350	0.05367	6.52	89.15	1219.00	19.97	61.20
					14.145		1368.38	6893.35	50656.20	796.46	1079.38

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CALCULATIONS FOR

Shinobu - Bashi for Fukushima - Ken

			at crown point 0				Panel Point no 1.				Panel Point no 2.		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0	0	0	0	0								
1	1.065	1.065	164.50	175.20	2.47	0							
2	2.065	2.065	312.00	644.00	18.73	1.00	151.20	312.00	9.07				
3	3.065	3.065	449.00	1375.00	62.80	2.00	293.00	898.00	41.00	1.00	146.50	449.00	20.50
4	4.065	4.065	581.00	2361.00	151.10	3.00	429.00	1743.00	111.60	2.00	286.00	1162.00	74.40
5	5.065	5.065	666.00	3370.00	263.00	4.00	526.00	2664.00	207.60	3.00	394.50	1998.00	155.70
6	6.065	6.065	709.50	4300.00	404.50	5.00	584.50	3547.50	333.50	4.00	468.00	2838.00	266.80
7	7.065	7.065	730.50	5160.00	570.00	6.00	620.40	4383.00	483.90	5.00	517.00	3652.50	403.25
8	8.065	8.065	744.00	6000.00	755.00	7.00	645.40	5208.00	655.20	6.00	553.20	4464.00	561.60
9	9.065	9.065	706.50	6405.00	912.00	8.00	624.00	5652.00	804.80	7.00	546.00	4945.50	704.20
10	10.065	10.065	574.20	5780.00	919.00	9.00	513.90	5167.80	821.70	8.00	456.80	4593.60	730.40
11	11.065	11.065	513.50	5680.00	1002.50	10.00	464.00	5135.00	906.50	9.00	417.60	4621.50	815.85
12	12.065	12.065	383.00	4625.00	900.00	11.00	349.36	4213.00	820.60	10.00	317.60	3830.00	746.00
13	13.065	13.065	270.50	3562.00	750.00	12.00	248.40	3246.00	688.80	11.00	227.70	2975.50	631.40
Sp.	13.675	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		5534.96	43293.48	6136.09		4406.59	36564.63	5341.95

			Panel Point 3				Panel Point 4				Panel Point 5		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
4	4.065	1.00	143.00	581.00	37.20								
5	5.065	2.00	263.00	1332.00	103.80	1.00	131.50	666.00	51.90				
6	6.065	3.00	351.00	2128.50	200.10	2.00	234.00	1419.00	133.40	1.00	117.00	709.50	66.70
7	7.065	4.00	413.60	2922.00	322.60	3.00	310.20	2191.50	241.95	2.00	206.80	1461.00	161.30
8	8.065	5.00	461.00	3720.00	468.00	4.00	368.80	2976.00	374.40	3.00	276.60	2232.00	280.80
9	9.065	6.00	468.00	4239.00	603.60	5.00	390.00	3532.50	503.00	4.00	312.00	2826.00	402.40
10	10.065	7.00	399.70	4019.40	639.10	6.00	342.60	3445.20	547.80	5.00	285.50	2871.00	456.50
11	11.065	8.00	371.20	4108.00	725.20	7.00	324.80	3594.50	634.55	6.00	278.40	3081.00	543.90
12	12.065	9.00	285.84	3447.00	671.40	8.00	254.08	3064.00	596.80	7.00	222.32	2681.00	522.20
13	13.065	10.00	207.00	2705.00	574.00	9.00	186.30	2434.50	516.60	8.00	165.60	2164.00	459.20
Sp.	13.675	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	30147.78	4556.88		2604.94	24179.93	3792.31		1920.36	18793.08	3064.94

			Panel Point 6				Panel Point 7				Panel Point 8		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
7		1.00	103.40	730.50	80.65								
8		2.00	184.40	1488.00	187.20	1.00	92.20	744.00	93.60				
9		3.00	234.00	2119.50	301.80	2.00	156.00	1413.00	201.20	1.00	78.00	706.5	100.60
10		4.00	228.40	2296.80	365.20	3.00	171.30	1722.60	273.90	2.00	114.20	1148.14	182.60
11		5.00	232.00	2567.50	453.25	4.00	185.60	2054.00	362.60	3.00	139.20	1540.5	271.95
12		6.00	190.56	2298.00	$\overset{76}{446.70}$	5.00	158.80	1915.00	378.00	4.00	127.04	1532.0	298.40
13		7.00	144.90	1893.50	401.80	6.00	124.20	1623.00	344.40	5.00	103.50	1352.5	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	6780.03	1252.58

			Panel Point 9				Panel Point 10				Panel Point 11		
		m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
10		1.00	57.10	574.20	91.30								
11		2.00	92.80	1027.00	181.30	1.00	46.40	513.50	90.65				
12		3.00	95.28	1149.00	223.80	2.00	63.52	766.00	149.20	1.00	31.76	383.00	74.60
13		4.00	82.80	1082.00	229.60	3.00	62.10	811.50	172.20	2.00	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	4243.18	818.06		195.56	2412.83	484.14		90.18	1156.68	241.52

Shinobu-Bashi for Fukushima-Ken

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	Panel Point 12					Panel Point 13		
x	m	$\frac{m\,ds}{I}$	$\frac{mx\,ds}{I}$	$\frac{my\,ds}{I}$	m	$\frac{m\,ds}{I}$	$\frac{mx\,ds}{I}$	$\frac{my\,ds}{I}$
13	1.00	20.70	270.50	57.40				
Sp.	1.61	10.49	143.53	32.15	0.61	3.97	54.38	12.18
		31.19	414.03	89.55		3.97	54.38	12.18

Crown Thrust $H_0 = \dfrac{\int\frac{ds}{I}\int my\frac{ds}{I} - \int m\frac{ds}{I}\int y\frac{ds}{I}}{2\left[\int\frac{ds}{I}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I}\right)^2\right]} = \dfrac{A}{B}$ $B = 1.685.308$

Loaded Point	Value of A	B		
Crown 0	4.066.000	÷ 1685.308	=	2.411
1	3910.000	"	=	2.365
2	3800.000	"	=	2.254
3	3502.000	"	=	2.078
4	3112.000	"	=	1.847
5	2665.000	"	=	1.580
6	2180 700	"	=	1.292
7	1701 900	"	=	1.009
8	1237 000	"	=	0.734
9	834400	"	=	0.495
10	506700	"	=	0.301
11	258600	"	=	0.153
12	97700	"	=	0.058
13	13470	"	=	0.008

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

							C	D	
Crown 0	2 × 2.411 × 796.46	=	− 3840.50	+	6893.35	=	+ 3052.85	÷ 2736.76	= + 1.1155
1	2.365		− 3767.25	+	5534.96		+ 1767.75		+ 0.6460
2	2.254		− 3590.44	+	4406.59		+ 816.15		+ 0.2980
3	2.078		− 3310.09	+	3432.52		+ 122.43		+ 0.0447
4	1.847		− 2942.12	+	2604.94		− 337.18		− 0.1232
5	1.580		− 2516.81	+	1920.36		− 596.45		− 0.2180
6	1.292		− 2058.05	+	1367.28		− 690.77		− 0.2525
7	1.009		− 1607.25	+	931.19		− 676.06		− 0.2470
8	0.734		− 1169.20	+	598.52		− 570.68		− 0.2084
9	0.495		− 788.50	+	358.04		− 430.46		− 0.1573
10	0.301		− 479.46	+	195.56		− 283.90		− 0.1036
11	0.153		− 243.72	+	90.18		− 153.54		− 0.0552
12	0.058		− 92.38	+	31.19		− 61.19		− 0.0224
13	0.008		− 12.74	+	3.97		− 8.77		− 0.0032
Sp.	0		0		0		0		− 0.0000

Crown Shear $V_0 = \dfrac{\int mx\frac{ds}{I}}{2\int x^2\frac{ds}{I}} = \dfrac{E}{F}$

Shinobu- Bashi for Fukushima- Ken

4 Vertical shear at crown

Point loaded	E		F		V_0	$1- V_0$
crown	50656. 20	÷	101 312. 40	=	.5000	.5000
1	43293. 48				.4270	.5730
2	36564. 63				.3609	.6391
3	30147. 78				.2975	.7025
4	24179. 93				.2385	.7615
5	18973. 08				.1872	.8128
6	14072. 23				.1389	.8611
7	10060. 88				.0993	.9007
8	6780. 03				.0669	.9331
9	4243. 18				.0419	.9581
10	2412. 83				.0238	.9762
11	1156. 68				.0114	.9886
12	414. 03				.0041	.9959
13	54. 38				.0005	.9995
Sp.	0. 00				.0000	1. 0000

Moment at various point for unit load

Let x and y co-ordinates of center of sections

d' lever arm of unit load about center of sections, origin at crown.

For Left Hand Sections $M_L = M_0 + H_0y + V_0x - d'$

" Right " " $M_R = M_0 + H_0y - V_0x$.

Moment at various points

Point	Springing x = 13.675 y = 3.064						Point 12 x = 12.065 y = 2.350					
	Mo	Hoy	Vox	d'	ML.	MR	Mo	Hoy	Vox	d'	ML	MR
0		7.3873	6.8375	13.675	+ 1.6653	+ 1.6653	+ 1.1155	5.6659	6.0325	12.065	+0.7489	+ 0.7489
1	+1.1155	7.2464	5.8392	12.610	+1.1216	+ 2.0532	+ 0.6460	5.5578	5.1518	11.00	+0.3556	+ 1.0520
2	+0.6460	6.9063	4.9353	11.610	+0.5296	+2.2690	+ 0.2980	5.2969	4.3543	10.00	-0.0508	+ 1.2406
3	+0.2980	6.3670	4.0683	10.610	-0.1300	+2.3434	+ 0.0447	4.8833	3.5893	9.00	-0.4828	+ 1.3387
4	+0.0447	5.6592	3.2615	9.610	-0.8125	+2.2745	- 0.1232	4.3405	2.8725	8.00	-0.9052	+1.3398
5	-0.1232	4.8441	2.5600	8.610	-1.4269	+2.0631	- 0.2180	3.7130	2.2586	7.00	-1.2464	+1.2364
6	-0.2180	3.9587	1.8995	7.610	-2.0043	+1.8067	-0.2525	3.0362	1.6758	6.00	-1.5405	+1.1079
7	-0.2525 -0.2470	3.0916	1.3792	6.610	-2.3862	+1.4654	-0.2470	2.3712	1.1981	5.00	-1.6777	+0.9261
8	-0.2084	2.2490	0.9148	5.610	-2.6546	+1.1258	-0.2084	1.7249	0.8071	4.00	-1.6764	+0.7094
9	-0.1573	1.5167	0.5730	4.610	-2.6776	+0.7864	- 0.1573	1.1633	0.5055	3.00	-1.4885	+ 0.5059
10	-0.1036	0.9223	0.3254	3.610	-2.4659	+0.4933	-0.1036	0.7074	0.2871	2.00	-1.1091	+ 0.3167
11	-0.0552	0.4688	0.1559	2.610	-2.0405	+0.2577	-0.0552	0.3596	0.1375	1.00	-0.5581	+ 0.1669
12	-0.0224	0.1777	0.0560	1.610	-1.3987	+0.0993	-0.0224	0.1363	0.0495	.00	+0.1643	+ 0.0644
13	-0.0032	0.0245	0.0068	0.610	-0.5819	+0.0145	-0.0032	0.0188	0.0060		+0.0216	+ 0.0096
Sp.	0.0000	0.0000	0.0000	0.000	-0.0000	0.0000	0.0000	0	0		0	0

CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

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Point 10, x=10.065 y = 1.600

Point	Mo	Hoy	Vox	d'	ML	MR
0	+1.1155	3.8576	5.0325	10.065	-0.0594	-0.0594
1	+0.6460	3.7840	4.2978	9.00	-0.2822	+0.1222
2	+0.2980	3.6064	3.6325	8.00	-0.4631	+0.2719
3	+0.0447	3.3248	2.9943	7.00	-0.6362	+0.3752
4	-.1232	2.9552	2.4005	6.00	-0.7675	+0.4315
5	-.2180	2.5280	1.8842	5.00	-0.8058	+0.4258
6	-.2525	2.0672	1.3980	4.00	-0.7873	+0.4467
7	-.2470	1.6144	.9995	3.00	-0.6331	+0.3679
8	-.2084	1.1744	.6734	2.00	-0.3606	+0.2926
9	-.1573	0.7920	.4217	1.00	+0.0564	+0.2130
10	-.1036	0.4816	.2395	00	+0.6175	+0.1385
11	-.0552	.2448	.1147		+0.3043	+0.0749
12	-.0224	.0928	.0413		+0.1117	+0.0291
13	-.0032	.0128	.0050		+0.0146	+0.0046
Sp.						

Point 8 x = 8.065 y= 1.015

Point	Mo	Hoy	Vox	d'	ML	MR
0	+1.1155	2.4472	4.0325	8.065	-.4698	-.4698
1	+0.6460	2.4005	3.4438	7.00	-.5097	-.3973
2	+0.2980	2.2878	2.9107	6.00	-.4935	-.3249
3	+.0447	2.1092	2.3993	5.00	-.4468	-.2454
4	-.1232	1.8747	1.9235	4.00	-.3250	-.1720
5	-.2180	1.6037	1.5098	3.00	-.1045	-.1241
6	-.2525	1.3114	1.1202	2.00	+.1791	-.0613
7	-.2470	1.0241	0.8009	1.00	+.5780	-.0238
8	-.2084	.7450	.5395	00	+1.0761	-.0029
9	-.1573	.5024	.3379		+.6830	+.0072
10	-.1036	.3055	.1919		+.3938	+.0100
11	-.0552	.1553	.0919		+.1920	+.0082
12	-.0224	.0587	.0331		+.0696	+.0034
13	-.0032	.0081	.0040		+.0089	+.0009
Sp.	0					

Point 6 x = 6.065 y = 5.70

Point	Mo	Hoy	Vox	d'	ML	MR
0	+1.1155	1.3743	3.0325	6.065	-.5427	-.5427
1	+.6460	1.3481	2.5898	5.00	-.4161	-.5957
2	+.2980	1.2848	2.1889	4.00	-.2283	-.6061
3	+.0447	1.1845	1.8043	3.00	+.0335	-.5751
4	-.1232	1.0528	1.4465	2.00	+.3761	-.5169
5	-.2180	.9006	1.1354	1.00	+.8180	-.4528
6	-.2525	.7364	0.8424	0	+1.3263	-.3585
7	-.2470	.5751	.6023		+.9304	-.2742
8	-.2084	.4184	.4057		+.6157	-.1957
9	-.1573	.2822	.2541		+.3790	-.1292
10	-.1036	.1716	.1443		+.2123	-.0763
11	-.0552	.0872	.0691		+.1011	-.0371
12	-.0224	.0331	.0249		+.0356	-.0142
13	-.0032	.0046	.0030		+.0062	+.0002
Sp.	0					

Point 4 x = 4.065 y = 0.260

Point	Mo	Hoy	Vox	d'	ML	MR
0	+1.1155	.6269	2.0325	4.065	-.2901	-.2901
1	+.6460	.6149	1.7358	3.00	-.0033	-.4749
2	+.2980	.5862	1.4671	2.00	+.3511	-.5831
3	+.0447	.5403	1.2093	1.00	+.7943	-.6243
4	-.1232	.4802	.9695	0	+1.3265	-.6125
5	-.2180	.4108	.7610		+.9538	-.5682
6	-.2525	.3359	.5646		+.6480	-.4806
7	-.2470	.2623	.4037		+.4190	-.3884
8	-.2084	.1908	.2719		+.2543	-.2895
9	-.1573	.1287	.1703		+.1417	-.1989
10	-.1036	.0783	.0967		+.0714	-.1220
11	-.0552	.0398	.0463		+.0309	-.0617
12	-.0224	.0151	.0167		+.0094	-.0240
13	-.0032	.0021	.0020		+.0009	-.0031
Sp.	0					

Point 2 x = 2.065 y = 0.060

Point	Mo	Hoy	Vox	d'	ML	MR
0	+1.1155	.1447	1.0325	2.065	+.2277	+.2277
1	+.6460	.1419	.8818	1.00	+.6697	-.0939
2	+.2980	.1352	.7453	00	+1.1785	-.3121
3	+.0447	.1247	.6143		+.7837	-.4449
4	-.1232	.1108	.4925		+.4801	-.5049
5	-.2180	.0948	.3866		+.2634	-.5098
6	-.2525	.0775	.2868		+.1118	-.4618
7	-.2470	.0600	.2051		+.0181	-.3921
8	-.2084	.0440	.1381		-.0263	-.3025
9	-.1573	.0297	.0865		-.0411	-.2141
10	-.1036	.0181	.0491		-.0364	-.1346
11	-.0552	.0092	.0235		-.0225	-.0695
12	-.0224	.0035	.0085		-.0104	-.0274
13	-.0032	.0005	.0010		-.0017	-.0037
Sp.	0					

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

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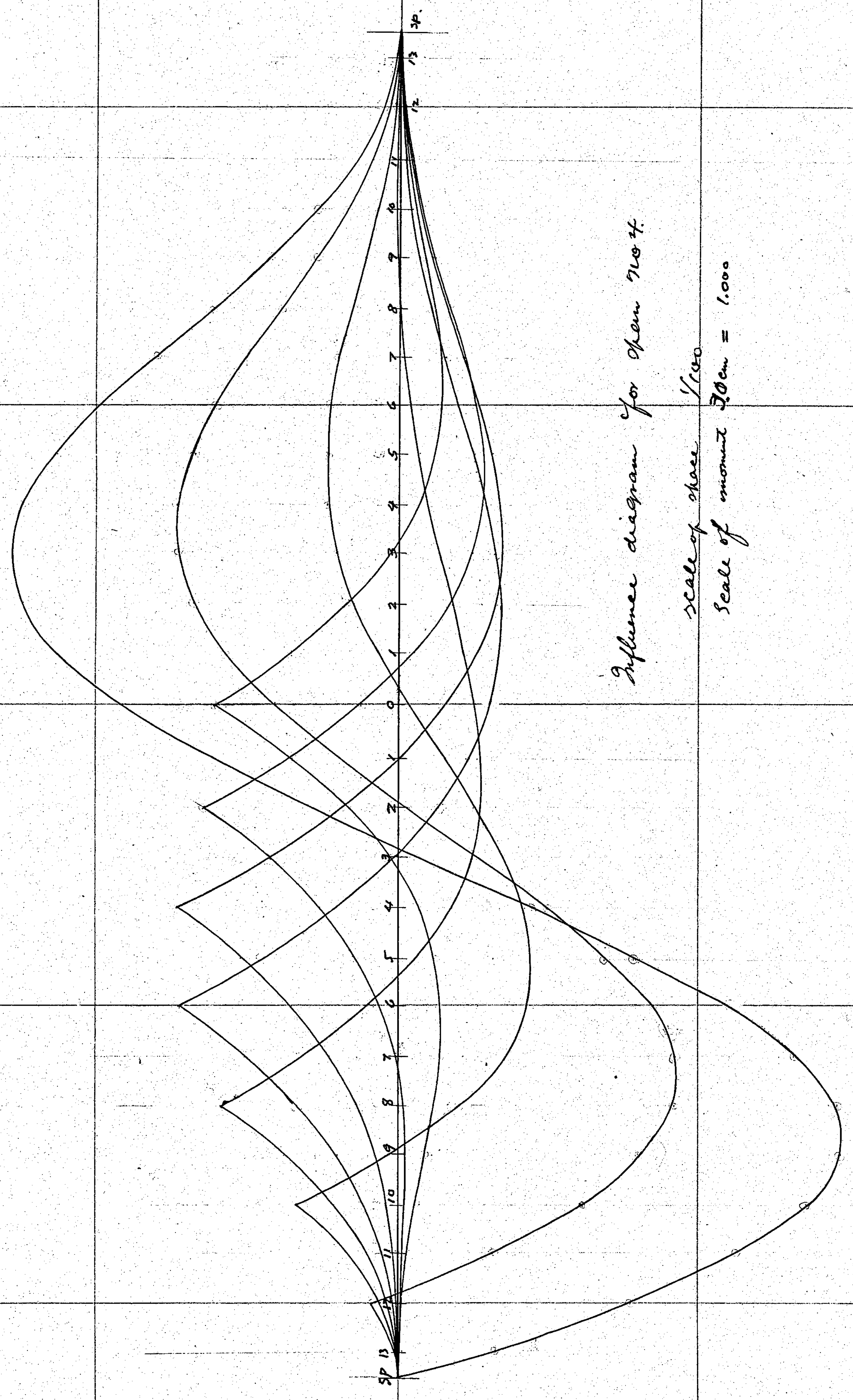

Influence diagram for span no 4.

Scale of space 1/100

Scale of moment 3.0cm = 1.000

Shinobu-Bashi for Fukushima-Ken

4 Dead Load moment at various panel Points.

		Crown	
	Load	Mo	M.
0	9440	+ 1.1155	+ 1.0,480
1	16860	+ .6460	+ 10,890
2	17970	+ .2980	+ 5350
3	19550	+ .0447	+ 870
4	24100	- .1232	- 2970
5	9490	- .2180	- 2070
6	28700	- .2525	- 7240
7	9800	- .2470	- 2420
8	32200	- .2084	- 6710
9	11200	- .1573	- 1760
10	34000	- .1036	- 3525
11	13050	- .0552	- 720
12	39020	- .0224	- 870
13	12000	- .0032	- 40
			+ 27.590
			- 28.325
			- 735 × 2 = -1470 kgm

		Panel Point 2		Panel Point 4		Panel Point 6		Panel Point 8	
	load	Mo	M.	unit load M	M	unit load M	M	unit load M	M.
13^L	12000	-.0017	- 20	+ .0009	10	.0062	74	.0089	107
12	39020	-.0104	- 406	+ .0094	367	.0356	1390	.0696	2730
11	13050	-.0225	- 294	+ .0309	403	.1011	1320	.1920	2500
10	34000	-.0364	- 1.237	+ .0714	2427	.2123	7220	.3938	13380
9	11200	-.0411	- 460	+ .1417	1588	.3790	4250	.6830	7650
8	32200	-.0263	- 847	+ .2543	8200	.6157	19820	1.0761	34600
7	9800	+.0181	+ 177	+ .4190	4110	.9304	9120	.5780	5650
6	28700	+.1118	+ 3210	+ .6480	18600	1.3263	38100	.1791	5140
5	9490	+.2634	+ 2500	+ .9538	9052	.8180	7750	- .1045	- 990
4	24100	+.4801	+ 11.560	+ 1.3265	32000	.3761	9060	- .3250	- 7830
3	19550	+.7837	+ 15.320	+ .7943	15500	.0335	+ 655	- .4468	- 8735
2	17970	+ 1.1785	+ 21.180	+ .3511	6320	- .2283	- 4110	- .4935	- 8870
1	16860	+ .6697	+ 11.280	- .0033	- 56	- .4161	- 7000	- .5097	- 8600
0	18880	+ .2277	+ 4300	- .2901	- 5480	- .5427	- 10250	- .4698	- 8870
1	16860	- .0939	- 1585	- .4749	- 8000	- .5957	- 10020	- .3973	- 6700
2	17970	- .3121	- 5610	- .5831	- 10500	- .6061	- 10900	- .3249	- 5850
3	19550	- .4449	- 8700	- .6243	- 12200	- .5751	- 11280	- .2454	- 4800
4	24100	- .5049	- 12.160	- .6125	- 14750	- .5169	- 12450	- .1720	- 4150
5	9490	- .5098	- 4835	- .5682	- 5380	- .4528	- 4300	- .1241	- 1180
6	28700	- .4618	- 13.250	- .4806	- 13800	- .3585	- 10300	- .0613	- 1760
7	9800	- .3921	- 3840	- .3884	- 3810	- .2742	- 2690	- .0238	- 234
8	32200	- .3025	- 9740	- .2895	- 9320	- .1957	- 6300	- .0029	- 93
9	11200	- .2141	- 2380	- .1989	- 2230	- .1292	- 1450	+ .0072	80
10	34000	- .1346	- 4578	- .1220	- 4148	- .0763	- 2592	+ .0100	340
11	13050	- .0695	- 910	- .0617	- 805	- .0371	- 484	+ .0082	107
12	39020	- .0274	- 1070	- .0240	- 935	- .0142	- 554	+ .0034	132
13^R	12000	- .0037	- 44	- .0031	- 37	+ .0002	+ 2	+ .0009	10
			+ 69.527		+ 98577		+ 98716		+ 72426
			- 71966		- 91451		- 94768		- 68662
			- 2439		+ 7126		+ 3956		+ 3764

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

4

		Panel 10		Panel 12		Springing	
	Load	unit load M	M.	unit load M	M	unit load M.	M
13L	12000	+0.0146	175	+ .0216	+ 260	- .5819	= 6980
12	39020	+ .1117	4360	+ .1643	+ 6410	- 1.3987	-54600
11	13050	+ .3043	3970	- .5581	- 7280	- 2.0405	= 26600
10	34000	+ .6175	20990	- 1.1091	- 37680	- 2.4659	- 83820
9	11200	+ .0564	630	- 1.4885	- 16650	- 2.6776	- 30000
8	32200	- .3606	- 11610	- 1.6764	- 54000	- 2.6546	- 85400
7	9800	- .6331	- 6210	- 1.6777	- 16480	- 2.3862	- 23400
6	28700	- .7873	- 22600	- 1.5405	- 44200	- 2.0043	- 57500
5	9490	- .8058	- 7650	- 1.2462	- 11800	- 1.4269	= 13530
4	24100	- .7675	- 18500	- .9052	- 21800	- .8125	= 19600
3	19550	- .6362	- 12440	- .4828	- 9450	- .1300	- 2540
2	17970	- .4631	- 8340	- .0508	- 915	+ .5296	+ 9510
1	16860	- .2822	- 4750	+ .3556	+ 6000	1.1216	18910
0	18880	- .0594	- 1120	+ .7489	14120	1.6653	31400
1	16860	+ .1222	2060	+ 1.0520	17720	2.0532	34600
2	17970	+ .2719	4880	+ 1.2406	22350	2.2690	40800
3	19550	+ .3752	7335	+ 1.3387	26200	23434	45800
4	24100	+ .4315	10400	+ 1.3398	32300	2.2745	54800
5	9490	+ .4258	4040	+ 1.2364	11710	2.0631	19570
6	28700	+ .4167	11950	+ 1.1079	31800	1.8067	51800
7	9800	+ .3679	3600	+ .9261	9080	1.4685	14380
8	32200	+ .2926	9430	+ .7094	22800	1.1258	36250
9	11200	+ .2130	2380	+ .5005	5600	.7864	8800
10	34000	+ .1385	4710	+ .3167	10760	.4933	16770
11	13050	+ .0749	977	+ .1669	2180	.2577	3360
12	39020	+ .0291	1135	+ .0644	2510	.0993	3870
13R	12000	+ .0046	55	+ .0096	115	.0145	1740
			+ 93077		+ 221915		397360
			- 93220		- 220255		- 403970
			- 143		+ 1660		- 11610

Dead Load Thrust

	Load	unit load H_0.	H_0				Normal Thrust.	Unit Shear		normal thrust
0	9440	2.411	22750	587740	· 1.060	=	587500	0	, 0.000	=
1	16860	2.365	39900					17870		
2	17970	2.254	40500		0.999	=	587000 ✓	35285	.070	2570
3	19550	2.078	40600					54045		
4	24100	1.847	44500		0.990	=	581500 ✓	75870	0.125	9500
5	9490	1.580	15000					92665		
6	28700	1.292	37000		0.980	=	576000 ✓	111760	0.185	20600
7	9800	1.009	9900					131010		
8	32200	.734	23600		0.970	=	570000 ✓	152010	0.250	38000
9	11200	.495	5540					173710		
10	34000	.301	10230		0.950	=	558000 ✓	196310	0.325	63800
11	13050	.153	1990					219835		
12	39020	.058	2260		0.920	=	540.000 ✓	245870	0.390	95850
13	12000	.008	100					271380		
½b.	6650	0			0.905	=	532.000 ✓	284030	0.440	125.000
	284030		293870							

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587748

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

4 Summary for Dead Load normal thrusts

	0	2	4	6	8	10	12	sp.
vert shear	—	2570	9500	20600	38000	63800	95850	125000
normal thrust	587500	587000	581500	576000	570000	558000	540000	532000
	587500	589570	591000	596600	608000	621800	635850	657.000

Live Load Stresses

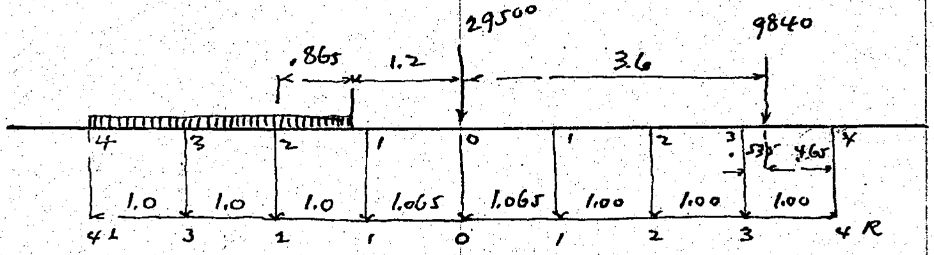
Uniform Live Load $\frac{100.000}{170+27.35}$ = 506 kg/m² use 500 kg/m²

impact for motor truck loading = $\frac{20}{60+27.35}$ = 22.9 %

Rear wheel Concentration 3000
impact 22.9 % 687
3687 × 2 = 7374 kg

For 4 motor trucks 7374 × 4 = 29500 kg for rear wheel
29500 ÷ 3 = 9840 " " front wheel.

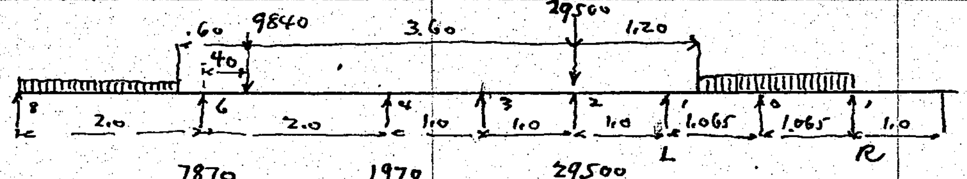
Crown stress + moment



2750 / 2750 (2750 neglected)
2750 + 2750 = 5500
2750 + 2690 = 5440
2060
29500
4570
5270

Point	load	M unit load	moment	H unit load	Hor. thrust
4R	5270	−.1232	− 650	1.847	9740
3	4570	+.0447	+ 200	2078	9500
2	—				
1	—				
0	29500	+ 1.1155	+ 32900	2.411	71100
1L	2060	+.6460	+ 1330	2.365	4870
2L	5440	+.2980	+ 1620	2.254	12250
3L	5500	+.0447	+ 246	2.087	11500
			35646		118960

Panel Point 2. + moment.



5440
7870 + 4460 = 12230
1970
29500
1930 = 1930
2925 + 2820 = 5745
2925 = 2925

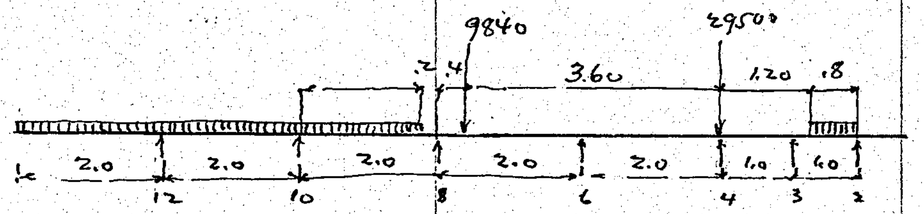
Point	load	M unit load	moment	Ho unit load	Hor. thrust	shear unit load	V shear
1R	2925	−.0938	− 274	2.365	6910	+.4270	1250
0	5745	+.2277	1305	2.411	13800	+.5000	2372
1L	1930	+.6697	1290	2.365	4560	+.5730	1110
2	29500	+1.1785	34700	2.254	66500	+.6391	18800
3							
4	1970	+0.4801	945	1.847	3640	−.2385	− 470
6	12230	+0.1118	1370	1.292	15800	−.1389	− 1700
8	5440	−0.0263	− 143	0.734	4000	−.0669	− 363
			39193		115210		20999

normal thrust 115210 × .999 = 115100
20999 × .070 = 1470
116570

CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

4 Panel Point no 4. + moment

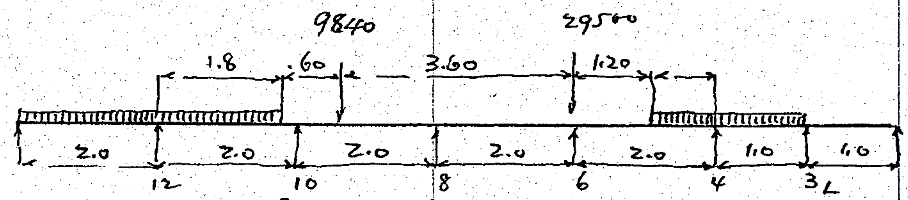


		7870	1970	29500		
5500	5440	4460			1760	2640
5500	5500					
11000	10940	12330	1970	29500	1760	2640

Point	load	M unit load	moment	H unit load	Hor. thrust	V unit load	vert shear
2L	2640	.3511	925	2.254	5950	0.6391	1690
3	1760	.7943	1400	2.087	3680	0.7025	1235
4	29500	1.3265	39100	1.847	54500	0.7615	22450
6	1970	.6480	1276	1.292	2540	- 0.1389	- 2740
8	12330	.2543	3140	0.734	9050	- 0.0669	- 825
10	10940	.0714	780	0.301	3300	- 0.0238	- 260
12	11000	.0094	104	0.058	640	- 0.0041	- 45
			46725		79660		21505

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

Panel Point no 6. + moment

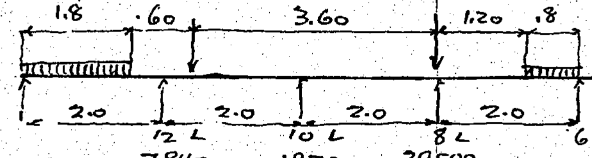


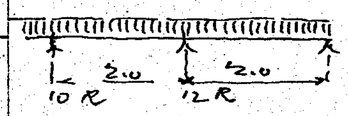
5440	7840	1970	29500	2750	2750
5500	4460		880 -	3520	
10940	12300	1970	30380	6270	2750

Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert shear
3L	2750	0.0355	92	2.087	5470	.7025	1930
4	6270	.3761	2360	1.847	11580	.7615	4780
6	30380	1.3263	40200	1.292	39200	.8611	26150
8	1970	.6157	1214	0.734	1445	.0669	- 132
10	12300	.2123	2610	0.301	3700	.0238	- 293
12	10940	.0356	390	0.058	635	.0041	- 45
			468666		62300		32860 -460 32400

Normal thrust 62300 . 0.98 = 61100
32400 . 0.185 = 6000
67100 kg.

Panel Point 8 + moment





7840	1970	29500			
4460		880 -	3520		
12300	1970	30380	3520	11000	11000

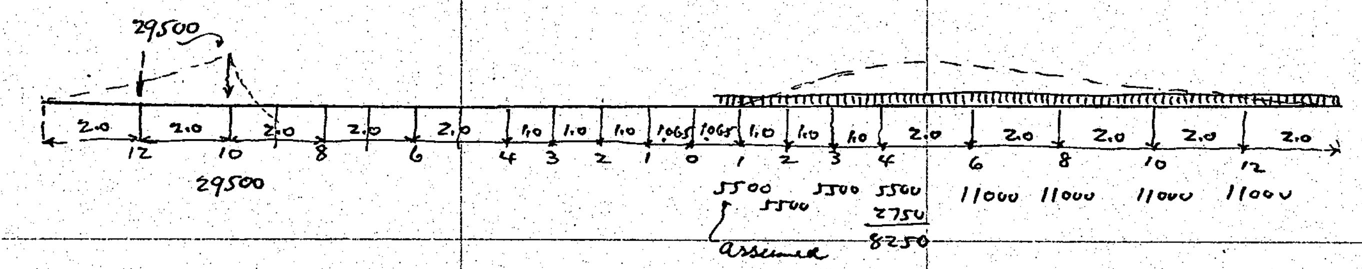
Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert shear
12R	11000	.0034	37	.058	640	.0041	45
10R	11000	.0100	110	.301	3320	.0238	262
6	3520	.1791	630	1.292	4550	.8611	3030
8	30380	1.0761	32600	.734	22300	.9311	28300
10	1970	.3938	775	.301	592	-.0238	- 47
12	12300	.0696	855	.058	714	-.0041	- 50
			35007		32116		31540

CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Normal thrust 32116 · .970 = 31100
31540 · .250 = 7870
38970 kg.

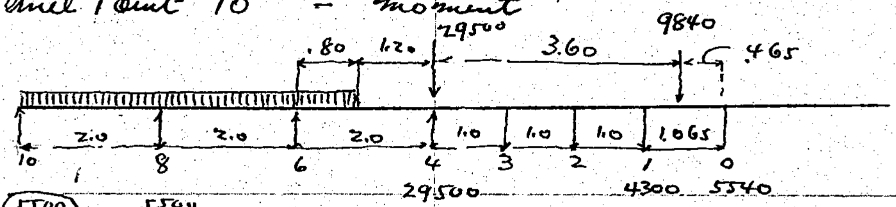
Panel Point 10 + moment



Point	load	M unit-load	moment	H unit-load	Hor. thrust	V unit-load	Vert shear
12R	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
1R	5500	.1222	672	2.365	13000	.4270	2350
10L	29500	.6175	18200	0.301	8880	.9762	28800
			35632		87218		39304

normal thrust 87218 · 0.950 = 82700
39304 · 0.325 = 12750
95450 kg.

Panel Point 10 − moment



5500 neglected
5500
5500
11000

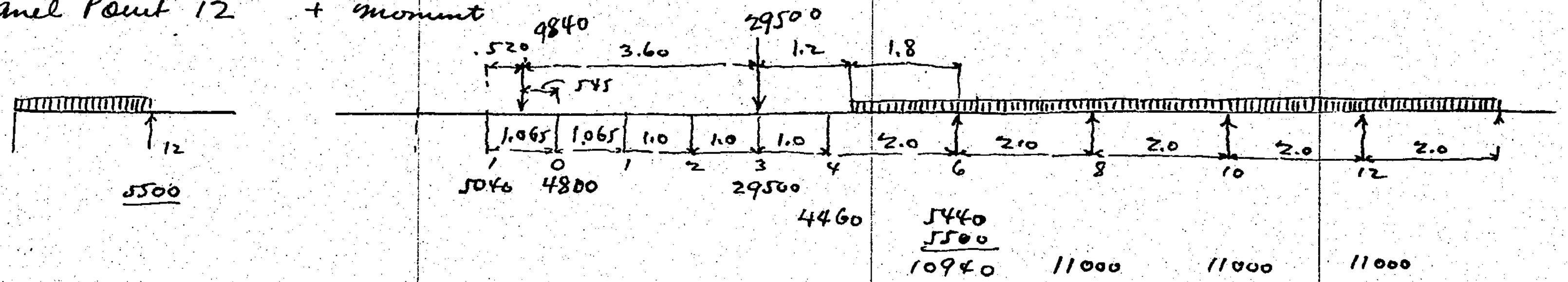
3520
5500
9020

29500
880
30380

Point	load	M unit-load	moment	H unit-load	Hor thrust	V unit-load	Vert shear
0L	5540	−.0594	− 329	2.411	13350	.5000	2770
1L	4300	−.2822	− 1215	2.365	10200	1-.4270	2465
4L	30380	−.7675	−23300	1.847	56000	.7615	23150
6L	9020	−.7873	− 7100	1.292	11680	.8611	7760
8L	5500	−.3606	− 1980	.734	4040	.9331	5130
			−33924		95270		41275

normal thrust 95270 · 0.950 = 90500
41275 · 0.325 = 13400
103900 kg.

Panel Point 12 + moment



増田淳氏関係資料
（独立行政法人 土木研究所蔵）

CALCULATIONS FOR

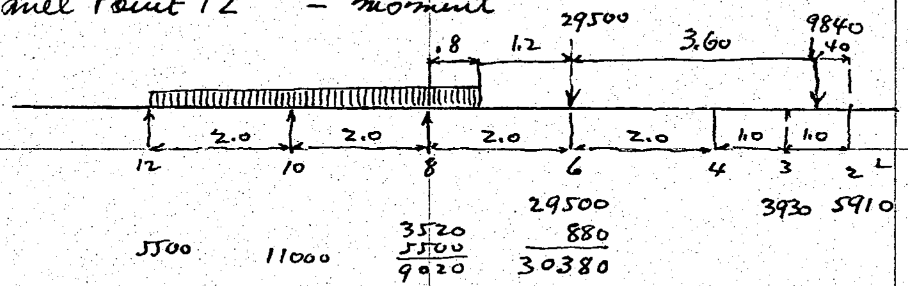
Shinobu-Bashi for Fukushima-Ken

4 Panel Point 12 + moment

Point	load	M unit load	moment	H unit load	Hor. thrust.	V. unit load	V. shear.
12^R	11000	+ .0644	708	.058	638	.0041	45
10	11000	.3167	3445	.301	3310	.0238	262
8	11000	.7094	7800	.734	8070	.0669	735
6	10940	1.1079	12170	1.292	14140	.1389	1520
4	4460	1.3398	5970	1.847	8230	.2385	1065
3	29500	1.3387	39450	2.087	61500	.2975	8760
0	4860	.7489	3600	2.411	11580	.5000	2400
1L	5040	.3556	1790	2.365	11900	.5730	2890
12L.	5500	.1643	905	.058	320	- .0041	- 22
			75768		119688		17655

normal thrust 119688 × .92 = 110.000
17655 × .39 = 6900
116900 kg

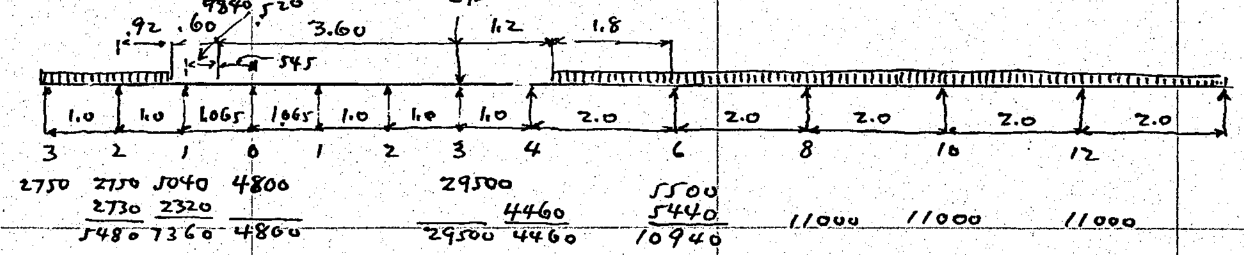
Panel Point 12 − moment



Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert. Load
2^L	5910	- .0508	- 300	2.254	13300	.6391	3770
3^L	3930	- .4828	- 1900	2.087	8200	.7025	2760
6^L	30380	- 1.5405	- 46750	1.292	39200	.8611	26150
8^L	9020	- 1.6764	- 15100	.734	6610	.9331	8420
10^L	11000	- 1.1091	- 12200	.301	3310	.9762	10750
12^L	5500	+ .1643	+ 900	.058	320	.9959	5480
			75350		70940		57330

normal thrust 70940 × .92 = 65200
57330 × .39 = 22300
87500 kg.

Springing + moment



Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert shear
12^R	11000	+ .0993	1094	.058	638	.0041	45
10	11000	+ .4933	5420	.301	3310	.0238	262
8	11000	+ 1.1258	12400	.734	8070	.0669	735
6	10940	+ 1.8067	19800	1.292	14140	.1389	1520
4	4460	+ 2.2745	10150	1.847	8230	.2385	1065
3	29500	+ 2.3434	69200	2.078	61500	.2975	8760
0	4800	+ 1.6653	8000	2.411	11580	.5000	2400
1^L	7360	+ 1.1216	8250	2.365	17400	.5730	4220
2	5480	+ .5296	2900	2.254	12350	.6391	3500
3	2750	- .1300	- 358	2.078	5700	.7025	1930
			136856		142918		24437

normal thrust 142918 × .905 = 129.000
24437 × .44 = 10750
139750 kg

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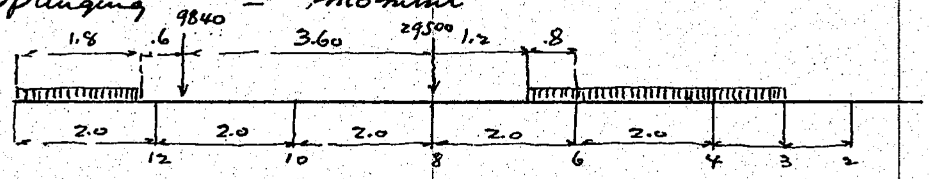
CALCULATIONS FOR

Shinobu- Bashi for Fukushima-Ken

4 Springing - moment



12	10	8	6	4	3
7840	1970	29500	3520	5500	2750
4460		880	5500	2750	
12300	1970	30380	9020	8250	2750

Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert. shear
3 L	2750	.1300	358	2.087	5750	.7025	1930
4	8250	.8125	6700	1.847	15200	.7615	6280
6	9020	2.0043	18050	1.292	11670	.8611	7770
8	30340	2.6546	80500	0.734	22250	.9331	28300
10	1970	2.4659	4860	0.301	593	.9762	1920
12	12300	1.3987	17200	0.058	714	.9959	12250
			127668		56177		58450

normal thrust 56177 × .905 = 50750
58450 × .44 = 25700
76450 kg.

Temperature Stresses

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

where $E = 1400.000.000$ kg/m²
coef of Exp ω = 0.00012 for 1°C
variation of temperature ±15°C
l = span length 27.35 meters
$E\omega t$ = 252000 kg.

For fall of 15° in temperature

$$H_0 = -\frac{252000 \times 27.35 \times 1368.38}{1.685.300} = -5590 \text{ kg}$$

for 8.5 meter wide $-5590 \times 8.5 = -47500$ kg

$$M_0 = -\frac{H_0 \int y \frac{ds}{I}}{\int \frac{ds}{I}} = 47500 \times \frac{796.46}{1368.38} = 27600 \text{ kgm}$$

Temperature stress at various panel points

Panel Point
2 M = 27600 − 47500 × 0.060 = + 24750 kgm 47500 × 0.999 = 47400 kg
4 M = 27600 − 47500 × 0.260 = + 15250 " × 0.990 = 47000 "
6 M = 27600 − 47500 × 0.570 = + 500 " × 0.980 = 46500 "
8 M = 27600 − 47500 × 1.015 = − 20600 " × 0.970 = 46100 "
10 M = 27600 − 47500 × 1.600 = − 48400 " × 0.950 = 45100 "
12 M = 27600 − 47500 × 2.350 = − 84000 " × 0.920 = 43700 "
Springing M = 27600 − 47500 × 3.064 = −117900 " × 0.905 = 43000 "

Average stress in arch ring
Amount of average stress in arch ring for Entire span are only approximate. Average stresses are found by the diagram prepared by the author, the same diagram are published in Concrete Engineering Hand Booke by Hool and Johnson's

Concrete area at crown .4000
Equivalent Steel area .0438
for 8.5 m wide .4438 × 8.5 = 3.770 square meters

Ratio = $\dfrac{\text{depth of springing}}{\text{depth of crown}} = \dfrac{.800}{.400} = 2.00$ Rise Ratio $= \dfrac{3.064}{27.35} = .112$

Shinobu-Bashi for Fukushima-Ken

4 Average Stresses span no 4

		Hor. Thrust at Crown				Coef for Average stress		Average Stress
Dead Load Stress		587740	÷ 3.77	=	156.000	@ .90	=	140500 kg/m²
Live Load stresses								
Crown	+ moment	118960	÷ 3.77	=	31500	.89		28000
Panel Point 2	+ moment	115210	÷ 3.77	=	30600	.89		27200
Panel Point 4	+ moment	79660	÷ 3.77	=	21100	.89		18800
Panel Point 6	+ moment	62300	÷ 3.77	=	16500	.89		14700
Panel Point 8	+ moment	32116	÷ 3.77	=	6150	.89		5460
Panel Point 10	+ moment	87218	÷ 3.77	=	23100	.89		20600
	− moment	95270	÷ 3.77	=	25250	.91		23000
Panel Point 12	+ moment	119688	÷ 3.77	=	31700	.89		28200
	− Moment	70940	÷ 3.77	=	18800	.91		17100
Springing	+ moment	142918	÷ 3.77	=	37900	.89		33700
	− moment	56177	÷ 3.77	=	14900	.91		13550
For temperature		47500	÷ 377	=	12600	.85		10700

Fibre stresses in arch ring

Crown Section Positive moment Compression in upper fibre

	Thrust	moment	av. stress
Dead Load	+ 587700	− 1470	140500
Live Load	+ 118960	+ 35650	28000
temperature	− 47500	+ 27600	− 10700
Rib shortening	− 28500	+ 16600	− 6420
	630660	79850 − 1470 78380	151380

151380 ÷ 252000 = .60 Ecc = .1268 $E/h = \frac{.1268}{4000} = .317$

$d/h = \frac{4.5}{40.0} = 0.113$ $p = 0.0073$ $h = .400$

$k = .680$ $C_z = .11\overset{7}{5}$

$$f_c = \frac{\overset{78380}{\cancel{79850}}}{.11\underset{7}{5} \times 8.5 \times .40^2} = \overset{493}{\cancel{500}}.000 \text{ or } \overset{49.3}{\cancel{50.0}}\ kg/cm^2$$

Panel Point 2 positive moment

	Thrust	moment	Aver. stress
Dead Load	589,570	− 2439	140500
Live Load	116570	+ 39193	27200
Temperature	− 47400	+ 24750	− 10700
Rib Shortening	− 28400	+ 14800	− 6400
	630340	76304	150700

150700 ÷ 252000 = .598 Ecc = 0.121 d = .405

Panel Point 4 positive moment

	Thrust	moment	Aver. stress
Dead Load	591000	+ 7126	140500
Live Load	81490	+ 46725	18800
Temperature	− 47000	+ 15250	− 10700
Rib shortening	− 26600	+ 8650	− 6100
	598890	77751	142500

142500 ÷ 252000 = .566 Ecc = .13 d = .414

CALCULATIONS FOR

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4 Panel Point 6 positive moment

	Thrust	moment	aver stress
Dead Load	596600	+ 3956	140500
Live Load	67100	+ 46866	14700
Temperature	- 46500	+ 500	- 10700
Rib shortening	- 25600	+ 275	- 5900
	591600	51591	138600

138600 ÷ 252.000 = .55   Ecc = .0875   d = .445

Panel Point 8 Positive moment

	Thrust	moment	Aver. stress
Dead Load	608000	+ 3764	140500
Live Load	38970	+ 35007	5460
Temperature Rise	+ 46100	+ 20600	+ 10700
Rib shortening	- 27600	- 12300	- 6400
	665470	47071	150260

150260 ÷ 252000 = .597   Ecc = .0707   d = .485

Panel Point 10 Positive moment compression on upper fibre

	Thrust	Moment	Aver. stress
Dead Load	621800	- 143	140500
Live Load	95450	+ 35632	20600
Temperature Rise	45100	+ 48400	+ 10700
Rib Shortening	- 29600	- 31700	- 7000
	732750	52189	164800

164800 ÷ 252000 = .655   Ecc = .0711   d = .55

Panel Point 10 negative moment compression on lower fibre

	Thrust	Moment	Aver. stress
Dead Load	621800	- 143	140500
Live Load	103900	- 33924	23000
Temperature fall	- 45100	- 48400	- 10700
Rib shortening	- 26200	- 28200	- 6200
	654400	110667	146600

146600 ÷ 25200 = .581   Ecc = .17   d = .55

$e/d = .31$ $d'/d = \frac{4.5}{55.0} = 0.082$ $p = .0106$

$k = \overset{.742}{.724}$ $C_2 = .1305$

$f_c = \frac{110667}{.1305 \times 8.5 \times .55^2} = 330000 \, kg/m^2$ or $33 \, kg/cm^2$

Panel Point 12 positive moment Compression on upper fibre

	Thrust	moment	Aver. stress
Dead Load	635850	+ 1660	140500
Live Load	116900	+ 75768	28200
Temperature rise	43700	+ 84000	+ 10700
Rib shortening	- 29900	- 57500	- 7300
	7665500	+ 103928	172100

172100 ÷ 25200 = .683   Ecc = 0.135   d = .660

Panel Point 12 negative moment Compression on lower fibre

	Thrust	moment	Aver. stress
Dead Load	635850	+ 1660	140500
Live Load	87500	- 75350	17100
Temperature fall	- 43700	- 84000	- 10700
Rib shortening	- 24400	- 47900	- 6000
	655250	- 204690	140900

140900 ÷ 252000 = .559   Ecc = .312   d = .660

$e/d = .473$ $\frac{d'}{d} = \frac{4.5}{66.0} = 0.068$ $p = 0.0875$

$k = .534$ $C_2 = .1315$

$f_c = \frac{204690}{.1315 \times 8.5 \times .66^2} = 420.000 \, kg/m^2$ or $42. \, kg/cm^2$

Springing Positive moment compression on upper fibre

	Thrust	moment	Aver. stress
Dead Load	657000	- 11610	140500
Live Load	139750	+ 136856	33700
Temperature rise	+ 43600	+ 117900	+ 10700
Rib shortening	- 30300	- 83000	- 7550
	809450	+ 160145	177350

177350 ÷ 252000 = .705   Ecc = .198   d = .80

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4 Springing negative moment Compression on lower fibre

	Thrust	moment	ave. stress
Dead Load	657000	− 11610	140500
Live Load	76450	− 127668	13550
Temperature fall −	43000	− 117900	−10700
Rib shortening −	23400	− 65200	− 5850
	667050	322378	137500

137500 ÷ 252.000 = .545 ecc = .484 d = .800

$e/d = .605$ $\frac{4.5}{80.0} = 0.056$ steel $p = 0.073$

$k = .438$ $c_2 = .1265$

$f_c = \frac{322378}{.1265 \times 8.5 \times .80^2} = 468000 \, kg/m^2$ or $46.8 \, kg/cm^2$

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CALCULATIONS FOR

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3 Span no 3 arch ring.

The arch ring will consist of 2-4.25 meter rings separated at center line of bridge. reinforcing bars 22 mm bars = 3.80 cm² at top end bottom spaced 26 cm at crown and 13 cm for springing.

at crown 1 meter strip $3.80 \times \frac{1.00}{.26} = 14.6$ cm²

$2 \times 14.6 = 29.2$ cm²

moment of inertia of Concrete for 1 meter strip $= \frac{1}{12} d^3$ where d = depth of arch ring.

Moment of inertia of ~~Concrete~~ steel for 1 meter strip $= \frac{29.2 \times 15}{10000} \left(\frac{d}{2} - 0.045\right)^2$

$= 0.0438 \left(\frac{d}{2} - 0.045\right)^2$

From panel point 10 to springing the reinforcement will be doubled.

Division	d	d^3	$I_c = \frac{1}{12}d^3$	$\left(\frac{d}{2} - 0.045\right)^2$			I_s	$I_c + I_s$	Concrete area
0	.400	.0640	.00533	.0240	× 0.0438	=	.00105	.00638	.400
1	.401	.0645	.00537	.0242	"	=	.00106	.00643	.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	.0564	0.0876	=	.00494	.01997	.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

Point	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	.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	652.34	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	8.964	.340	.05371	6.33	84.66	1132.38	18.95	56.74
					13.824		1,279.08	6,187.16	44017.63	705.47	930.87

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CALCULATIONS FOR

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3		Crown 0				①				②			
Division	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0	0	0	0	0								
1	.765	.765	118.97	90.98	1.19	0							
2	1.765	1.765	267.15	471.49	12.83	1.0	157.36	267.15	7.27	0			
3	2.765	2.765	413.92	1144.46	49.66	2.0	299.40	827.84	35.92	1	149.70	413.92	17.96
4	3.765	3.765	514.60	1937.44	115.77	3.0	410.04	1543.80	92.25	2	273.36	1209.20	61.50
5	4.765	4.765	601.58	2866.51	213.57	4.0	505.00	2406.32	179.28	3	378.75	1804.74	134.46
6	5.765	5.765	641.53	3698.39	336.79	5.0	556.40	3207.65	292.10	4	445.12	2566.12	233.68
7	6.765	6.765	655.33	4433.26	475.11	6.0	581.22	3931.98	421.38	5	484.35	3276.65	351.15
8	7.765	7.765	652.34	5065.38	622.99	7.0	588.07	4566.38	561.61	6	504.06	3914.04	481.38
9	8.765	8.765	637.30	5585.95	780.70	8.0	581.68	5098.40	712.56	7	508.97	4461.10	623.49
10	9.765	9.765	513.93	5018.53	786.28	9.0	473.67	4625.37	724.68	8	421.04	4111.44	644.16
11	10.765	10.765	451.48	4860.22	848.82	10.0	419.40	4514.80	788.50	9	377.46	4063.32	709.65
12	11.765	11.765	385.07	4530.32	874.14	11.0	360.03	4235.77	817.30	10	327.30	3850.70	743.00
13	12.765	12.765	249.30	3182.32	670.67	12.0	234.36	2991.60	630.48	11	214.83	2742.30	577.94
Sp	13375	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	39284.62	5502.29		4158.43	33396.47	4798.38

		③				④				⑤		
Division	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
4	1.0	136.68	514.60	30.75	0							
5	2.0	252.50	1203.16	89.64	1	126.25	601.58	44.82	0			
6	3.0	333.84	1924.59	175.25	2	222.56	1283.06	116.84	1	111.28	641.53	58.42
7	4.0	387.48	2621.32	280.92	3	290.61	1965.99	210.69	2	193.74	1310.66	140.46
8	5.0	420.05	3261.70	401.15	4	336.04	2609.36	320.92	3	252.03	1957.02	240.69
9	6.0	436.26	3823.80	534.42	5	363.55	3186.50	445.35	4	290.84	2549.20	356.28
10	7.0	368.41	3597.51	563.64	6	315.78	3083.58	483.12	5	263.15	2569.65	402.60
11	8.0	335.52	3611.84	630.80	7	293.58	3160.36	551.95	6	251.64	2708.88	473.10
12	9.0	294.57	3465.63	668.70	8	261.84	3080.56	594.40	7	229.11	2695.49	520.10
13	10.0	195.30	2493.00	525.40	9	175.77	2243.70	472.86	8	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	17155.75	2775.13

		⑥				⑦				⑧		
Division	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
7	1.0	96.87	655.33	70.23	0							
8	2.0	168.02	1304.68	160.46	1	84.01	652.34	80.23	0			
9	3.0	218.13	1911.90	267.21	2	145.42	1274.60	178.14	1	72.71	637.30	89.07
10	4.0	210.52	2055.72	322.08	3	157.89	1541.79	241.56	2	105.26	1027.86	161.04
11	5.0	209.70	2257.40	394.25	4	167.76	1805.92	315.40	3	125.82	1354.44	236.55
12	6.0	196.38	2310.42	445.80	5	163.65	1925.35	371.50	4	130.92	1540.28	297.20
13	7.00	136.71	1745.10	367.78	6	117.18	1495.80	315.24	5	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

		⑨				⑩				⑪		
Div.	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
10	1.0	52.63	513.93	80.52	0							
11	2.0	83.88	902.96	157.70	1	41.94	451.48	78.85	0			
12	3.0	98.19	1155.21	222.90	2	65.46	770.14	148.60	1	32.73	385.07	74.30
13	4.0	78.12	997.20	210.66	3	58.59	747.90	157.62	2	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	453.48		88.31	1104.63	228.84

		⑫				⑬		
Div.	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
13	1.0	19.53	249.30	52.54	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

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

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CALCULATIONS FOR

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Crown Thrust $H_0 = \dfrac{\int\frac{ds}{I}\int\frac{my\,ds}{I} - \int\frac{m\,ds}{I}\int\frac{y\,ds}{I}}{2[\int\frac{ds}{I}\int\frac{y^2ds}{I} - (\int\frac{y\,ds}{I})^2]} = \dfrac{A}{B}$

$B = 2[1.279.08 \cdot 930.87 - 705.47^2] = 1.385.939.$

Loaded Point.	Values of A.		B		H_0
Crown 0	3363.320	÷	1385.939	=	2.427
1	3340889		"	=	2.411
2	3203864		"	=	2.312
3	2969346		"	=	2.142
4	2652217		"	=	1.914
5	2277982		"	=	1.644
6	1872.011		"	=	1.351
7	1462459		"	=	1.055
8	1073.998		"	=	.775
9	729090		"	=	.526
10	446816		"	=	.322
11	230405		"	=	.166
12	85261		"	=	.062
13	12063		"	=	.009
sp.	0				0

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

Loaded Point				$-H_0 2\int\frac{y\,ds}{I}$		$\int\frac{m\,ds}{I}$				$2\int\frac{ds}{I}$		
Crown 0	2 ×	2.427	× 705.47	= − 3.424.35	+	6.187.16	=	+ 2762.81	÷	2558.16	=	+ 1.0800 ✓
1	2 ×	2.411		= − 3401.78	+	5240.45	=	+ 1838.17			=	+ .7186 ✓
2	2 ×	2.312		= − 326.209	+	4158.43	=	+ 896.34			=	+ .3504 ✓
3	2 ×	2.142		= − 3022.23	+	3227.77	=	+ 205.54			=	+ .0835 ✓
4	2 ×	1.914		= − 2700.54	+	2446.81	=	− 253.73			=	− .0992 ✓
5	2 ×	1.644		= − 2319.59	+	1802.53	=	− 517.06			=	− .2021 ✓
6	2 ×	1.351		= − 1906.18	+	1284.50	=	− 621.68			=	− .2430 ✓
7	2 ×	1.055		= − 1488.54	+	877.75	=	− 610.79			=	− .2388 ✓
8	2 ×	.775		= − 1093.48	+	569.87	=	− 525.61			=	− .2055 ✓
9	2 ×	.526		= − 742.15	+	342.00	=	− 400.15			=	− .1564 ✓
10	2 ×	.322		= − 454.32	+	188.84	=	− 265.48			=	− .1038 ✓
11	2 ×	.166		= − 234.22	+	88.31	=	− 145.91			=	− .0570 ✓
12	2 ×	.062		= − 87.48	+	29.72	=	− 57.76			=	− .0226 ✓
13	2 ×	.009		= − 12.70	+	3.86	=	− 8.84			=	− .0035 ✓
Sp.												0

Shinobu-Bashi for Fukushima-Ken.

3

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

Loaded Point		E		F		V_0	$1 - V_0$
Crown	0	44017.63	÷	88035.26	=	0.5000	.5000
	1	39284.62			=	.4462	.5538
	2	33396.49			=	.3794	.6206
	3	27415.39			=	.3114	.6886
	4	22028.27			=	.2502	.7498
	5	17155.75			=	.1949	.8051
	6	12884.81			=	.1464	.8536
	7	9255.40			=	.1051	.8949
	8	6281.32			=	.0714	.9286
	9	3959.58			=	.0450	.9550
	10	2275.14			=	.0258	.9742
	11	1104.63			=	.0125	.9875
	12	385.60			=	.0044	.9956
	13	51.64			=	.0006	.9994
	Sp.	0				0	0

moment at various point for unit load

let x and y co-ordinates of center of sections

d' lever arm of unit load about center of sections, origin at crown.

For Left Hand Sections $M_L = M_0 + H_0 y + V_0 x - d'$

" Right Hand Sections $M_R = M_0 + H_0 y - V_0 x$

moment at various points.

		Springing x = 13.375 y = 2.994					Point 12 x = 11.765 y = 2.270				
	M_0	H_0y	V_0x	d'	M_L	M_R	H_0y	V_0x	d'	M_L	M_R
0	+ 1.0800	7.2664	6.6875	13.375	1.6589	1.6589	5.5093	5.8825	11.765	.7068	.7068
1	+ .7186	7.2185	5.9679	12.61	1.2950	1.9692	5.4730	5.2495	11.0	.4411	.9421
2	+ .3504	6.9221	5.0745	11.61	.7370	2.1980	5.2482	4.4636	10.0	.0622	1.1350
3	+ .0835	6.4131	4.1650	10.61	.0516	2.3316	4.8623	3.6636	9.0	−.3906	1.2822
4	− .0992	5.7305	3.3464	9.61	− .6323	2.2848	4.3448	2.9436	8.0	− .8108	1.3020
5	− .2021	4.9221	2.6068	8.61	− 1.2832	2.1132	3.7319	2.2930	7.0	− 1.1772	1.2368
6	− .2430	4.0449	1.9581	7.61	− 1.8500	1.8438	3.0668	1.7224	6.0	− 1.4538	1.1014
7	− .2388	3.1587	1.4057	6.61	− 2.2844	1.5142	2.3949	1.23365	5.0	− 1.6075	.9196
8	− .2055	2.3204	.9550	5.61	− 2.5401	1.1599	1.7593	.8400	4.0	− 1.6052	.7148
9	− .1564	1.5748	.6019	4.61	− 2.5897	.8161	1.1940	.5294	3.0	− 1.4330	.5082
10	− .1038	.9641	.3451	3.61	− 2.4046	.5152	.7309	.3035	2.0	− 1.0694	.3236
11	− .0570	.4970	.1672	2.61	− 2.0028	.2728	.3768	.1471	1.0	− .5331	.1727
12	− .0226	.1856	.0589	1.61	− 1.3881	.1041	.1407	.0518		+ .1699	.0663
13	− .0035	.0269	.0080	0.61	− .5786	.0154	.0204	.0071		+ .0240	.0098
Sp.											

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

3

Panel Point 10 x = 9.765 y = 1.530

	Mo	Hoy	Vox	d'	ML	MR
0	+1.0800	3.7133	4.8825	9.765	-.0897	-.0897
1	+.7186	3.6888	4.3571	9.0	-.2355	+.0563
2	+.3504	3.5374	3.7048	8.0	-.4074	+.1830
3	+.0835	3.2773	3.0408	7.0	-.5984	+.3200
4	-.0992	2.9284	24432	6.0	-.7276	+.3860
5	-.2021	2.5153	1.9032	5.0	-.7836	+.4100
6	-.2430	2.0670	1.4296	4.0	-.7464	+.3944
7	-.2388	1.6142	1.0263	3.0	-.5983	+.3491
8	-.2055	1.1858	.6972	2.0	-.3225	+.2831
9	-.1564	.8033	.4394	1.0	+.0863	+.2075
10	-.1038	.4927	.2519		+.6408	+.1370
11	-.0570	.2540	.1221		+.3191	+.0749
12	-.0226	.0949	.0430		+.1153	+.0293
13	-.0035	.0138	.0059		+.0162	+.0044

Panel Point 8 x = 7.765 y = 0.955

Mo	Hoy	Vox	d'	ML	MR
	2.3178	3.8825	7.765	-.4847	-.4847
	2.3025	3.4647	7.00	-.5142	-.4436
	2.2080	2.9460	6.0	-.4956	-.3876
	2.0456	2.4180	5.0	-.4529	-.2889
	1.8279	1.9428	4.0	-.3285	-.2141
	1.5700	1.5134	3.0	-.1187	-.1455
	1.2902	1.1368	2.0	+.1840	-.0896
	1.0075	.8161	1.0	+.5848	-.0474
	.7401	.5544		+1.0890	-.0198
	.5023	.3494		+.6953	-.0035
	.3075	.2003		+.4040	+.0034
	.1585	.0971		+.1986	+.0044
	.0592	.0342		+.0708	+.0024
	.0086	.0047		+.0098	+.0004

Panel Point 6 x = 5.765 y = .525

	Mo	Hoy	Vox	d'	ML	MR
0	+1.0860	1.2742	2.8825	5.765	-.5283	-.5283
1	+.7186	1.2658	2.5723	5.0	-.4433	-.5879
2	+.3504	1.2138	21872	4.0	-.2486	-.6230
3	+.0835	1.1246	1.7952	3.0	+.0033	-.5871
4	-.0992	1.0049	1.4424	2.0	+.3481	-.5367
5	-.2021	.8631	1.1236	1.0	+.7846	-.4626
6	-.2430	.7093	.8440		+1.3103	-.3777
7	-.2388	.5539	.6059		+.9210	-.2908
8	-.2055	.4069	.4116		+.6130	-.2102
9	-.1564	.2762	.2594		+.3792	-.1396
10	-.1038	.1691	.1487		+.2140	-.0834
11	-.0570	.0872	.0721		+.1023	-.0419
12	-.0226	.0326	.0254		+.0354	-.0154
13	-.0035	.0047	.0035		+.0047	-.0023

Panel Point 4 x = 3.765 y = .225

Mo	Hoy	Vox	d'	ML	MR
	.5461	1.8825	3.765	-.2564	-.2564
	.5425	1.6799	3.00	-.0590	-.4188
	.5202	1.4284	2.00	+.2990	-.5578
	.4820	1.1724	1.00	+.7379	-.6069
	.4307	.9420		+1.2735	-.6105
	.3699	.7338		+.9016	-.5660
	.3040	.5512		+.6122	-.4902
	.2374	.3957		+.3943	-.3971
	.1744	.2688		+.2377	-.2999
	.1184	.1694		+.1314	-.2074
	.0725	.0971		+.0658	-.1284
	.0374	.0471		+.0275	-.0667
	.0140	.0166		+.0080	-.0252
	.0020	.0023		+.0008	-.0038

Panel Point 2 x = y =

	Mo	Hoy	Vox	d'	ML	MR
0	+1.0860	.1165	.8825	1.765	+.3140	+.3140
1	+.7186	.1157	.7875	1.0	+.6218	+.0468
2	+.3504	.1110	.6696		+1.1310	-.2082
3	+.0835	.1028	.5496		+.7358	-.3633
4	-.0992	.0919	.4416		+.4343	-.4489
5	-.2021	.0789	.3440		+.2208	-.4672
6	-.2430	.0648	.2584		+.0802	-.4366
7	-.2388	.0526	.1855		-.0007	-.3717
8	-.2055	.0372	.1260		-.0423	-.2943
9	-.1564	.0252	.0794		-.0518	-.2106
10	-.1038	.0155	.0455		-.0428	-.1338
11	-.0570	.0056	.0221		-.0293	-.0735
12	-.0226	.0030	.0078		-.0118	-.0274
13	-.0035	.0004	.0011		-.0020	-.0042

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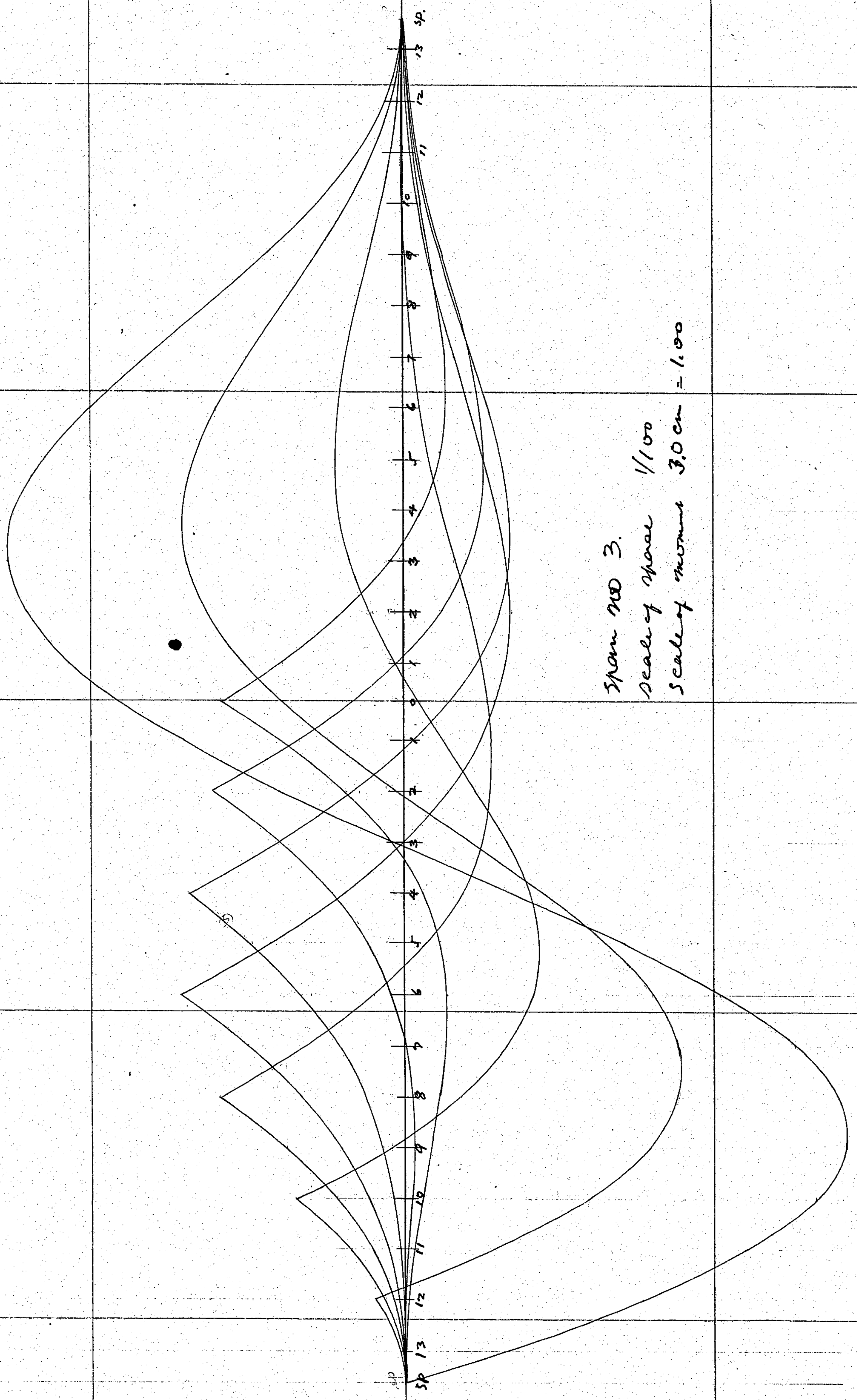
CALCULATIONS FOR

(3

Shinobu-Bashi for Fukushima-Ken

3



Span No 3.
Scale of span 1/100
Scale of moment 3.0 cm = 1.00

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

3

		Crown section	
	Load	$\frac{M_o}{\text{unit load}}$	M
13	12000	-.0035	- 42
12	39140	-.0226	- 885
11	13250	-.0570	- 757
10	33980	-.1038	- 3527
9	11200	-.1569	- 1.755
8	32040	-.2055	- 6583
7	9900	-.2388	- 2363
6	28410	-.2430	- 6902
5	9440	-.2021	- 1908
4	23600	-.0992	- 2340
3	18860	+.0835	+ 1575
2	17680	+.3504	+ 6200
1	16860	+.7186	+ 12110
0	4390	+1.0800	+ 4740
			- 54.124
			+ 49.250
			- 4.874

		Panel 2.		Panel 4		Panel 6		Panel 8	
	Load	$\frac{M}{\text{unit load}}$	M	$\frac{M}{\text{unit load}}$	M	$\frac{M}{\text{unit load}}$	M	$\frac{M}{\text{unit load}}$	M
13L	12000	-.0020	- 24	+.0008	+ 10	+.0047	+ 56	+.0098	+ 118
12	39140	-.0118	- 464	+.0080	+ 313	+.0354	+ 1385	+.0708	+ 2767
11	13250	-.0293	- 388	+.0275	+ 364	+.1023	+ 1356	+.1986	+ 2631
10	33980	-.0428	- 1454	+.0658	+ 2235	+.2140	+ 7270	+.4040	+ 13730
9	11200	-.0578	- 581	+.1314	+ 1472	+.3792	+ 4250	+.6953	+ 7788
8	32040	-.0423	- 1355	+.2377	+ 7616	+.6130	+ 19640	+1.0890	+ 34.890
7	9900	-.0007	- 7	+.3943	+ 3905	+.9210	+ 9120	+.5848	+ 5790
6	28410	+.0802	+ 2277	+.6122	+ 17380	+1.3103	+ 37.220	+.1840	+ 5226
5	9440	+.2208	+ 2083	+.9016	+ 8510	+.7846	+ 7410	-.1187	- 1120
4	23600	+.4343	+ 10250	+1.2735	+ 30050	+.3481	+ 8215	-.3285	- 7750
3	18860	+.7358	+ 13870	+.7379	+ 13910	+.0033	+ 62	-.4529	- 8540
2	17680	+1.1310	+ 20.000	+.2990	+ 5285	-.2486	- 4395	-.4956	- 8765
1	16860	+.6218	+ 10475	-.0590	- 994	-.4433	- 7472	-.5142	- 8670
0	8780	+.3140	+ 2756	-.2564	- 2250	-.5283	- 4640	-.4847	- 4252
1	16860	+.0468	+ 789	-.4188	- 7060	-.5879	- 9900	-.4436	- 7475
2	17680	-.2082	- 3683	-.5577	- 9860	-.6230	- 11025	-.3876	- 6855
3	18860	-.3633	- 6850	-.6069	- 11450	-.5871	- 11070	-.2889	- 5442
4	23600	-.4489	- 10590	-.6105	- 14410	-.5367	- 12660	-.2141	- 5053
5	9440	-.4672	- 4410	-.5660	- 5341	-.4626	- 4365	-.1455	- 1372
6	28410	-.4366	- 12400	-.4902	- 13920	-.3777	- 10720	-.0896	- 2545
7	9900	-.3717	- 3678	-.3971	- 3932	-.2908	- 2878	-.0474	- 469
8	32040	-.2943	- 9430	-.2999	- 9605	-.2102	- 6728	-.0198	- 634
9	11200	-.2106	- 2358	-.2074	- 2323	-.1396	- 1564	-.0035	- 39
10	33980	-.1338	- 4546	-.1284	- 4362	-.0834	- 2833	+.0034	+ 115
11	13250	-.0735	- 974	-.0667	- 884	-.0419	- 555	+.0044	+ 58
12	39140	-.0274	- 1072	-.0252	- 986	-.0154	- 602	+.0024	+ 94
13	12000	-.0042	- 50	-.0038	- 46.	-.0023	- 28	+.0004	+ 5
			- 64.314		+ 91.050		+ 95.984		+ 73212
			+ 62.500		- 87423		- 91.435		- 68981
			- 1.814		+ 3627		+ 4549		+ 4231

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CALCULATIONS FOR

Shinobu - Bashi for Fukushima - Ken.

		Panel 10 M		Panel 12 M		Springing M	
13^{L}	12000	+ .0162	+ 194	+ .0240	+ 288	- .5786	- 6948
12	39140	+ 1153	+ 4515	+ .1699	+ 6646	-1.3881	- 54.350
11	13250	+ 3191	+ 4238	∓ .5331	- 7062	- 2.0028	- 26530
10	33980	+ 6408	+ 21770	- 1.0694	- 36320	- 2.4046	- 81700
9	11200	+ .0863	+ 967	- 1.4330	- 16060	- 2.5897	- 29000
8	32040	- .3225	- 10325	- 1.6052	- 51420	- 2.5401	- 81400
7	9900	- .5983	- 5925	- 1.6075	- 15910	- 2.2844	- 22610
6	28410	- .7464	- 21200	- 1.4538	- 41300	- 1.8500	- 52550
5	9440	- .7836	- 7390	- 1.1772	- 11110	- 1.2832	- 12110
4	23600	- .7276	- 17160	- .8108	- 19130	- .6323	- 14920
3	18860	- .5984	- 11280	- .3906	- 7362	+ .0516	+ 973
2	17680	- .4074	- 7205	+ .0622	+ 1100	+ .7370	+ 13040
1	16860	- .2355	- 3968	+ .4411	+ 7438	+ 1.2950	+ 21820
0	8780	- .0892	- 783	+ .7068	+ 6202	+ 1.6589	+ 14560
1	16860	+ .0503	+ 848	+ .9421	+ 15880	+ 1.9692	+ 33180
2	17680	+ .1830	+ 3235	+ 1.1350	+ 20080	+ 2.1980	+ 38860
3	18860	+ .3200	+ 6030	+ 1.2822	+ 24170	+ 2.3316	+ 43950
4	23600	+ .3860	+ 9110	+ 1.3020	+ 30720	+ 2.2848	+ 53900
5	9440	+ .4100	+ 3868	+ 1.2368	+ 11670	+ 2.1132	+ 19930
6	28410	+ .3944	+ 11200	+ 1.1014	+ 31300	+ 1.8438	+ 52370
7	9900	+ .3491	+ 3455	+ .9196	+ 9100	+ 1.5142	+ 14980
8	32040	+ .2831	+ 9070	+ .7148	+ 22900	+ 1.1599	+ 37170
9	11200	+ .2075	+ 2325	+ .5082	+ 5695	+ .8161	+ 9145
10	33980	+ .1370	+ 4655	+ .3236	+ 10980	+ .5152	+ 17500
11	13250	+ .0749	+ 993	+ .1727	+ 2288	+ .2728	+ 3615
12	39140	+ .0293	+ 1146	+ .0663	+ 2595	+ .1041	+ 4075
13	12000	+ .0044	+ 53	+ .0098	+ 118	+ .0154	+ 185
			+ 87672		+ 209170		- 382118
			- 85236		- 205674		+ 379253
			+ 2436		+ 3496		- 2865

4390
8430
12820

Dead Load Thrust

Point	Load	H unit load	Hor Thrust			normal thrust	vert shear		normal thrust
0	4390	2.427	10.650	576988	× 1.000	= 576988	0	× 0	=
1	16860	2.411	40650				12820		
2	17680	2.312	40900		× .999	= 576100	30090	× .050	= 1504
3	18860	2.142	40400				48360		
4	23600	1.914	45150		× .992	= 572200	59590	× .118	= 7033
5	9440	1.644	15510				86110		
6	28410	1.351	38400		× .985	= 568200	105030	× .180	= 18900
7	9900	1.055	10440				124190		
8	32040	.775	24830		× .975	= 562500	145210	× .245	= 35600
9	11200	.526	5890				166780		
10	33980	.322	10940		× .950	= 548000	189370	× .320	= 60600
11	13250	.166	2200				212985		
12	39140	.062	2426		× .925	= 533900	239185	× .385	= 92100
13	12000	.009	108				264750		
sp	6650	0	0		× .900	= 519400	~~274075~~	× .425	= 118000
	277400		288494				277400		
			2						
			576.988						

Summary for normal thrust

Panel point →	0	2	4	6	8	10	12	sp.
Due to vert shear		1504	7033	18900	35600	60600	92100	118000
" " Hor. Thrust.	576988	576100	572220	568200	562500	548000	533900	519400
	576988	577604	579253	587100	598100	608600	626000	637400 kg.

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

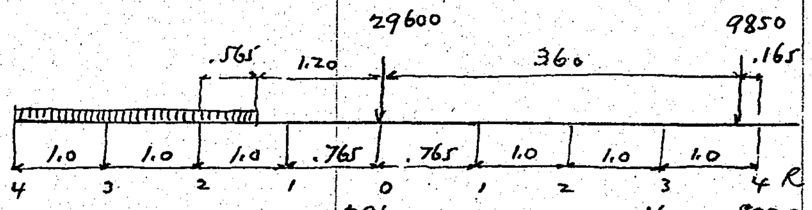
3. Live Load stresses

uniform live load $\frac{100.000}{170+26.75}$ = 509 kg/m² use 500 kg/m²

impact for motor truck loading = $\frac{20}{60+26.75}$ = 23.1 %

Rear wheel concentration	3000	
impact 23.1 %	693	
	3693 × 2	= 9386
For 4 motor trucks	7386 × 4	= 29600 kg.
	29600 ÷ 3	= 9850 kg.

Crown stress positive moment



.575 × 5500 = 3160
890
2270

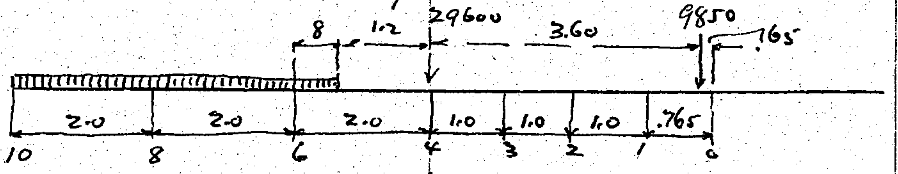
29600 1625 8220

2750 5500 2270 890
5500 2750
5500 5020 890 29600 1625 8220

neglected

Point	load	N unit load	moment	H unit load	Hor thrust	V unit load
4R	8220	-.0992	- 816	1.914	15730	+.2502
3R	1625	.0835	136	2.142	3480	+.3114
0	29600	1.0800	32000	2.427	71700	±.5000
1	890	.7186	640	2.411	2140	-.4462
2	5020	.3504	1755	2.312	11600	-.3794
3	5500	.0835	460	2.142	11800	-.3114
			34175		116450	

Panel Point 10 negative moment



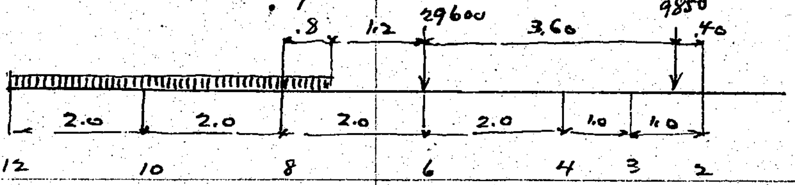
29600 2120 7730

5500 5500 3520 880
5500 5500
11000 9020 30480

neglected

Point	load	M unit load	moment	H unit load	Hor. thrust	V unit load	vert shear	normal thrust
0	7730	-.0897	- 695	2.427	18800	.5000	3865	92750 × .95 = 88100
1L	2120	-.2355	- 500	2.411	5110	.5538	1170	45735 × .32 = 14650
4	30480	-.7276	- 22200	1.914	58300	.7498	22800	102750
6	9020	-.7464	- 6730	.775	7000	.8536	7700	
8	11000	-.3225	- 3550	.322	3540	.9286	10200	
			-33675		92750		45735	

Panel Point 12 negative moment



29600 3940 5910

5500 5500 3520 880
5500 5500
11000 9020 30480

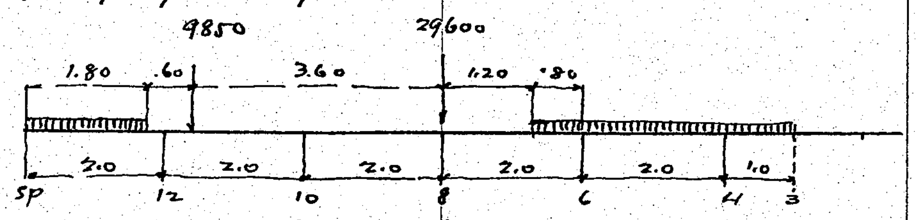
neglected

Shinobu-Bashi for Fukushima-Ken

Panel Point 12 negative moment

Point	load	M unit load	moment	H unit load	Hor thrust	V unit load	Vert 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
6	30480	− 1.4583	− 44300	1.351	44300	.8536	26000	90800
8	9020	− 1.6052	− 14480	.775	7000	.9286	8370	
10	11000	−1.0694	− 11790	.322	3540	.9742	10700	
			− 71743		76940		51450	

Springing negative moment



7880	1970	29600	3520	5500
4460	—	880	5500	2750
~~12340~~		30480	9020	8250

2750 ← neglected

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	71600
10	1970	− 2.4046	− 4730	.322	635	.9742	1920	
12	12340	− 1.3881	− 17100	.062	743	.9956	12300	
			− 121250		52978		56420	

Temperature stresses

Crown thrust $H_o = \dfrac{E\omega t\, l \int \frac{ds}{I}}{2\left[\int \frac{ds}{I} \int \frac{y^2 ds}{I} - \left(\int \frac{y\,ds}{I}\right)^2\right]} = \dfrac{G}{B}$

$E = 1400.000.000$ kg/m²
$\omega = 0.000012$
$t = 15°$
$E\omega t = 252000$

For fall of 15° in temperature

$H_o = -\dfrac{252000 \times 26.75 \times 1279.08}{1385939} = -6210$ for 8.5 meters $-6210 \times 8.5 = -52800$

Crown moment $M_o = -\dfrac{H_o \int y \frac{ds}{I}}{\int \frac{ds}{I}} = 52800 \times \dfrac{705.47}{1279.08} = +29100$ kgm

Temperature stress at other panel points

Point				moment		normal thrust
2	M = 29100	− 52800 × .048	=	+ 26560	52800 × 0.999	= 52800
4	29100	× .225	=	+ 17200	× 0.992	= 52500
6	29100	× .525	=	+ 1400	× 0.985	= 52000
8	29100	× .955	=	− 21400	× 0.975	= 51500
10	29100	× 1.530	=	− 51800	× 0.950	= 50200
12	29100	× 2.270	=	− 90900	× 0.925	= 48900
sp	29100	× 2.994	=	− 128900	× 0.900	= 47500

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

3 Average stress in arch ring

Crown area concrete .4000
steel .0438
.4438 × 8.5 = 3.770 □m

Ratio = $\frac{\text{springing}}{\text{crown}} = \frac{.80}{.40} = 2.0$ Ratio rise = $\frac{2.994}{26.75} = .112$

By prepared curve approximate average stresses are as follows

Dead Load stresses	576988	÷ 3.77	=	153000	@ .90	=	138000 kg/m²
Live Load crown + moment	116450	÷ 3.77	=	30800	.89	=	27400
L.L. Panel Pt 10 - moment	92750	÷ 3.77	=	24600	.91	=	22400
L.L. Panel Pt 12 - moment	76940	÷ 3.77	=	20400	.91	=	18600
L.L. Springing - moment	52978	÷ 3.77	=	14050	.91	=	12800
Temperature	52800	÷ 3.77	=	14000	.85	=	11900

Fibre stress in arch ring.
Crown section Positive moment Compression in upper fibre

	Thrust	moment	Aver stress
Dead Load	577000	- 4874	138000
Live Load	116450	+ 34175	27400
Temperature fall	- 52800	+ 29100	- 11900
Rib Shortening	- 30600	+ 16900	- 6900
	610050	+ 75301	146600

146600 ÷ 252000 = .58 Ecc = .123 d = .400

$E/d = \frac{.123}{.400} = .308$ $\frac{d'}{d} = \frac{4.5}{40} = 0.113$ $p = 0.0073$

$k = 0.68$ $c = .117$

$f_c = \frac{75301}{.117 \cdot 8.5 \cdot 40^2} = 473000 \text{ kg/m}^2 = 47.3 \text{ kg/cm}^2$

Panel Point 10 - moment

	Thrust	moment	Aver stress
Dead Load	608600	+ 2436	138000
Live Load	102750	- 33675	22400
Temperature fall	- 50200	- 51800	- 11900
Rib Shortening	- 28200	- 29100	- 6700
	632950	112139	141800

141800 ÷ 252000 = .562 Ecc = .177 d = .565

$E/d = \frac{.177}{.565} = .313$ $\frac{d'}{d} = \frac{4.5}{56.5} = 0.0795$ $p = 0.0103$

$k = .722$ $c = .1315$

$f_c = \frac{11213900}{.1315 \cdot 850 \cdot 56.5^2} = 31.4 \text{ kg/cm}^2$

Panel Point 12 - moment

	Thrust	Moment	Aver stress
Dead Load	626000	+ 3496	138000
Live Load	90800	- 71743	18600
Temperature fall	- 48900	- 90900	- 11900
Rib shortening	- 26900	- 50000	- 6550
	642000	209147	138150

138150 ÷ 252000 = .549 Ecc = .326 d = .675

$E/d = \frac{.326}{.675} = .483$ $\frac{d'}{d} = \frac{4.5}{67.5} = 0.0667$ $p = 0.00865$

$k = .527$ $c = .131$

$f_c = \frac{20914700}{.131 \cdot 850 \cdot 67.5^2} = 41.2 \text{ kg/cm}^2$

Springing - moment

	Thrust	Moment	Average stress
Dead Load	637400	- 2865	138000
Live Load	71600	- 121250	12800
Temperature fall	- 47500	- 128900	- 11900
Rib Shortening	- 25000	- 67700	- 6250
	636500	320715	132650

132650 ÷ 252000 = .525 Ecc = .504 d = .800

$E/d = \frac{.504}{.800} = .630$ $\frac{d'}{d} = \frac{4.5}{80.} = 0.056$ $p = 0.0073$

$k = .428$ $c = .128$

$f_c = \frac{32071500}{.128 \times 850 \cdot 80^2} = 46.0 \text{ kg/cm}^2$

CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

2 Span no 2 Arch ring

The arch ring will consist of 2- 4.25 meter rings separated at center line of bridge.
reinforcing bars 22 mm bars 3.8 cm² at top and bottom spaced 26 cm at crown and 13 cm spacing from panel point 9 to springing

~~at crown~~ 1 meter strip $3.80 \times \frac{1.00}{.26} = 14.6$ cm²

$2 \times 14.6 = 29.2$ cm²

moment of inertia of Concrete for 1 meter strip $\frac{1}{12}d^3$ d = depth of arch ring

moment of inertia of steel for 1 meter strip $= \frac{29.2 \times 15}{10000}\left(\frac{d}{2} - 0.045\right)^2$

$= 0.0438\left(\frac{d}{2} - 0.045\right)^2$

Division	d	d^3	$I_c = \frac{1}{12}d^3$	$\left(\frac{d}{2} - 0.045\right)^2$		I_s	$I_c + I_s$	Concrete area
0	.400	.0640	.00533	.0240	× 0.0438 =	.00105	.00638	.400
1	.402	.0650	.00542	.0243	″ =	.00106	.00648	.402
2	.408	.0679	.00566	.0253	″ =	.00111	.00677	.408
3	.416	.0720	.00600	.0266	″ =	.00117	.00717	.416
4	.430	.0795	.00663	.0289	″ =	.00127	.00790	.430
5	.446	.0887	.00739	.0317	″ =	.00139	.00878	.446
6	.466	.1012	.00843	.0353	″ =	.00155	.00998	.466
7	.488	.1162	.00968	.0396	″ =	.00173	.01142	.488
8	.515	.1366	.01138	.0452	″ =	.00198	.01336	.515
9	.550	.1664	.01389	.0529	× 0.0876 =	.00463	.01850	.550
10	.600	.2160	.01800	.0650	″ =	.00569	.02369	.600
11	.660	.2875	.02396	.0812	″ =	.00711	.03107	.660
12	.740	.4052	.03377	.1056	″ =	.00925	.04302	.740
Sp.	.800	.5120	.04267	.1260	″ =	.01104	.05371	.800

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	.0000	.415	.00638	65.05	0	0	0	0
1	.915	.837	.018	.0003	1.000	.00648	154.32	141.20	129.17	2.78	0.05
2	1.915	3.667	.062	.004	1.001	.00677	147.86	283.15	542.20	9.17	0.59
3	2.915	8.497	.140	.020	1.003	.00717	139.89	407.78	1188.65	19.58	2.80
4	3.915	15.327	.260	.068	1.007	.00790	127.47	499.05	1953.73	33.14	8.67
5	4.915	24.157	.405	.164	1.013	.00878	115.38	567.09	2787.23	46.73	18.92
6	5.915	34.987	.585	.342	1.019	.00998	102.10	603.92	3572.17	59.73	34.92
7	6.915	47.817	.810	.656	1.028	.01141	90.10	623.04	4308.31	72.98	59.11
8	7.915	62.647	1.060	1.124	1.038	.01336	77.69	614.92	4867.05	82.35	87.32
9	8.915	79.477	1.360	1.850	1.050	.01850	56.76	506.02	4511.11	77.19	105.01
10	9.915	98.307	1.700	2.890	1.063	.02369	44.87	444.89	4411.04	76.28	129.67
11	10.915	119.137	2.080	4.326	1.077	.03107	34.66	378.31	4129.29	72.09	149.94
12	11.915	141.967	2.510	6.300	.890	.04302	20.69	246.52	2937.30	51.93	130.35
Sp.	12.525	156.876	2.794	7.806	.340	.05371	6.33	79.28	993.03	17.69	49.41
					12.944		118317	5395.17	36330.28	621.64	776.76

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

		0				①				②			
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0	0	0	0	0								
1	.915	.915	141.20	129.17	252	0							
2	1.915	1.915	283.15	542.20	17.56	1	147.86	283.15	9.17				
3	2.915	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	3.915	499.05	1953.73	129.74	3	38241	1497.15	9942	2	254.94	998.10	66.28
5	4.915	4.915	567.09	2787.23	229.68	4	461.52	2268.36	186.92	3	346.14	1701.27	140.19
6	5.915	5.915	603.92	3572.17	35330	5	510.50	3019.60	298.65	4	408.40	2415.68	238.92
7	6.915	6.915	623.04	4308.31	504.66	6	540.60	3738.24	437.88	5	450.50	3115.20	364.90
8	7.915	7.915	614.92	4867.05	651.80	7	543.83	4304.44	576.45	6	466.14	3689.52	494.10
9	8.915	8.915	506.02	4511.11	688.15	8	454.08	4048.16	617.52	7	397.32	3542.14	540.33
10	9.915	9915	444.89	4411.04	756.32	9	403.83	4004.01	686.52	8	358.96	3559.12	610.24
11	10.915	10915	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	2937.30	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	221.57	11.61	73.49	920.44	205.38	10.61	67.16	841.16	187.69
			5395.17	36330.28	5018.01		4372.09	31393.93	4449.20		3408.29	26139.96	3830.34

		③				④				⑤			
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
4		1	~~127.47~~	499.05	33.14								
5		2	230.76	1134.18	93.46	1	115.38	567.09	46.73				
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	291.92	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	60.83	761.88	170.00	8.61	54.50	682.60	152.31	7.61	48.17	603.32	134.62
			2592.35	21169.14	3220.65		1916.30	16606.10	2630.54		1367.72	12542.11	2073.57

		⑥				⑦				⑧			
		m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
7		1	90.10	623.04	72.98								
8		2	155.38	1229.84	164.70	1	77.69	614.92	82.35				
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	41.84	524.04	116.93	5.61	35.51	444.76	99.24	4.61	29.18	365.48	81.55
			934.52	9045.21	1563.33		603.42	6152.23	1112.82		362.42	3882.29	735.29

		⑨				⑩				⑪			
		m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
10		1	44.87	444.89	76.28								
11		2	69.32	756.62	144.18	1	34.66	378.31	72.09				
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	22.85	286.20	63.86	2.61	16.52	206.92	46.17	1.61	10.19	127.64	28.48
			199.11	2227.27	440.11		92.56	1078.27	222.12		30.88	374.16	80.41

		⑫			
		m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
Sp.		.61	3.86	48.36	10.79

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

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

$B = 2(1183.17 \cdot 776.76 - 621.64^2) = 1065.206.$

Loaded Point	value of A		B		H_0
Crown 0	2583306	÷	1065.206	=	2.425
1	2546294			=	2.390
2	2413214			=	2.265
3	2199068			=	2.064
4	1921.127			=	1.804
5	1603.157			=	1.505
6	1268750			=	1.191
7	941593			=	.884
8	644678			=	.605
9	396950			=	.373
10	205267			=	.193
11	75943			=	.071
12	10366			=	.010
Sp	0				0

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

							e		D		M_0
0	2 × 2.425 × 621.64	=	−3014.95	+	5395.17	=	2380.22	÷	2366.34	=	+ 1.0059
1	2390		− 2971.44	+	4372.09	=	1400.65			=	+ .5919
2	2.265		− 2816.03	+	3408.29	=	59226			=	+ .2503
3	2.064		− 2566.13	+	2592.35	=	26.22			=	+ .0111
4	1.804		− 2242.88	+	1916.30	=	− 326.58			=	− .1380
5	1.505		− 1871.14	+	1367.72	=	− 50342			=	− .2127
6	1.191		− 148075	+	934.52	=	− 546.23			=	− .2308
7	.884		− 1099.06	+	60342	=	− 495.64			=	− .2095
8	.605		− 752.18	+	36242	=	− 389.76			=	− .1647
9	.373		− 46374	+	199.11	=	− 264.63			=	− .1118
10	.193		− 23995	+	92.56	=	− 147.39			=	− .0623
11	.071		− 88.27	+	30.88	=	− 57.39			=	− .0243
12	.010		− 1243	+	3.86	=	− 8.57			=	− .0036

Crown Shear $V_0 = \frac{\int\frac{mx\,ds}{I}}{2\int\frac{x^2ds}{I}} = \frac{E}{F}$

	E		F		V_0	$1 - V_0$
0	36330.28	÷	72660.56	=	.5000	.5000
1	31393.93			=	.4321	.5679
2	26139.96			=	.3598	.6402
3	21169.14			=	.2913	.7087
4	16606.10			=	.2285	.7715
5	12542.11			=	.1726	.8274
6	9045.21			=	.1245	.8755
7	6152.23			=	.0847	.9153
8	3882.29			=	.0534	.9466
9	2227.27			=	.0309	.9693
10	1078.27			=	.0148	.9852
11	374.16			=	.0051	.9949
12	48.36			=	.0007	.9993

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Moment at various panel points for unit load
x and y co-ordinate of center of section
d' lever arm of unit load about center of sections, origin at crown

For Left Hand section ML = Mo + Hoy + Vox - d'
" right Hand MR = Mo + Hoy - Vox

Moment at Springing x = 12.525 y = 2.794 | Panel Pt 11 x = 10.915 y = 2.080

	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	1.0059	6.7755	6.2625	12.525	1.5209	1.5209	5.0440	5.4575	10.195	.5924	.5924
1	.5919	6.6777	5.4121	11.61	1.0717	1.8575	4.9712	4.7164	10	.2795	.8467
2	.2503	6.3284	4.5065	10.61	.4752	2.0722	4.7112	3.9272	9	-.1113	1.0343
3	.0111	5.7668	3.6485	9.61	-.1836	2.1294	4.2931	3.1795	8	-.5163	1.1247
4	-.1380	5.0404	2.8620	8.61	-.8456	2.0404	3.7523	2.4941	7	-.8916	1.1202
5	-.2127	4.2050	2.1618	7.61	-1.4559	1.8305	3.1304	1.8839	6	-1.1984	1.0338
6	-.2308	3.3277	1.5594	6.61	-1.9537	1.5375	2.4773	1.3589	5	-1.3946	.8876
7	-.2095	2.4699	1.0609	5.61	-2.2887	1.1995	1.8387	.9245	4	-1.4463	.7047
8	-.1647	1.6904	.6688	4.61	-2.4155	.8569	1.2584	.5829	3	-1.3234	.5108
9	-.1118	1.0422	.3845	3.61	-2.2951	.5459	.7758	.3351	2	-1.0009	.3289
10	-.0623	.5392	.1854	2.61	-1.9477	.2915	.4014	.1615	1	-.4994	.1776
11	-.0243	.1984	.0639	1.61	-1.3720	.1102	.1477	.0557	0	+.1791	.0677
12	-.0036	.0279	.0088	.61	-.5769	.0155	.0208	.0076		+.0248	.0096

Panel Point 9 x = 8.915 y = 1.360 | Panel Point 7 x = 6.915 y = .810

	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	1.0059	3.2980	4.4575	8.915	-.1536	-.1536	1.9643	3.4575	6.915	-.4873	-.4873
1	.5919	3.2504	3.8522	8.	-.3055	-.0099	1.9359	2.9880	6	-.4842	-.4602
2	.2503	3.0804	3.2076	7	-.4617	+.1231	1.8347	2.4880	5	-.4270	-.4030
3	.0111	2.8070	2.5969	6	-.5850	+.2212	1.6718	2.0143	4	-.3028	-.3314
4	-.1380	2.4534	2.0371	5	-.6475	+.2783	1.4612	1.5801	3	-.0967	-.2569
5	-.2127	2.0468	1.5387	4	-.6272	+.2954	1.2191	1.1935	2	+.1999	-.1871
6	-.2308	1.6198	1.1099	3	-.5011	+.2791	.9647	.8609	1	+.5948	-.1270
7	-.2095	1.2022	.7551	2	-.2522	+.2376	.7160	.5857		+1.0922	-.0792
8	-.1647	.8228	.4761	1	+.1342	+.1820	.4901	.3693		+.6947	-.0439
9	-.1118	.5073	.2737		+.6692	+.1218	.3021	.2123		+.4026	-.0220
10	-.0623	.2625	.1319		+.3321	+.0683	.1563	.1023		+.1963	-.0083
11	-.0243	.0966	.0455		+.1178	+.0268	.0575	.0353		+.0685	-.0021
12	-.0036	.0136	.0062		+.0162	+.0038	.0081	.0048		+.0093	-.0003

Panel Point 5 x = 4.915 y = .405 | Panel Point 3 x = 2.915 y = .140

	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	1.0059	.9821	2.4575	4.915	-.4695	-.4695	.3395	1.4575	2.915	-.1121	-.1121
1	.5919	.9680	2.1238	4.0	-.3163	-.5639	.3346	1.2596	2.0	+.1861	-.3331
2	.2503	.9173	1.7684	3.0	-.0640	-.6008	.3171	1.0488	1.0	+.6162	-.4814
3	.0111	.8359	1.4317	2.0	+.2789	-.5847	.2890	.8491		+1.1492	-.5490
4	-.1380	.7306	1.1231	1.0	+.7157	-.5305	.2526	.6661		+.7807	-.5515
5	-.2127	.6095	.8483		+1.2451	-.4515	.2107	.5031		+.5011	-.5051
6	-.2308	.4824	.6119		+.8635	-.3603	.1667	.3629		+.2988	-.4270
7	-.2095	.3580	.4163		+.5648	+.2678	.1238	.2469		+.1612	-.3326
8	-.1647	.2450	.2625		+.3428	-.1822	.0847	.1557		+.0757	-.2357
9	-.1118	.1511	.1509		+.1902	-.1116	.0522	.0895		+.0299	-.1491
10	-.0623	.0782	.0729		+.0886	-.0568	.0270	.0431		+.0078	-.0784
11	-.0243	.0288	.0251		+.0296	-.0206	.0099	.0149		+.0005	-.0293
12	-.0036	.0041	.0034		+.0039	-.0029	.0014	.0020		-.0062	-.0042

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

2

	Panel Point 1 x=.915 y=.018					
	Mo	Hoy	Vox	d'	ML	MR
0	1.0059	.0437	.4575	.915	+.5921	+.5921
1	.5919	.0430	.3954		+1.0303	+.2395
2	.2503	.0408	.3292		+.6203	-.0381
3	.0111	.0372	.2665		+.3148	-.2182
4	-.1380	.0329	.2091		+.1036	-.3146
5	-.2127	.0271	.1579		-.0277	-.3435
6	-.2308	.0214	.1139		-.0955	-.3233
7	-.2095	.0159	.0775		-.1161	-.2711
8	-.1647	.0109	.0489		-.1049	-.2027
9	-.1118	.0067	.0281		-.0770	-.1332
10	-.0623	.0035	.0135		-.0453	-.0723
11	-.0243	.0013	.0047		-.0183	-.0277
12	-.0036	.0002	.0006		-.0028	-.0040

Dead Load moments

		Springing		Panel Pt. 11		Panel Pt. 9		Panel Pt. 7	
Point	load	M unit load	M	M unit load	M	M unit load	M	M unit load	M.
12L	12000	-.5769	- 6918	+ .0248	+ 298	+ .0162	+ 194	+ 0093	+ 112
11	38400	-1.3720	- 52620	+ .1791	+ 6875	+ .1178	+ 4524	+ .0685	+ 2630
10	13100	-1.9477	- 25.515	- .4994	- 6542	+ .3321	+ 4350	+ .1963	+ 2572
9	33230	- 2.2951	- 76265	- 1.0009	- 33260	+ .6692	+ 22240	+ 4026	+ 13380
8	10800	-2.4155	- 26089	- 1.3234	- 14.293	+ 0.1342	+ 1448	+ 6947	+ 7503
7	30800	-2.2887	- 70490	- 1.4463	- 44.545	- .2522	- 7770	+ 1.0922	+ 33640
6	9800	-1.9537	- 19145	-1.3946	- 13665	- .5011	- 4910	+ .5948	+ 5830
5	27550	- 1.4559	- 40.110	- 1.1984	- 33015	- .6272	- 17280	+ .1999	+ 5505
4	9140	- .8456	- 7.730	- 0.8916	- 8150	- .6475	- 5920	- .0967	- 884
3	22850	-.1836	- 4.195	- .5163	- 11800	- .5850	- 13365	- .3028	- 6920
2	17820	+.4752	+ 8468	- .1113	- 1983	- .4617	- 8227	- .4270	- 7610
1	16860	+1.0717	+ 18070	+ .2795	+ 4710	- .3055	- 5.150	- .4842	- 8165
0	13880	+1.5209	+ 21110	+ .5924	+ 8223	- .1536	- 2132	- .4873	- 6764
1	16860	+1.8575	+ 31320	+ .8467	+ 14.275	- .0099	- 167	- .4602	- 7760
2	17820	+2.0722	+ 36930	+ 1.0343	+ 18430	+ .1231	+ 2194	- .4030	- 7180
3	22850	+ 2.1294	+ 48657	+ 1.1247	+ 25700	+ .2212	+ 5055	- .3314	- 7572
4	9140	+ 2.0404	+ 18650	+ 1.1202	+ 10240	+ .2783	+ 2544	- .2569	- 2348
5	27550	+ 1.8305	+ 50430	+ 1.0338	+ 28480	+ .2954	+ 8138	- .1871	- 5155
6	9800	+ 1.5375	+ 15070	+ .8876	+ 8700	+ .2791	+ 2735	- .1270	- 1245
7	30800	+ 1.1995	+ 36945	+ .7047	+ 21.705	+ .2376	+ 7318	- .0792	- 2440
8	10800	+ .8569	+ 9255	+ .5108	+ 5.517	+ .1820	+ 1965	- .0439	- 474
9	33230	+ .5459	+ 18.140	+ .3289	+ 10.930	+ .1218	+ 4050	- .0220	- 731
10	13100	+ .2915	+ 3820	+ .1776	+ 2327	+ .0683	+ 895	- .0083	- 109
11	38400	+ .1102	+ 4.220	+ .0677	+ 2600	+ .0268	+ 1028	- .0021	- 81
12R	12000	+ .0155	+ 186	+ .0096	+ 115	+ .0038	+ 46	- .0003	- 4
			- 329.075		+ 169125		+ 68724		+ 71.172
			+ 321271		- 167253		- 64921		- 65442
			- 7.804		+ 1.872		+ 3803		+ 5730

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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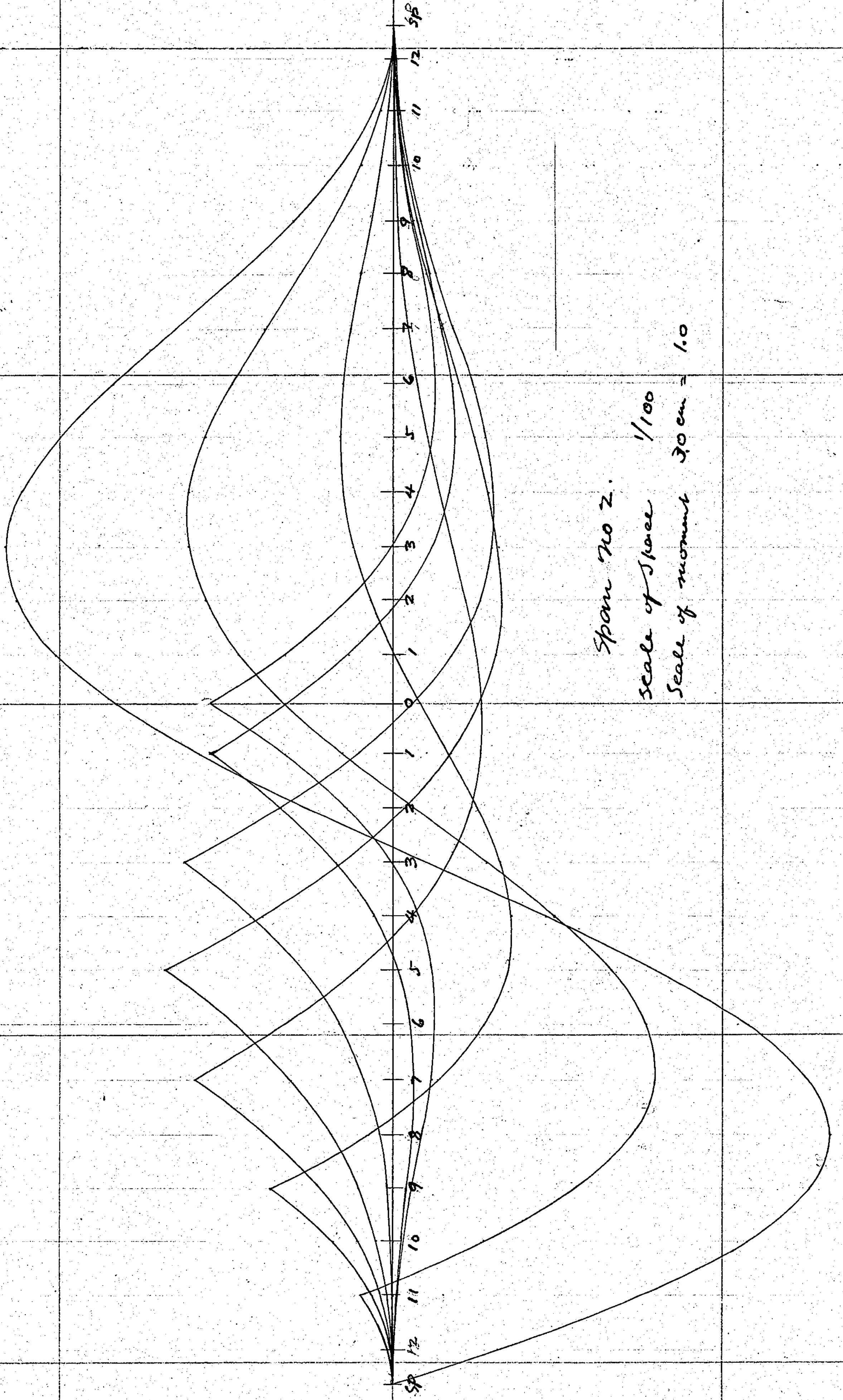
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken



Span No 2.
Scale of Space 1/100
Scale of moment 30cm = 1.0

CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

		Panel Pt 5		Panel Pt 3		Panel Pt. 1		Crown	
Point	load	M unit load	M		M		M		M
12	12000	+.0039	+ 47	-.0002	- 2	-.0028	- 34	-.0036	- 43
11	38400	+.0296	+ 1136	+.0005	+ 19	-.0183	- 703	-.0243	- 933
10	13100	+.0886	+ 1162	+.0078	+ 102	-.0453	- 594	-.0623	- 817
9	33230	+.1902	+ 6320	+.0299	+ 990	-.0770	- 2560	-.1118	- 3715
8	10800	+.3428	+ 3705	+.0757	+ 818	-.1049	- 1132	-.1647	- 1778
7	30800	+.5648	+ 17395	+.1612	+ 4965	-.1161	- 3575	-.2695	- 6453
6	9800	+.8635	+ 8460	+.2988	+ 2930	-.0955	- 936	-.2308	- 2260
5	27550	+1.2451	+ 34300	+.5011	+ 13805	-.0277	- 763	-.2127	- 5860
4	9140	+.7157	+ 6540	+.7807	+ 7135	+.1036	+ 947	-.1380	- 1262
3	22850	+.2787	+ 6370	+1.1492	+ 26260	+.3148	+ 7195	+.0111	+ 254
2	17820	-.0640	- 1140	+.6162	+ 10980	+.6203	+ 11055	+.2503	+ 4460
1	16860	-.3163	- 5333	+.1861	+ 3138	+1.0303	+ 17370	+.5919	+ 9980
0	13880	-.4695	- 6517	-.1121	- 1556	+.5921	+ 3220	(½) +1.0059	+ 6981
1	16860	-.5639	- 9507	-.3331	- 5615	+.2395	+ 4037		- 23121
2	17820	-.6008	- 10705	-.4814	- 8580	-.0381	- 679		+ 21675
3	22850	-.5847	- 13360	-.5490	- 12545	-.2182	- 4985		— 1446 × 2 = -2892
4	9140	-.5305	- 4850	-.5515	- 5040	-.3146	- 2875		
5	27550	-.4515	- 12440	-.5051	- 13915	-.3435	- 9460		
6	9800	-.3603	- 3530	-.4270	- 4185	-.3233	- 3170		
7	30800	-.2678	- 8250	-.3326	- 10245	-.2711	- 8350		
8	10800	-.1822	- 1967	-.2357	- 2547	-.2027	- 2190		
9	33230	-.1116	- 3710	-.1491	- 4955	-.1332	- 4428		
10	13100	-.0568	- 744	-.0784	- 1026	-.0723	- 948		
11	38400	-.0206	- 791	-.0293	- 1125	-.0277	- 1063		
12	12000	-.0029	- 35	-.0042	- 50	-.0040	- 48		
		+ 8'	+ 85435		- 71386		- 48493		
			- 82.879		+ 71142		+ 47877		
			+ 2556		- 244		- 616		

Dead Load thrust

Point	load	H unit load	H thrust			normal thrust	vert shear		normal
0	6940	2.425	16830	531.640 ×	1.000 =	531640	0		
1	16860	2.390	40300	×	.999 =	531110	15370	× 0.030 =	460
2	17820	2.265	40360				32710		
3	22850	2.064	47160	×	.995 =	529000	53045	× 0.095 =	5040
4	9140	1.804	16500				69040		
5	27550	1.505	41460	×	.985 =	523660	87385	× 0.162 =	14160
6	9800	1.191	11670				106060		
7	30800	.884	27230	×	.975 =	518350	126360	× 0.230 =	29060
8	10800	.605	6535				147160		
9	33230	.373	12400	×	.955 =	507720	169175	× 0.305 =	51600
10	13100	.193	2530				192340		
11	38400	.071	2725	×	.925 =	491.680	218090	× 0.380 =	82870
12	12000	.010	120				243290		
sp	6650	0	0	×	.900 =	478480	255940	× 0.425 =	108770
	255.940		265820						
			2						
			531640						

Summary for normal thrust

	0	1	3	5	7	9	11	sp
Due to Vert. shear	0	460	5040	14160	29060	51600	82870	108770
Due to Hor. thrust	531640	531110	529000	523660	518350	507720	491680	478.480
	531640	531570	534040	537.820	547410	559320	574550	587.250

Shinobu-Bashi for Fukushima-Ken

Live load stresses

Uniform live load $\frac{100.000}{170+25.05} = 513$ kg/m² use 500 kg/m²

impact for motor truck = $\frac{20}{60+25.05}$ = 23.5%

Rear wheel concentration 3000
impact 23.5% 705
3705 × 2 = 7410

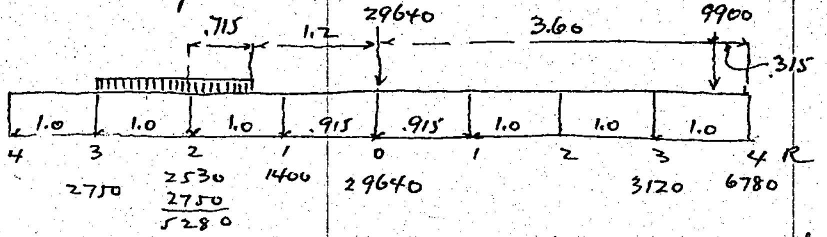
For 4 motor trucks 7410 × 4 = 29640 kg for rear wheel
29640 ÷ 3 = 9900 for front wheel

Crown stress positive moment

Uniform load 500 × 11.0 = 5500 per meter

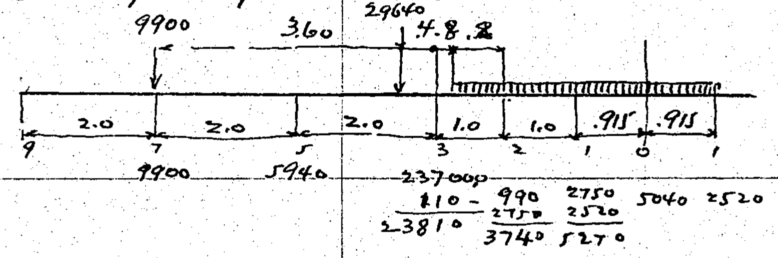
9900
3120
6780

.715 × 5500 = 3930
1400
2530



Point	load	M unit load	moment	H unit load	Hor. Thrust
4R	6780	-.1380	-935	1.804	12200
3R	3120	+.0111	+34	2.064	6450
0	29640	+1.0059	29800	2.425	71900
1	1400	+.5919	827	2.390	3340
2	5280	+.2503	1320	2.265	12000
3	2750	+.0111	30	2064	5670
			+31076		111560

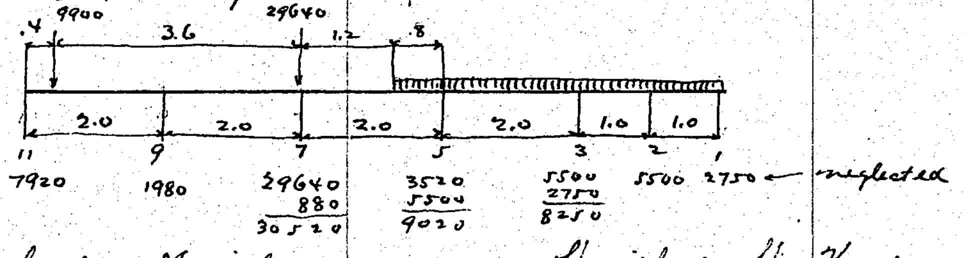
Panel Point [illegible] negative moment



Point	load	M unit load	moment	H unit load	Hor. Thrust	V unit load	vert shear
1R	2520	-.0099	-25	2.390	6020	+.4321	1090
0	5040	-.1536	-775	2.425	12220	+.5000	2520
1L	5270	-.3055	-1610	2.390	12600	+.5679	3000
2	3740	-.4617	-1725	2.265	8460	+.6402	2400
3	23810	-.5850	-13920	2.064	49200	+.7087	16880
5	5940	-.6270	-3730	1.505	9000	+.8274	4920
7	9900	-.2522	-2500	.884	8750	+.9153	9050
			-24285		106250		39860

normal thrust
106250 × .955 = 101500
39860 × .305 = 12200
113700

Panel Point 11 negative moment

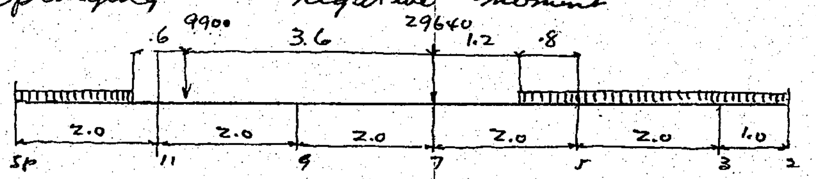


Point	load	M unit load	moment	H unit load	Hor. Thrust	V unit load	vert shear
2	5500	-.1113	-613	2.265	12480	.6402	3520
3	8250	-.5163	-4260	2.064	17050	.7087	5850
5	9020	-1.1984	-10800	1.505	13590	.8274	7370
7	30520	-1.4463	-44200	.884	27000	.9153	27900
9	1980	-1.0009	-1980	.373	738	.9693	1920
11	7920	+.1791	+1420	.071	560	.9949	7870
			-60433		71418		54430

normal thrust
71418 × .925 = 66000
54430 × .380 = 20700
86700

Shinobu- Bashi for Fukushima- Ken

2 Springing negative moment



7920	1980	29640	3520	5500	2750 ← neglected
4460		880	5500	2750	
12380	1980	30520	9020	8250	

Point	load	M unit load	Moment	H unit load	Hor Thrust	V unit load	Vert shear	normal thrust
3	8250	- .1836	- 1516	2.064	17050	.7087	5850	59268 · .90 = 53300
5	9020	- 1.4559	- 13120	1.505	13600	.8274	7460	55430 · .425 = 23600
7	30520	- 2.2887	- 69800	.884	27000	.9153	27900	76900
9	1980	- 2.2951	- 4550	.373	7380	.9693	1920	
11	12380	- 1.3720	- 17000	.071	880.	.9949	12300	
			-105986		59268		55430	

Temperature stresses

Crown Thrust $H_o = \frac{E\omega t l \int \frac{ds}{I}}{2[\int \frac{ds}{I} \int y^2 \frac{ds}{I} - (\int y \frac{ds}{I})^2]} = \frac{G}{B}$

$E = 1400\,000\,000$ kg/m²
$\omega = 0.000012$
$t = \pm 15°c$
$E\omega t = 252000$

For fall of 15° in temperature

$H_o = - \frac{252000 \cdot 25.05 \cdot 1183.17}{1065\,206} = 7010$ for 8.5 meter $7010 \cdot 8.5 = 59590$ kg.

Crown moment $M_o = - \frac{H_o \int y \frac{ds}{I}}{\int \frac{ds}{I}} = \frac{59590 \cdot 621.64}{1183.17} = 31.310$ kgm

moments at other panel points

		y		moment				normal thrust
1	31310 - 59590 ·	0.018	=	+ 30240	kgm	59590 · .999	=	59530
3		.140	=	+ 22970		.995	=	59290
5		.405	=	+ 7180		.985	=	58700
7		.810	=	- 16960		.975	=	58100
9		1.360	=	- 49730		.955	=	56900
11		2.080	=	- 92640		.925	=	55120
sp		2.794	=	- 135180		.900	=	53630

Average stresses

Crown area with steel = 3.77 □m Ratio = $\frac{\text{springing}}{\text{crown}} = \frac{.80}{.40} = 2.0$

Rise Ratio. = $\frac{2794}{25.05}$ = .1118

By prepared curve the approximate average stresses are as follows.

Dead Load	531640 ÷ 3.77	=	141000	@ .90	=	127000 kg/m²
Live Load crown + moment	111560 ÷ 3.77	=	29600	@ .89	=	26400
Live Load Panel 9 - moment	106250 ÷ 3.77	=	28200	@ .91	=	25600
Live Load Panel 11 - moment	71418 ÷ 3.77	=	18900	@ .91	=	17200
Live Load Springing - moment	59268 ÷ 3.77	=	15700	@ .91	=	14300
Temperature	59590 ÷ 3.77	=	15800	@ .85	=	13400

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CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

Fibre stresses in Arch Ring.

Crown section Positive moment Compression in upper fibre

	Thrust	moment	Aver stress
Dead Load	531640	− 2892	127000
Live Load	111560	+ 31076	26400
Temperature fall	− 59590	+ 31310	− 13400
rib shortening	− 31700	+ 16650	− 7100
	551910	76144	132900

132900 ÷ 252000 = .532 $\Sigma cc = .138$ $d = 400$

$\Sigma/d = \frac{.138}{.400} = .345$ $\frac{d'}{d} = \frac{4.5}{40.} = 0.113$ $p = 0.0073$

$k = .629$ $e = .118$

$f_c = \frac{76144}{.118 \times 8.5 \times .40^2} = 475000$ kg/m² or 47.5 kg/cm²

Panel Point 9 negative moment

	Thrust	moment	Aver. stress
Dead Load	559320	+ 3803	127000
Live Load	113700	− 24285	25600
Temperature fall	− 56900	− 49730	− 13400
Rib shortening	− 30000	− 26200	− 7050
	586120	− 96412	132150

132150 ÷ 25200 = .526 $\Sigma cc = .165$ $d = .550$

$\Sigma/d = \frac{.165}{.550} = .300$ $\frac{d'}{d} = \frac{4.5}{55.} = 0.082$ $p = 0.0106$

$k = .746$ $e = .131$

$f_c = \frac{96412}{.131 \times 8.5 \times .55^2} = 287000$ kg/m² = 28.7 kg/cm²

Panel Point 11 negative moment

	Thrust	moment	Aver. stress
Dead Load	574550	+ 1872	127000
Live Load	86700	− 60433	17200
Temperature fall	− 55120	− 92640	− 13400
Rib shortening	− 27100	− 45500	− 6600
	579030	− 196701	124200

124200 ÷ 25200 = .492 $\Sigma cc = .339$ $d = .660$

$\Sigma/d = \frac{.339}{.660} = .513$ $\frac{d'}{d} = \frac{4.5}{66.0} = 0.0683$ $p = 0.00885$

$k = .484$ $e = .1325$

$f_c = \frac{196701}{.1325 \times 8.5 \times .66^2} = 400.000$ kg/m² = 40. kg/cm²

Springing negative moment

	Thrust	moment	Aver. stress
Dead Load	587250	− 7804	127000
Live Load	76900	− 105986	14300
Temperature	− 53630	− 135180	− 13400
Rib shortening	− 25900	− 65200	− 6450
	584620	− 314170	121450

121450 ÷ 252000 = .482 $\Sigma cc = .538$ $d = .800$

$\Sigma/d = \frac{.538}{.800} = .674$ $\frac{d'}{d} = \frac{4.5}{80.0} = 0.056$ $p = 0.0073$

$k = .410$ $e = .1271$

$f_c = \frac{314170}{.1271 \times 8.5 \times .80^2} = 455000$ kg/m² = 45.5 kg/cm²

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Span no 1 Arch ring Span length 22.55 meters rise = 2.484
The arch ring will consist of 2- 4.25 meter rings separated at center line of bridge.
reinforcing bars 22 mm bars 3.8 cm² at top and bottom spaced 26 cm at crown
and 13 cm spacing from panel point 8 to springing

at crown 1 meter strip $3.80 \cdot \frac{1.00}{.26} = 14.6$ cm²

$2 \cdot 14.6 = 29.2$ cm²

moment of inertia of Concrete for 1 meter strip $\frac{1}{12} d^3$ d being depth of ring

moment of inertia of Steel for 1 meter strip $= \frac{29.2 \times 15}{10000} \left(\frac{d}{2} - 0.045\right)^2$

$= 0.0438 \left(\frac{d}{2} - 0.045\right)^2$

Division	d	d^3	I_c	$(\frac{d}{2}-0.045)^2$			I_s	I_c+I_s	Concrete area
0	.400	.0640	.00533	.0240	× .0438	=	.00105	.00638	.400
1	.401	.0645	.00537	.0242	× "	=	.00106	.00643	.401
2	.408	.0679	.00566	.0253	"	=	.00111	.00677	.408
3	.414	.0710	.00592	.0263	"	=	.00115	.00707	.414
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	.0876	=	.00440	.01737	.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

Division	x	x^2	y	y^2	ds	I	$\frac{ds}{I}$	$x\frac{ds}{I}$	$\frac{x^2 ds}{I}$	$y\frac{ds}{I}$	$\frac{y^2 ds}{I}$
0	0	0	0	0	.165	.00638	25.86	0	0	0	0
1	.665	.442	.010	.0001	1.000	.00643	155.52	103.42	68.74	1.56	.01
2	1.665	2.772	.055	.003	1.002	.00677	148.01	246.44	410.28	8.14	.44
3	2.665	7.102	.130	.017	1.004	.00707	142.01	378.46	1008.56	18.46	2.41
4	3.665	13.432	.250	.063	1.011	.00789	128.14	469.63	1721.18	32.04	8.07
5	4.665	21.762	.400	.160	1.014	.00889	114.06	552.09	2482.19	45.62	18.25
6	5.665	32.092	.590	.348	1.020	.01055	96.68	547.69	3102.65	57.04	33.64
7	6.665	44.422	.820	.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

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CALCULATIONS FOR

Shinobu-Bashi for Tokushima-Ken

			⓪				①				②		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
0	0		0	0	0								
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	142.01	378.46	18.46
4	3.665		469.63	1721.18	117.43	3.0	384.42	1408.89	96.12	2	256.28	939.26	64.08
5	4.665		532.09	2482.17	212.82	4.0	456.24	2128.36	182.48	3	342.18	1596.27	136.86
6	5.665		547.69	3102.65	323.13	5.0	483.40	2738.45	285.20	4	386.72	2190.76	228.16
7	6.665		561.59	3743.00	460.48	6.0	505.56	3369.54	414.54	5	421.30	2807.95	345.45
8	7.665		459.36	3521.01	500.68	7.0	419.51	3215.52	457.24	6	359.58	2756.16	391.92
9	8.665		404.48	3504.83	572.32	8.0	373.44	3235.84	528.40	7	326.76	2831.36	462.35
10	9.665		332.19	3210.57	591.30	9.0	309.33	2989.71	550.62	8	274.96	2657.52	489.44
11	10.665		316.39	2307.83	476.09	10.0	202.90	2163.90	446.40	9	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

			③				④				⑤		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
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
			2020.48	14817.87	2214.39		1429.74	11223.08	1757.69		967.14	8097.92	1333.03

			⑥				⑦				⑧		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
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	5504.85	953.99		366.74	3459.47	631.99		199.14	1975.68	379.08

			⑨				⑩				⑪		
	x	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$	m	$m\frac{ds}{I}$	$mx\frac{ds}{I}$	$my\frac{ds}{I}$
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	.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

Shinobu Bashi for Fukushima-Ken

1

Crown Thrust $H_o = \dfrac{\int\frac{ds}{I}\int\frac{my\,ds}{I} - \int\frac{m\,ds}{I}\int\frac{y\,ds}{I}}{2[\int\frac{ds}{I}\int\frac{y^2ds}{I} - (\int\frac{y\,ds}{I})^2]} = \dfrac{A}{B}.$

$B = 2[1062.17 \times 530.23 - 484.86^2] = 656.210$

Loaded Point	Value of A		B		H_o
Crown 0	1616.479	÷	656210	=	2.462
1	1608.130			=	2.450
2	1521.828			=	2.318
3	1372 409			=	2.091
4	1 173 742			=	1.788
5	946 976			=	1.442
6	713 366			=	1.086
7	493 463			=	.752
8	306 092			=	.466
9	159 045			=	.242
10	59 520			=	.091
11	8 314			=	.013
sp.	0			=	0

Crown Moment $M_o = \dfrac{-H_o 2\int y\frac{ds}{I} + \int\frac{m\,ds}{I}}{2\int\frac{ds}{I}} = \dfrac{C}{D}$

Loaded Point								C		D		M_o
Crown 0	2 × 2.462	× 484.86	=	− 2387.45	+	4323.11	=	+ 1935.66	÷	2124.34	=	+ 0.9112
1	2.450			− 2375.81	+	3633.99	=	+ 1258.18				+ 0.5923
2	2.318			− 2247.81	+	2753.23	=	+ 505.42				+ 0.2379
3	2.091			− 2027.68	+	2020.48	=	− 7.20				− 0.0034
4	1.788			− 1733.86	+	1429.74	=	− 304.12				− 0.1432
5	1.442			− 1398.34	+	967.14	=	− 431.20				− 0.2030
6	1.086			− 1053.12	+	618.66	=	− 434.52				− 0.2045
7	.752			− 729.23	+	366.74	=	− 362.49				− 0.1706
8	.466			− 451.89	+	199.14	=	− 252.75				− 0.1190
9	.242			− 234.67	+	91.47	=	− 143.20				− 0.0674
10	.091			− 88.24	+	30.48	=	− 57.76				− 0.0272
11	.013			− 12.61	+	3.86	=	− 8.75				− 0.0041
sp.	.000											0

Crown Shear $V_o = \dfrac{\int\frac{mx\,ds}{I}}{2\int\frac{x^2ds}{I}} = \dfrac{E}{F}.$

Loaded Point	E		F		V_o	$1 - V_o$
Crown 0	25885.53	÷	51771.06	=	.5000	.5000
1	23010.81				.4445	.5555
2	18791.12				.3630	.6370
3	14817.87				.2862	.7138
4	11223.08				.2168	.7832
5	8097.92				.1564	.8436
6	5504.85				.1063	.8937
7	3459.47				.0668	.9332
8	1975.68				.0382	.9618
9	951.25				.0184	.9816
10	331.30				.0064	.9936
11	43.54				.0008	.9992
sp	0				0	1.0000

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

1 moment at various panel points for unit load
x and y co-ordinates of center of sections
d' lever arm of unit load about center of sections origin being at crown

For Left Hand section ML = Mo + Hoy + Vox - d'
MR = Mo + Hoy - Vox

		Springing x=11.275 y = 2.484					Panel Pt 10 x = 9.665 y = 1780				
	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	+.9112	6.1156	5.6375	11.275	+1.3893	+1.3893	4.3824	4.8325	9.665	+.4511	+.4511
1	+.5923	6.0858	5.0117	10.610	+1.0798	+1.6664	4.3610	4.2961	9.00	+.2494	+.6572
2	+.2379	5.7579	4.0928	9.61	+.4786	+1.9030	4.1260	3.5084	8.0	-.1277	+.8555
3	-.0034	5.1940	3.2269	8.61	-.1925	+1.9637	3.7220	2.7661	7.0	-.5153	+.9521
4	-.1432	4.4414	2.4444	7.61	-.8672	+1.8540	3.1826	2.0954	6.0	-.8650	+.9442
5	-.2030	3.5819	1.7634	6.61	-1.4677	+1.6155	2.5668	1.5116	5.0	-1.1246	+.8522
6	-.2045	2.6976	1.1985	5.61	-1.9184	+1.2946	1.9331	1.0274	4.0	-1.2440	+.7012
7	-.1706	1.8680	.7532	4.61	-2.1594	+.9442	1.3386	$\overset{56}{.6465}$	3.0	-1.1864	+.5224
8	-.1190	1.1575	.4307	3.61	-2.1408	+.6078	.8290	.3692	2.0	-.9208	+.3408
9	-.0674	.6011	.2075	2.61	-1.8688	+.3232	.4308	.1778	1.0	-.4588	+.1856
10	-.0272	.2260	.0722	1.61	-1.3390	+.1266	.1620	.0619		+.1967	+.0729
11	-.0041	.0323	.0090	.61	-.5728	+.0192	.0231	.0077		+.0267	+0113
Sp.	0	0	0		0	0	0	0		0	0

		Panel Point 8 x = 7.665 y = 1.090					Panel Point 6 x = 5.665 y = 0.590				
	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	+.9112	2.6836	3.8325	7.665	-.2377	-.2377	1.4526	2.8325	5.665	-.4687	-.4687
1	+.5923	2.6705	3.4071	7.0	-.3301	-.1443	1.4455	2.5181	5.0	-.4441	-.4803
2	+.2379	2.5266	2.7824	6.0	-.4531	-.0179	1.3676	2.0564	4.0	-.3381	-.4509
3	-.0034	2.2792	2.1937	5.0	-.5305	+.0821	1.2337	1.6213	3.0	-.1484	-.3910
4	-.1432	1.9489	1.6618	4.0	-.5323	+.1441	1.0549	1.2282	2.0	+.1401	-.3163
5	-.2030	1.5718	1.1988	3.0	-.4324	+.1700	.8508	.8860	1.0	+.5338	-.2382
6	-.2045	1.1837	.8148	2.0	-.2060	+.1644	.6407	.6022		+1.0384	-.1660
7	-.1706	.8197	.5120	1.0	+.1611	+.1371	.4437	.3784		+.6515	-.1053
8	-.1190	.5079	.2928		+.6817	+.0961	.2749	.2164		+.3723	-.0605
9	-.0674	.2638	.1410		+.3374	+.0554	.1428	.1042		+.1796	-0288
10	-.0272	.0992	.0491		+.1211	+.0229	.0537	.0363		+.0638	-.0098
11	-.0041	.0142	.0061		+.0162	+.0040	.0077	.0045		+.0081	-.0009
Sp.		0	0		0	0	0			0	0

		Panel Point 4 x = 3.665 y = 0.250					Panel Point 2 x = 1.665 y = 0.055				
	Mo	Hoy	Vox	d'	ML	MR	Hoy	Vox	d'	ML	MR
0	.9112	.6155	1.8325	3.665	-.3058	-.3058	.1354	.8325	1.665	+.2141	+.2141
1	.5923	.6125	1.6291	3.0	-.1661	-.4243	.1348	.7401	1.0	+.4672	-.0130
2	.2379	.5795	1.3304	2.0	+.1478	-.5130	.1275	.6044		+.9698	-.2390
3	-.0034	.5228	1.0489	1.0	+.5683	-.5295	.1150	.4765		+.5881	-.3649
4	-.1432	.4470	.7946		+1.0986	-.4906	.0983	.3610		+.3163	$\overset{57}{-.4075}$
5	-.2030	.3605	.5732		+.7307	-.4157	.0793	.2604		+.1367	-.3841
6	-.2045	.2715	.3896		+.4566	-.3226	.0597	.1770		+.0322	-.3218
7	-.1706	.1880	.2448		+.2622	-.2274	.0414	.1112		-.0180	-.2404
8	-.1190	.1165	.1400		+.1375	-.1425	.0256	.0636		-.0298	-.1570
9	-.0674	.0605	.0674		+.0605	-.0743	.0133	.0306		-.0235	-.0847
10	-.0272	.0228	.0253		+.0191	-.0279	.0050	.0107		-.0115	-.0329
11	-.0041	.0033	.0029		+.0021	-.0037	.0007	.0013		-.0021	-.0047
Sp	0				0	0				0	0

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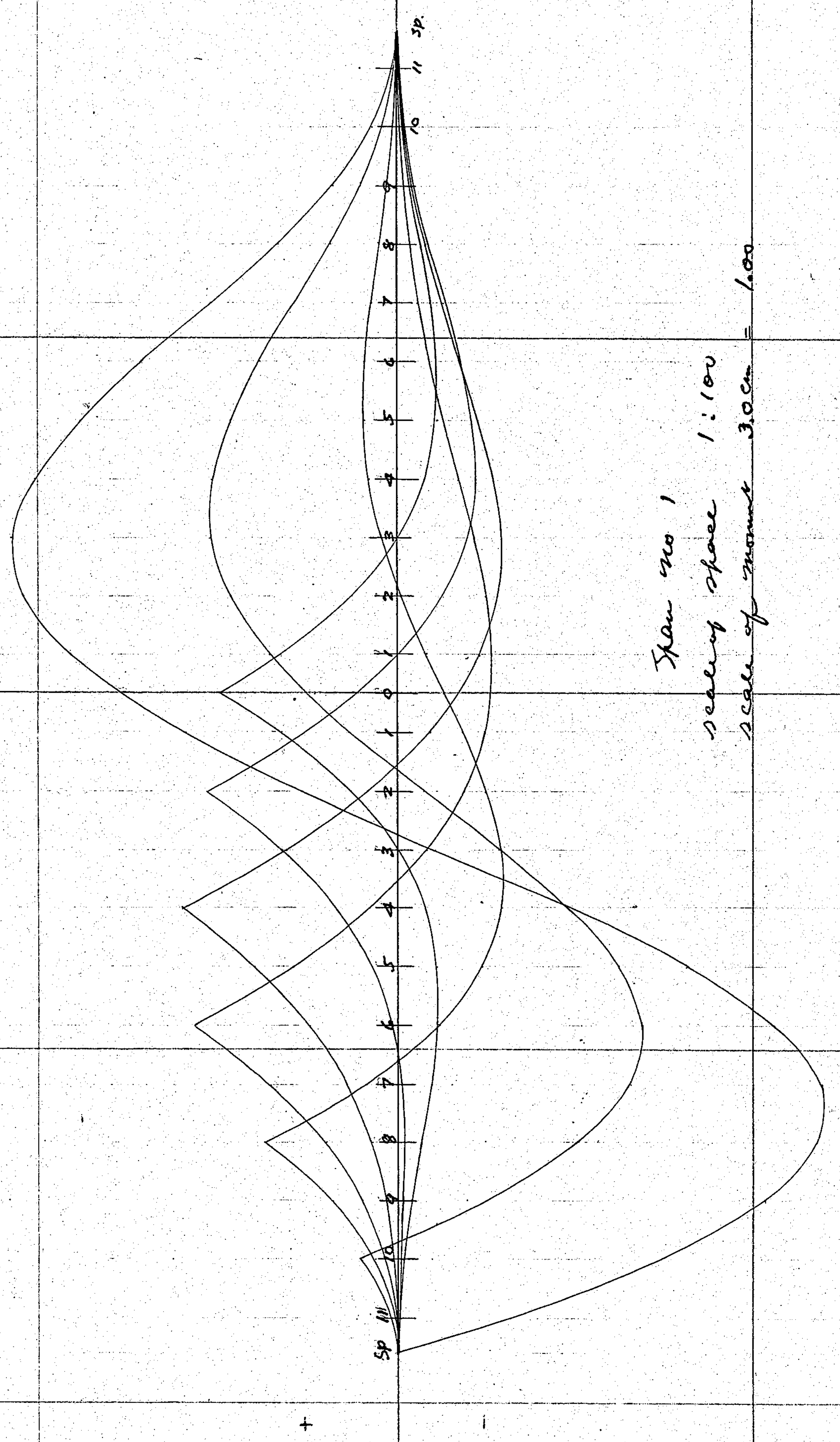
CALCULATIONS FOR (1)

Shinobu-Bashi for Fukushima-Ken

1



増田淳氏関係資料
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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

1

		Springing		Panel Point 10		Panel Point 8		Panel Point 6	
.	load	M unit load	moment M	M unit-load	moment M	M unit load	moment M	M unit load	moment M
11	12000	- .5728	- 6875	+.0267	+ 320	+ .0162	+ 194	+.0081	97
10	37150	- 1.3390	- 49720	+ .1967	+ 7306	+ .1211	+ 4500	+ .0638	2370
9	12750	- 1.8688	- 23820	- .4588	- 5850	+ .3374	+ 4305	+ .1796	2291
8	31900	- 2.1408	- 68290	- .9208	- 29370	+ .6817	+ 21720	+ .3723	11870
7	10400	- 2.1594	- 22460	- 1.1864	- 12340	+ .1611	+ 1676	+ .6515	6780
6	29180	- 1.9184	- 55950	- 1.2440	- 36280	- .2060	- 6010	+ 1.0384	30300
5	9200	- 1.4677	- 13495	- 1.1246	- 10340	- .4324	- 3976	+ .5338	· 4908
4	24230	- .8672	- 21000	- .8650	- 20960	- .5323	- 12910	+ .1401	+ 3396
3	19000	- .1925	- 3658	- .5153	- 9790	- .5305	- 10080	- .1484	- 2820
2	17680	+ .4786	+ 8470	- .1277	- 2260	- .4531	- 8015	- .3381	- 5980
1	16860	+ 1.0798	18200	+ .2494	+ 4205	- .3301	- 5564	- .4441	- 7488
0	5520	+ 1.3893	7665	+ .4511	+ 2490	- .2377	- 1310	- .4687	- 2587
1	16860	+ 1.6664	28090	+ .6572	+ 11075	- .1443	- 2432	- .4803	- 8100
2	17680	+ 1.9030	33650	+ .8555	+ 15125	- .0179	- 317	- .4509	- 7980
3	19000	+ 1.9637	37300	+ .9521	+ 18090	+ .0821	+ 1560	- .3910	- 7430
4	24230	+ 1.8540	44910	+ .9442	+ 22900	+ .1441	+ 3491	- .3163	- 7664
5	9200	+ 1.6155	14860	+ .8522	+ 7843	+ .1700	+ 1563	- .2382	- 2191
6	29180	+ 1.2946	37740	+ .7012	+ 20450	+ .1644	+ 4795	- .1660	- 4842
7	10400	+ .9442	9825	+ .5224	+ 5438	+ .1371	+ 1426	- .1053	- 1096
8	31900	+ .6078	19370	+ .3408	+ 10860	+ .0961	+ 3065	- .0605	- 1930
9	12750	+ .3262	4162	+ .1856	+ 2368	+ .0554	+ 706	- .0288	- 367
10	37150	+ .1266	4705	+ .0729	+ 2710	+ .0229	+ 851	- .0098	- 364
11	12000	+ .0192	230	+ .0113	+ 136	+ .0040	+ 48	- .0009	- 11
			+ 269.177		+ 131.316		+ 49900		+ 62012
			- 265.268		- 127.190		- 50614		- 60850
			+ 3909		+ 4126		- 714		+ 1162

		Panel Point 4		Panel Point 2		Crown	
	load	M unit load	M	M unit load	M	M unit load	M
11	12000	+ .0021	+ 25	- .0021	- 25	- .0041	- 49
10	37150	+ .0191	+ 710	- .0115	- 427	- .0272	- 1010
9	12750	+ .0605	+ 772	- .0235	- 300	- .0674	- 860
8	31900	+ .1375	+ 4385	- .0298	- 950	- .1190	- 3795
7	10400	+ .2622	+ 2728	- .0180	- 187	- .1706	- 1775
6	29180	+ .4566	+ 13320	+ .0322	+ 940	- .2045	- 5968
5	9200	+ .7307	+ 6721	+ .1367	+ 1256	- .2030	- 1867
4	24230	+ 1.0986	+ 26620	+ .3163	+ 7668	- .1430	- 3465
3	19000	+ .5683	+ 10800	+ .5881	+ 11175	- .0034	- 65
2	17680	+ .1478	+ 2615	+ .9698	+ 17150	+ .2379	+ 4210
1	16860	- .1661	- 2860	+ .4672	+ 7880	+ .5923	+ 10000
0	5520	- .3058	- 1687	+ .2141	+ 1181	+ .9112/2	+ 2515
1	16860	- .4243	- 7155	- .0130	- 219		
2	17680	- .5130	- 9070	- .2390	- 4228		+ 16725
3	19000	- .5295	- 10.060	- .3649	- 6932		- 18854
4	24230	- .4906	- 11880	- .4057	- 9830		- 2129 × 2 = - 4258
5	9200	- .4157	- 3820	- .3841	- 3564		
6	29180	- .3226	- 9530	- .3218	- 9390		
7	10400	- .2274	- 2365	- .2404	- 2502		
8	31900	- .1425	- 4545	- .1570	- 5070		
9	12750	- .0743	- 948	- .0847	- 1080		
10	37150	- .0279	- 1036	- .0329	- 1222		
11	12000	- .0037	- 44	- .0047	- 56		
			+ 68696		+ 47250		
			- 64940		- 45982		
			+ 3.756		+ 1268		

Shinobu-Bashi for Fukushima-Ken.

1 Dead Load Thrust.

Point	load	Ho unit load	Ho			normal thrust	vert shear		normal thrust
0	2760	2.462	6794	492862 ×	1.000 =	492862	0	=	0
1	16860	2.450	41320				11190		
2	17680	2.318	40990	×	0.998 =	491800	28460	× .060 =	1707
3	19000	2.091	39740				46800		
4	24230	1.788	43350	×	.992 =	489000	68415	× .130 =	8900
5	9200	1.442	13260				85130		
6	29180	1.086	31680	×	.982 =	484000	104320	× .205 =	21380
7	10400	.752	7825				123110		
8	31900	.466	14850	×	.958 =	472100	145260	× .288 =	41380
9	12750	.242	3086				167585		
10	37150	.091	3380	×	.935 =	460700	192535	× .365 =	70250
11	12000	.013	156				217110		
sp.	6650	0	0	×	.912 =	449400	229760	× .415 =	95300
	229.760		246.431 2 492862						

Summary for Dead Load normal thrusts

	0	2	4	6	8	10	sp
Due to vert shear	0	1707	8900	21380	41380	70250	95300
" " Hor. thrust	492862	491.800	489000	484000	472100	460700	449400
	492862	493507	497900	505380	513480	530950	544700

Live Load Stresses

uniform live load $\frac{100.000}{170+22.55}$ = 520 use 500 kg/m² × 11.0 = 5500 kg

impact for motor truck = $\frac{20}{60+22.55}$ = 24.2 %.

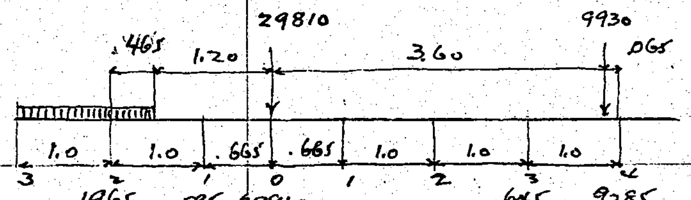
Rear wheel concentration	3000
impact 24.2 %	726
	3726 × 2 = 7452

For 4 motor trucks 4 × 7452 = 29810 kg

front wheel 29810 ÷ 3 = 9930 kg.

Crown stress positive moment

.465 × 5500 = 2560
595
1965

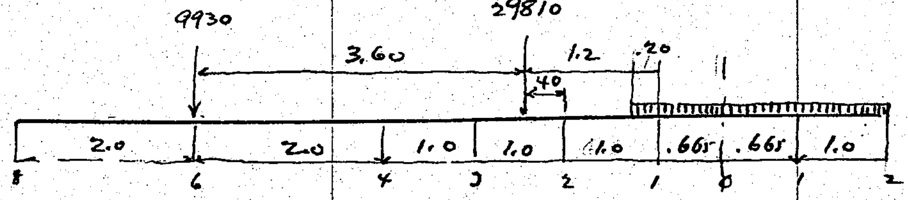


neglected → 2750 1965 595 29810 645 9285
2750
4715

Point	load	M unit load	moment	H unit load	Hor thrust
4^R	9285	− .1430	− 1330	1.788	16600
3	645	− .0034	− 2	2.091	1350
0	29810	+ .9112	27200	2.462	73500
1^L	595	+ .5923	352	2.450	1460
2	4715	+ .2379	1120	2.318	10900
			+ 27340		103810

Panel Point 8 − moment

5500 × .2 = 1100
5500 × .665 = 3660



9930 11920 17890 990 3660 1830
110 1830 2750
11920 18000 2820 4580 2750

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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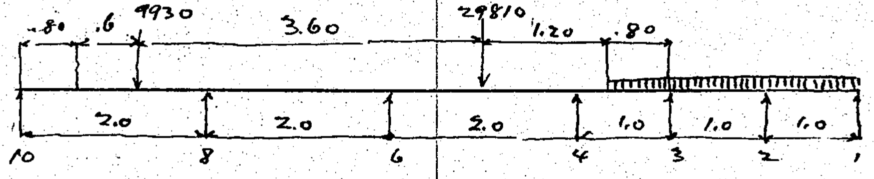
CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

1 Panel Point 8 - moment

Point	load	M unit load	moment	H unit load	Hor Thrust	V unit load	Vert shear	normal thrust
2R	2750	-.0179	- 49	2.318	6360	.3630	1000	110800 × .958 = 106000
1	4580	-.1443	- 660	2.450	11220	.4445	2040	35255 × .285 = 10000
0	3660	-.2377	- 870	2.462	9020	.5000	1830	116000
1	2820	-.3301	- 930	2.450	6900	.5555	1565	
2	18000	-.4531	- 8150	2.318	41600	.6370	11460	
3	11920	-.5305	- 6310	2.091	24900	.7138	8500	
6	9930	-.2060	- 2045	1.086	10800	.8937	8860	
			19014		110800		35255	

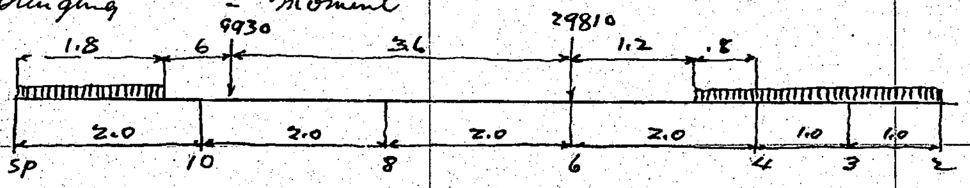
Panel Point 10 - moment



2980 neglected
6950
14905
14905 + 1760 = 16665
2640 + 2750 = 5390
2750 + 2750 = 5500
(2750) neglected

Point	load	M unit load	Moment	H unit load	Hor Thrust	V unit load	Vert shear	normal thrust
2	5500	-.1277	- 703	2.318	12740	.6370	3500	73280 × .935 = 68500
3	5390	-.5153	- 2780	2.091	11300	.7138	3850	40340 × .365 = 14750
4	16665	-.8650	- 14400	1.788	29800	.7832	13000	83250
6	14905	-1.2440	- 18550	1.086	16200	.8937	13300	
8	6950	-.9208	- 6400	.466	3240	.9618	6690	
			-42833		73280		40340	

Springing - moment



9930 - 1990 = 7940

7940 + 4460 = 12400
1990
29810 + 880 = 30690
3520 + 2750 = 6270
5500 2750 neglected

Point	load	M unit load	Moment	H unit load	Hor Thrust	V unit load	Vert shear	normal thrust
3	5500	-.1925	- 1060	2.091	11500	.7138	3920	58157 × .912 = 53000
4	6270	-.8672	- 5440	1.788	11200	.7832	4910	50440 × .415 = 20900
6	30690	-1.9184	- 58900	1.086	33400	.8937	27400	73900
8	1990	-2.1408	- 4260	.466	927.0	.9618	1910	
10	12400	-1.3390	- 16600	.091	1130	.9936	12300	
			86260		58157		50440	

Temperature stress

Crown Thrust $H_0 = \frac{E\omega t l \int \frac{ds}{I}}{2[\int\frac{ds}{I}\int y^2\frac{ds}{I} - (\int y\frac{ds}{I})^2]} = \frac{G}{B}$

E = 1400.000 000 kg/m²
ω = 0.000012
t = ±15°
$E\omega t$ = 252000

for fall of 15° $H_0 = -\frac{252000 \times 2255 \times 106.217}{656210} = -9198$

For 8.5 meters wide $-9198 \times 8.5 = -78180$ kgs

$M_0 = -\frac{H_0 \int y \frac{ds}{I}}{\int \frac{ds}{I}} = \frac{78180 \times 484.86}{106.217} = 35690$ kgm

		moments			normal thrust
2	M = 35690 - 78180 × .055	= +31390 kgm	78180 × .998	=	78027 kg
4	× .250	= +16140	.992	=	77558 "
6	× .590	= -10440	.982	=	76776 "
8	× 1.090	= -49530	.958	=	74900 "
10	× 1.780	= -103480	.935	=	73100 "
sp	× 2.484	= -158520	.912	=	71300 "

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

1 Average stresses

crown area with steel = 3.770 ^{m}

Ratio = $\frac{\text{springing}}{\text{crown}} = \frac{.80}{.40} = 2.0$ Ratio rise = $\frac{2.484}{22.55} = .1104$

By prepared curve ~~the~~ approximate average stress in arch ring are as follows.

				average stress
Dead Load	492862 ÷ 3.77 =	131000	@ .90 =	118000
LL crown + moment	103810 ÷ 3.77 =	27500	@ .89 =	24500
LL Panel 8 - moment	110800 ÷ 3.77 =	29300	@ .91 =	26700
LL Panel 10 - moment	73280 ÷ 3.77 =	19450	@ .91 =	17700
LL Springing - moment	58157 ÷ 3.77 =	15400	@ .91 =	14000
Temperature	78180 ÷ 3.77 =	20700	@ .85 =	17600

Fibre stress in Arch Ring

Crown Section Positive moment Compression in upper fibre

	thrust	moment	aver. stress
Dead Load	492860	- 4258	118000
Live Load	103810	+ 27340	24500
Temperature fall	- 78180	+ 35690	- 17600
Rib shortening	- 36200	+ 16500	- 8150
	482290	+ 75272	116750

116750 ÷ 252000 = .462 $\Sigma cc = .156$ $d = .400$

$e/d = \frac{.156}{.400} = .39$ $\frac{d'}{d} = \frac{4.5}{40} = 0.113$ $p = 0.0073$

$k = .565$ $c = .117$

$f_c = \frac{7527200}{.117 \times 850 \times 40.^2} = 47.5$ kg/cm²

Panel Point 8 - moment

	thrust	moment	aver. stress
Dead Load	513480	- 714	118000
Live Load	116000	- 19014	26700
Temperature fall	- 74900	- 49530	- 17600
Rib shortening	- 35200	- 23300	- 8250
	519380	- 92558	118850

118850 ÷ 252000 = .47 $\Sigma cc = .178$ $d = .538$

$e/d = \frac{.178}{.538} = .331$ $\frac{d'}{d} = \frac{4.5}{53.8} = 0.0835$ $p = .0108$

$k = .711$ $c = .135$

$f_c = \frac{9255800}{.135 \times 850 \times 53.8^2} = 27.9$ kg/cm²

Panel Point 10 - moment

	thrust	moment	aver. stress
Dead Load	530950	+ 4126	118000
Live Load	83250	- 42833	17700
Temperature fall	- 73100	- 103480	- 17600
Rib shortening	- 32000	- 45200	- 7700
	509100	187387	110400

110400 ÷ 252000 = .436 $\Sigma cc = .368$ $d = .662$

$e/d = \frac{.368}{.662} = .555$ $\frac{d'}{d} = \frac{4.5}{66.2} = 0.068$ $p = 0.0088$

$k = .453$ $c = .132$

$f_c = \frac{18738700}{.132 \times 850 \times 66.2^2} = 38.1$ kg/cm²

Springing - moment

	thrust	moment	aver. stress
Dead Load	544700	+ 3909	118000
Live Load	73900	- 86260	14000
Temperature fall	- 71300	- 158520	- 17600
Rib shortening	- 30300	- 67500	- 7500
	517000	- 307371	106900

106900 ÷ 252000 = .425 $\Sigma ee = .594$ $d = .800$

$e/d = \frac{.594}{.800} = .743$ $\frac{d'}{d} = \frac{4.5}{80.} = 0.056$ $p = 0.0073$

$k = .392$ $c = .1275$

$f_c = \frac{30737100}{.1275 \times 850 \times 80^2} = 44.3$ kg/cm²

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Deflection of arch ring due to moment

Span no. 4

Crown deflection due to dead load

$\int x\frac{ds}{I} = 6,893.35$ $\int xy\frac{ds}{I} = 6,984.10$

point	Mo.	Ho	$2M_o\int x\frac{ds}{I}$	$2H_o\int xy\frac{ds}{I}$	$-\int mx\frac{ds}{I}$	sum.	Load	Product
0	+1.1155	2.411	+15,379	33,677	-50,656	-1,600	9,440	-15,100,000
1	+.6460	2.365	+ 8,906	33,035	-43,293	-1,352	16,860	-22,800,000
2	+.2980	2.254	+ 4,108	31,484	-36,565	- 973	17,970	-17,470,000
3	+.0447	2.078	+ 616	29,026	-30,148	- 506	19,550	- 9,900,000
4	-.1232	1.847	- 1,699	25,799	-24,180	- 80	24,100	- 1,928,000
5	-.2180	1.580	- 3,006	22,070	-18,793	+ 271	9,490	+ 2,572,000
6	-.2525	1.292	- 3,481	18,047	-14,072	+ 494	28,700	+14,180,000
7	-.2470	1.009	- 3,405	14,094	-10,061	+ 628	9,800	+ 6,160,000
8	-.2084	.734	- 2,873	10,253	- 6,780	+ 600	32,200	+19,300,000
9	-.1573	.495	- 2,169	6,914	- 4,243	+ 502	11,200	+ 5,625,000
10	-.1036	.301	- 1,428	4,204	- 2,413	+ 363	34,000	+12,330,000
11	-.0552	.153	- 761	2,137	- 1,157	+ 219	13,050	+ 2,860,000
12	-.0224	.058	- 309	810	- 414	+ 87	39,020	+ 3,400,000
13	-.0032	.008	- 44	112	- 54	+ 14	12,000	+ 168,000
								+66,595,000
								-67,198,000
								-603,000

$$\text{Deflection} = -\frac{603,000 \times 100}{1,400,000,000 \times .85} = -.0051^{cm}$$ fall neglected

Span no. 3

Crown deflection due to dead load

$\int x\frac{ds}{I} = 6,187.16$ $\int xy\frac{ds}{I} = 6,041.98$

point	Mo	Ho	$2M_o\int x\frac{ds}{I}$	$2H_o\int xy\frac{ds}{I}$	$-\int mx\frac{ds}{I}$	Sum	Load	Product
0	+1.0800	2.427	+13,364	29,328	-44,018	-1,326	4,390	- 5,821,000
1	+ .7186	2.411	+ 8,892	29,134	-39,285	-1,259	16,860	-21,227,000
2	+ .3504	2.312	+ 4,336	27,938	-33,396	-1,122	17,680	-19,800,000
3	+ .0835	2.142	+ 1,033	25,884	-27,415	- 498	18,860	- 9,400,000
4	- .0992	1.914	- 1,228	23,129	-22,028	- 127	23,600	- 3,000,000
5	- .2021	1.644	- 2,501	19,866	-17,156	+ 209	9,440	+ 1,974,000
6	- .2430	1.351	- 3,007	16,325	-12,885	+ 433	28,410	+12,320,000
7	- .2388	1.055	- 2,955	12,749	- 9,255	+ 539	9,900	+ 5,330,000
8	- .2055	.775	- 2,543	9,365	- 6,281	+ 541	32,040	+17,330,000
9	- .1564	.526	- 1,935	6,356	- 3,960	+ 461	11,200	+ 5,160,000
10	- .1038	.322	- 1,284	3,891	- 2,275	+ 332	33,980	+11,280,000
11	- .0570	.166	- ,705	2,006	- 1,105	+ 196	13,250	+ 2,598,000
12	- .0226	.062	- 280	749	- 386	+ 83	39,140	+ 3,250,000
13	- .0035	.009	- 43	109	- 52	+ 14	12,000	+ 168,000
								-59,248,000
								+59,410,000
								+ 162,000

$$\text{Deflection} = \frac{+162,000 \times 100}{1,400,000,000 \times .85} = +.0013^{cm}$$ Rise neglected

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

Deflection of arch ring due to moment

Span no. 2

·Crown deflection due to dead load

$\int x\frac{ds}{I}$ = 5,395.17 $\int xy\frac{ds}{I}$ = 5,018.01

point	M_0	H_0	$2M_0\int x\frac{ds}{I}$	$2H_0\int xy\frac{ds}{I}$	$-\int Mx\frac{ds}{I}$	Sum	Load	Product
0	+1.0059	2.425	+10,854	24,337	-36,330	-1,139	6,940	-7,910,000
1	+.5919	2.390	+6,387	23,986	-31,394	-1,021	16,860	-17,220,000
2	+.2503	2.265	+2,701	22,732	-26,140	-707	17,820	-12,600,000
3	+.0111	2.064	+120	20,714	-21,169	-335	22,850	-7,670,000
4	-.1380	1.804	-1,489	18,105	-16,606	+10	9,140	+91,400
5	-.2127	1.505	-2,295	15,104	-12,542	+267	27,550	+7,350,000
6	-.2308	1.191	-2,490	11,953	-9,045	+418	9,800	+4,100,000
7	-.2095	.884	-2,261	8,872	-6,152	+459	30,800	+14,120,000
8	-.1647	.605	-1,777	6,072	-3,882	+413	10,800	+4,460,000
9	-.1118	.373	-1,206	3,743	-2,227	+310	33,230	+10,310,000
10	-.0623	.193	-672	1,937	-1,078	+187	13,100	+2,450,000
11	-.0243	.071	-262	713	-374	+77	38,400	+2,960,000
12	-.0036	.010	-39	100	-48	+13	12,000	+156,000
								-45,400,000
								+45,997,400
								+597,400

Deflection = $\frac{+597,400\times100}{1,400,000,000\times.85}$ = +.005 Rise neglected

Span no. 1

Crown deflection due to dead load

$\int x\frac{ds}{I}$ = 4,323.11 $\int xy\frac{ds}{I}$ = 3,495.28

point	M_0	H_0	$2M_0\int x\frac{ds}{I}$	$2H_0\int xy\frac{ds}{I}$	$-\int Mx\frac{ds}{I}$	Sum	Load	Product
0	+.9112	2.462	+7,878	17,211	-25,886	-797	2,760	-2,200,000
1	+.5923	2.450	+5,121	17,127	-23,011	-763	16,860	-12,870,000
2	+.2379	2.318	+2,057	16,204	-18,791	-530	17,680	-9,370,000
3	-.0034	2.091	-29	14,617	-14,818	-230	19,000	-4,370,000
4	-.1432	1.788	-1,238	12,499	-11,223	+38	24,230	+921,000
5	-.2030	1.442	-1,755	10,080	-8,098	+227	9,200	+2,088,000
6	-.2045	1.086	-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

Deflection = $\frac{-296,000\times100}{1,400,000,000\times.85}$ = -.0025 Fall neglected

Shinobu-Bashi for Fukushima-Ken

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

$A = 4{,}066{,}000 \quad B = 1{,}685{,}308$

$\frac{A}{B} = 2{,}411$

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
Temperature 15° fall = -10,700
124,500

Ratio 124,500 ÷ 252,000 = .495 -2,370 × .495 = -1,170 cm fall

Dead load moment deflection = neglected
Temperature 15° fall = -2,370
Rib shortening = -1,170
-3,540 cm fall

average stresses due to dead load = 140,500
Rib shortening = -5,720
134,780

Ratio 134,780 ÷ 252,000 = .535 -2,370 × .535 = -1,270 cm fall

Dead load moment deflection = neglected
Rib shortening = -1,270
-1,270 cm fall

Span no. 3

$A = 7{,}728{,}176 \quad B = 1{,}385{,}939$

$\frac{A}{B} = 2{,}427$

Deflection for crown for 15° fall of temperature

$\Delta y = -2 \times .000012 \times 15 \times 2675 \times 2{,}427 \times 100 = -2{,}340$ cm fall

Deflection of crown due to rib shortening

average stresses due to dead load = 138,000
Rib shortening = -5,680
Temperature 15° fall = -11,900
120,420

Ratio 120,420 ÷ 252,000 = .478 -2,340 × .478 = -1,118 cm fall

Dead load moment deflection = neglected
Temperature 15° fall = -2,340
Rib shortening = -1,118
-3,458 cm fall

average stresses due to dead load = 138,000
Rib shortening = -6,220
131,780

Ratio 131,780 ÷ 252,000 = .523 -2,340 × .523 = -1,224

Dead load moment deflection = neglected
Rib shortening = -1,224
-1,224 cm fall

Shinobu-Bashi for Fukushima-Ken

Deflection at crown due to temperature
Span no. 2

$A = 2{,}583306$ $B = 1{,}065{,}206$
$\frac{A}{B} = 2{,}425$

Deflection of Crown for 15° fall of temperature
$\Delta y = -2 \times .000012 \times 15 \times 25{,}05 \times 2{,}425 \times 100 = -2{,}180$ cm fall

Deflection of crown due to rib shortening
average stresses due to dead load = 127,000
Rib shortening = -5,730
Temperature 15° fall = -13,400
107,870

ratio 107,870 ÷ 252,000 = ,428 -2,180 × 0,428 = -,933

Dead load moment deflection = neglected
Temperature 15° fall = -2,180
Rib shortening = -,933
-3,113 cm fall

average stresses due to dead load = 127,000
Rib shortening = -6,420
120,580

Ratio 120,580 ÷ 252,000 = ,479 -2,180 × ,479 = -1,044

Dead load moment deflection = neglected
Rib shortening = -1,044
-1,044 cm fall

Span no. 1
$A = 1{,}616{,}479$ $B = 656{,}210$
$\frac{A}{B} = 2{,}462$

Deflection of crown for 15° fall of temperature
$\Delta y = -2 \times .000012 \times 15 \times 22{,}55 \times 2{,}462 \times 100 = -2{,}000$ cm fall

Deflection of crown due to rib shortening
Average stresses due to dead load = 118,000
Rib shortening = -6,560
Temperature 15° fall = -17,600
93,840

Ratio 93,840 ÷ 252,000 = ,373 -2,000 × ,373 = -,746

Dead load moment deflection = neglected
Temperature 15° fall = -2,000
Rib shortening = -,746
-2,746 cm fall

average stresses due to dead load = 118,000
Rib shortening = -7,700
110,300

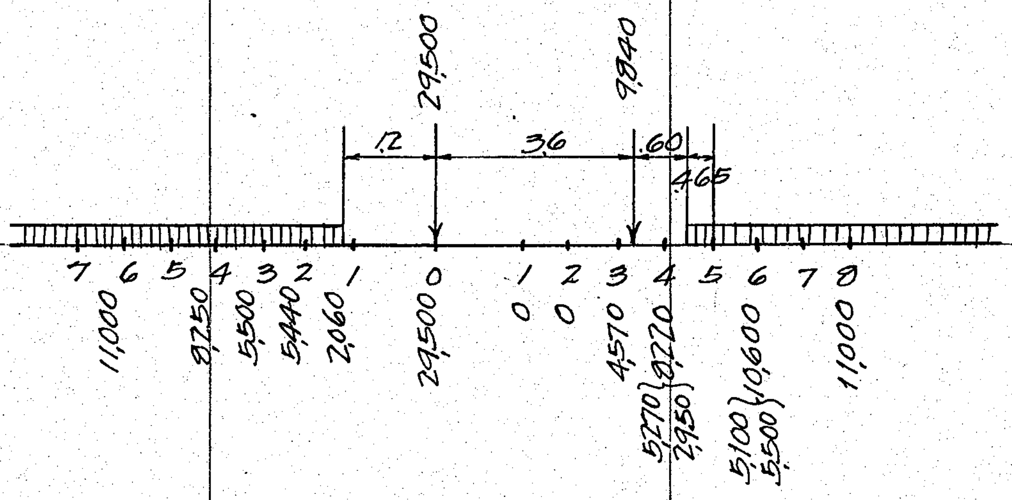
Ratio 110,300 ÷ 252,000 = ,438 -2,000 × ,438 = -,876

Dead load moment deflection = neglected
Rib shortening = -,876
-,876 cm fall

Shinobu-Bashi for Fukushima-Ken

Deflection at crown due to live load
Span no. 4
Live load thrust

point	load	Ho	thrust	
12	11,000	.058	638	
10	"	.301	3,310	
8	"	.734	8,080	−M
6	"	1.292	14,210	
4	8,250	1.847	15,230	
3	5,500	2.078	11,420	
2	5,440	2.254	12,260	
1	2,060	2.365	4,873	
0	29,500	2.411	71,130	+M
1	0	2.365	0	
2	0	2.254	0	
3	4,570	2.078	9,500	
4	8,220	1.847	15,180	
6	10,600	1.292	13,700	
8	11,000	.734	8,080	−M
10	"	.301	3,310	
12	"	.058	638	



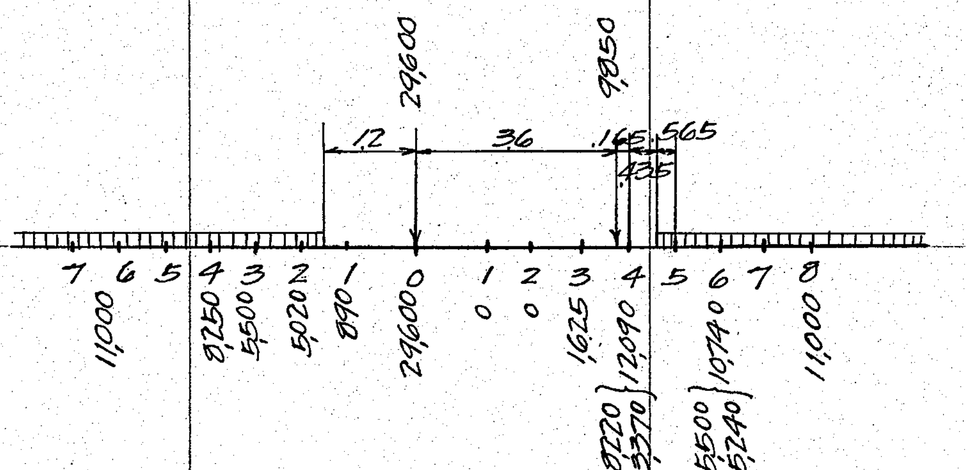
+M = 109,183 ÷ 3.77 = 29,000 @ .89 = 25,800
−M = 82,376 ÷ 3.77 = 21,850 @ .91 = 19,880
average thrust for live load = 45,680 kg

average stresses due to live load = 45,680
Rib shortening = 1,860
43,820 kg Ratio 43,820 ÷ 252,000 = .174

Live load moment deflection = − 2.370 × .174 = − .413 cm fall

Span no. 3
Live load thrust

point	load	Ho	thrust	
12	11,000	.062	682	
10	"	.322	3,540	
8	"	.775	8,530	−M
6	"	1.351	14,860	
4	8,250	1.914	15,780	
3	5,500	2.142	11,780	
2	5,020	2.312	11,600	
1	890	2.411	2,150	
0	29,600	2.427	71,820	+M
1	0	2.411	0	
2	0	2.312	0	
3	1,625	2.142	3,480	
4	12,090	1.914	23,120	
6	10,740	1.351	14,520	
8	11,000	.775	8,530	−M
10	"	.322	3,540	
12	"	.062	682	



+M = 100,830 ÷ 3.77 = 26,750 @ .89 = 23,800
−M = 93,784 ÷ 3.77 = 24,870 @ .91 = 22,630
average thrust for live load = 46,430 kg

average stresses due to live load = 46,430
Rib shortening = −2,090
44,340 kg Ratio 44,340 ÷ 252,000 = .176

Live load moment deflection = − 2.34 × .176 = −.412 cm fall

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CALCULATIONS FOR

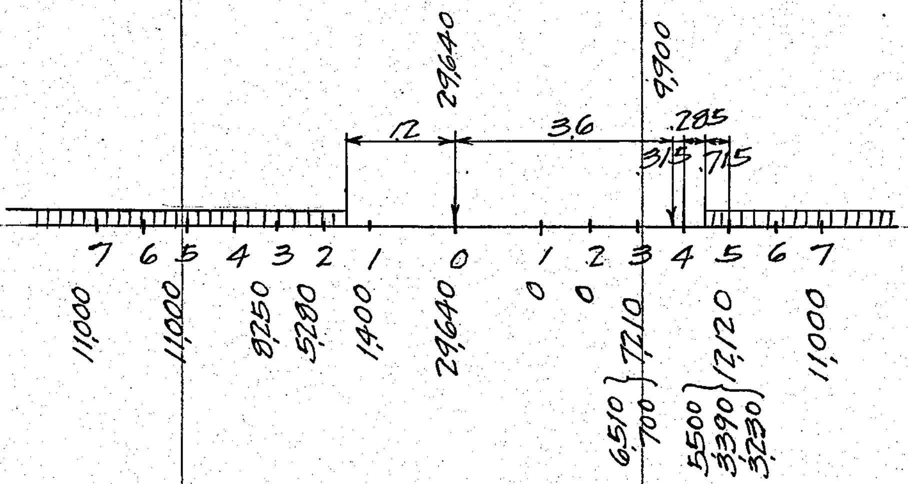
Shinobu-Bashi for Fukushima-Ken

Deflection at crown due to live load

Span no. 2

Live load thrust

point	load	Ho	thrust	
11	11,000	.071	781	
9	"	.373	4,100	-M
7	"	.884	9,280	
5	"	1.505	16,550	
3	8,250	2.064	16,770	
2	5,280	2.265	11,960	
1	1,400	2.390	3,345	
0	29,640	2.425	71,860	+M
1	0	2.390	0	
2	0	2.265	0	
3	7,210	2.064	14,970	
5	12,120	1.505	18,250	
7	11,000	.884	9,280	-M
9	"	.373	4,100	
11	"	.071	781	



+ M = 118,905 ÷ 3.77 = 31,550 @ .89 = 28,080
- M = 63,122 ÷ 3.77 = 16,780 @ .91 = 15,260
average thrust for live load = 43,340 kg

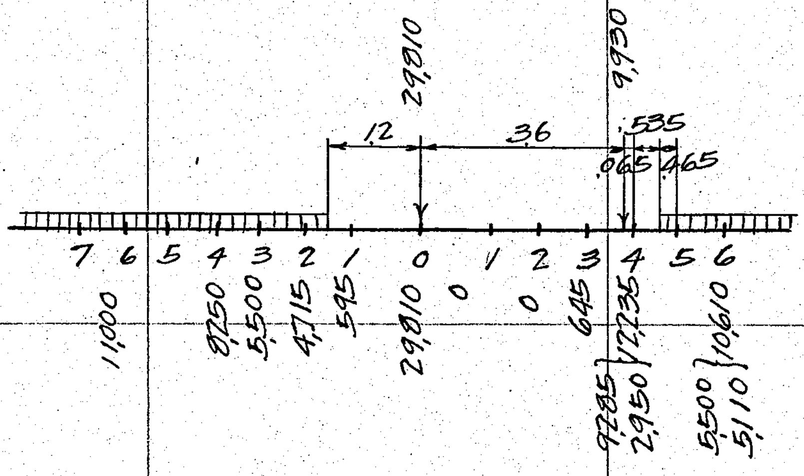
average stresses due to live load = 43,340
Rib shortening = 2,180
41,160 kg Ratio 41,160 ÷ 252,000 = .163

Live load moment deflection = -2.18 @ .163 = -.355 cm fall

Span no. 1

Live load thrust

point	load	Ho	thrust	
10	11,000	.091	1,002	
8	"	.466	5,125	
6	"	1.086	11,950	-M
4	8,250	1.788	14,750	
3	5,500	2.091	11,500	
2	4,715	2.318	10,930	
1	595	2.450	1,457	
0	29,810	2.462	73,400	+M
1	0	2.450	0	
2	0	2.318	0	
3	645	2.091	1,350	
4	12,235	1.788	21,880	
6	10,610	1.086	11,950	-M
8	11,000	.466	5,125	
10	"	.091	1,002	



+ M = 85,787 ÷ 3.77 = 22,750 @ .89 = 20,250
- M = 85,634 ÷ 3.77 = 22,720 @ .91 = 21,350
average thrust for live load = 41,600 kg

average stresses due to live load = 41,600
Rib shortening = -2,720
38,880 kg ratio 38,880 ÷ 252,000 = .154

Live load moment deflection = -2.000 · .154 = -.308 cm fall

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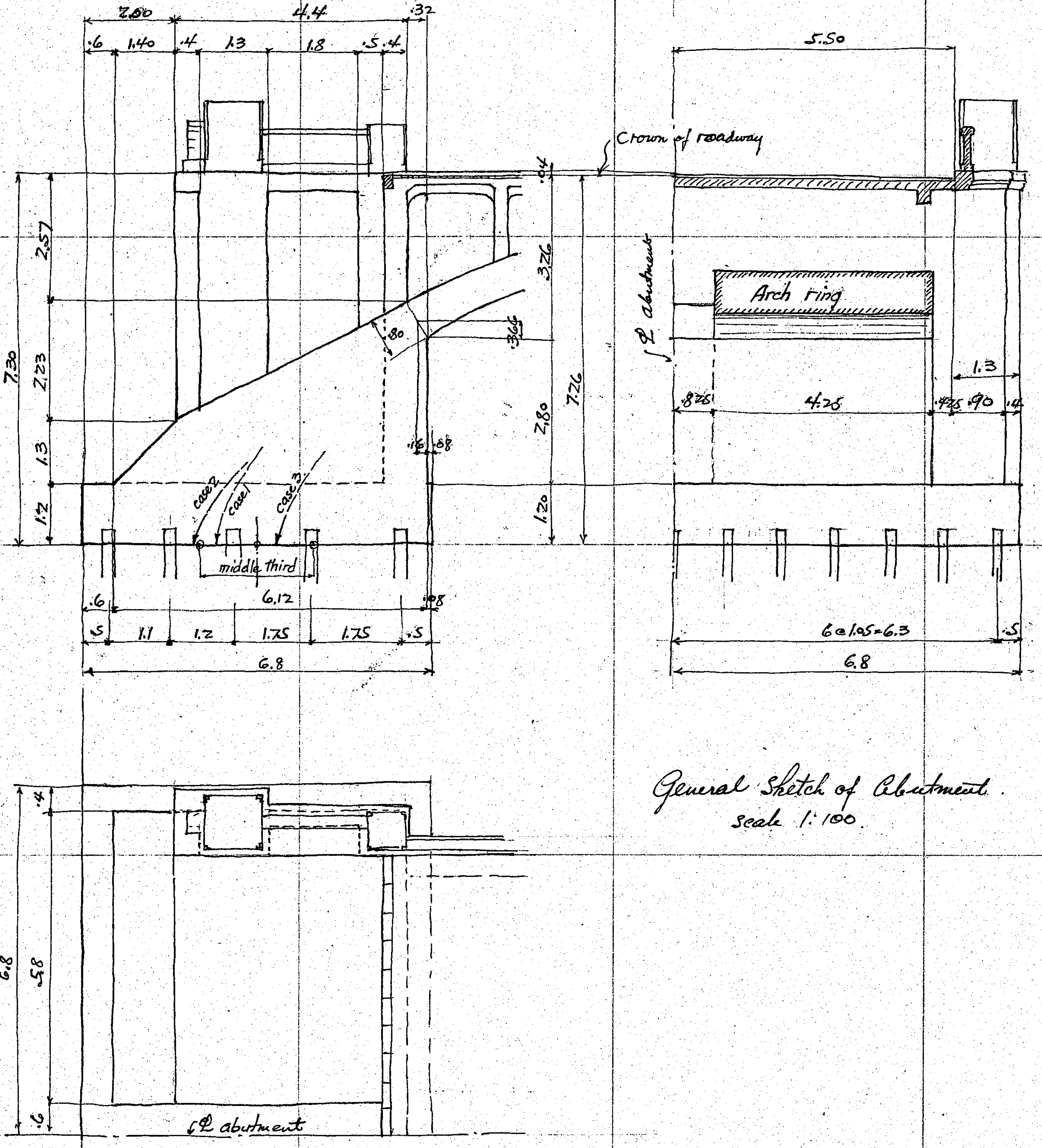
CHECKED BY M. Iinda DATE 5-2-24 PAGE NO 67

CALCULATIONS FOR

Shinobu Bashi for Fukushima ken.

Design of Abutment. General dimensions are as shown on sketch below:-

South abutment.



General Sketch of Abutment.
scale 1:100.

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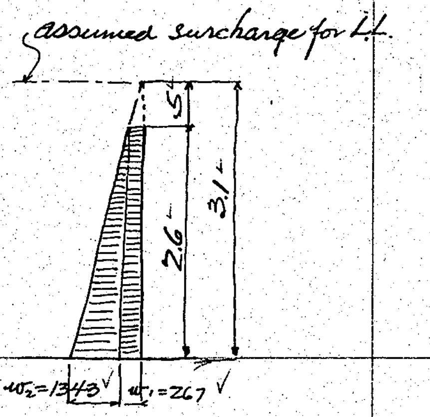
CALCULATIONS FOR

Shinobu Bashi for Fukushima ken

Design of Rear wall of abutment.



Earth pressure at top. $= \frac{1}{3} \times 1600 \times 0.5$ ✓ $= 267$ ✓ kg/m² --- w_1.

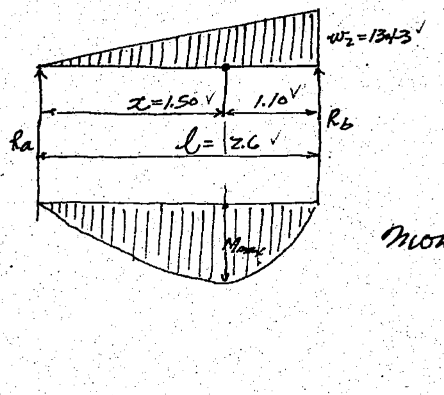
" " at bottom $= \frac{1}{3} \times 1600 \times 3.1$ ✓ $= \underline{1610}$ ✓ ..

1877 ✓

Defference 1610 − 267 ✓ = 1343 ✓ kg/m² -- w_2

Bending moment due to triangular load w_2.

$M_{max} = \frac{wl^2}{15.6}$ ✓ $= \frac{1343 \times 2.6^2}{15.6}$ ✓ $= 582$ ✓ kgm.



$x = \frac{l}{\sqrt{3}}$ ✓ $= .577l$ ✓ $= .577 \times 2.6$ ✓ $= 1.5$ m

$R_b = \frac{2wl}{3}$ ✓ $= \frac{2}{3} \times 1343 \times 2.6$ ✓ $= 2330$ ✓ kg

moment due to unif. load w_1. = 267 ✓ kg/m.

$m = \frac{1}{8} \times 267 \times 2.6^2$ ✓ $= 226$ ✓ kgm.

$R_b = \frac{1}{2} \times 267 \times 2.6$ ✓ $= 347$ ✓ kg

Total moment 582 ✓ + 226 ✓ = 808 ✓ kgm

for continuity of wall, moment can be taken at

0.8 × 808 ✓ = 646 ✓ kgm.

Total shear = 2330 ✓ + 347 ✓ = 2677 ✓ kg.

Effective depth required $= \sqrt{\frac{M}{bR}}$ where $R = 7.18$ ✓

$= \sqrt{\frac{646 \times 100}{100 \times 7.18}}$ ✓ $= 9.5$ ✓ cm

wall assumed 40cm ✓ thick

Effective depth say 40 − 3 ✓ = 37 cm.

Reinforcement required for $f_s = 1200$ ✓ kg/cm²

$= \frac{64600}{1200 \times \frac{7}{8} \times 37}$ ✓ $= 1.66$ ✓ cm² per meter strip of wall

Use 13φ bars at 28cm c to c ✓ = 4.75 ✓ cm² ok.

Reinforcements for negative moment at bottom assumed same as for positive one.

Unit shear $= \frac{2677}{100 \times \frac{7}{8} \times 37}$ ✓ $= 0.83$ ✓ kg/cm² ok.

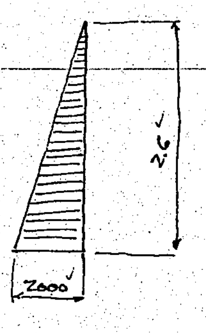
Unit bond $= \frac{2677}{\frac{4.08}{.28} \times \frac{7}{8} \times 37}$ ✓ $= \underline{\underline{5.7}}$ ✓ kg/cm² ok.

Note. Use same reinforcements on both sides of wall.

Stresses during earthquake on wall. Acceleration being assumed at 2000 mm/sec² or k = 0.2. ✓

Earth pressure during earthquake = 0.480 × 1600 × 2.6 ✓ = 2000 ✓ kg/m² at bottom.

$M_{max.} = \frac{2000 \times 2.6^2}{15.6}$ ✓ $= 866$ ✓ kgm.



for continuity of beam moment = 0.8 × 866 ✓ = 693 ✓ kgm. < 646 × 1.6 = 1035 ✓ ok

Shear at bottom $= \frac{2}{3} \times 2000 \times 2.6$ ✓ $= 3470$ ✓ kg. < 2677 × 1.6 = 4280 ✓ ok.

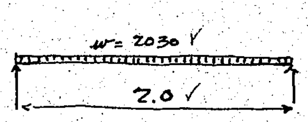
Design of wing wall.

Curtain wall. span length assumed 2.0 ✓ meters.

Earth pressure at normal state $= \frac{1}{3} \times 1600 \times (3.3 + .5)$ ✓ $= 2030$ ✓ kg/m²

" during earthquake = 0.48 × 1600 × 3.3 ✓ = 2540 ✓ .. (÷1.6 = 1590 ✓)

Earth pressure at normal state governs the section.



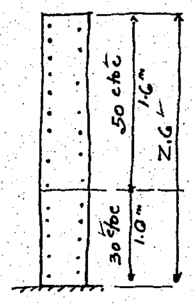
moment $= \frac{1}{10} \times 2030 \times 2.0^2$ ✓ $= 812$ ✓ kgm per meter meter strip at bottom.

Shear $= \frac{1}{2} \times 2030 \times 2.0$ ✓ $= 2030$ ✓ kg

Effective depth req'd. $= \sqrt{\frac{812}{7.18}}$ ✓ $= 10.6$ ✓ cm

Use $\overset{35}{\cancel{30}}$ cm ✓ wall effective depth 32cm ✓ insulation 3cm ✓.

Shinobu Bashi for Fukushima ken.



Reinforcements required = $\frac{812 \times 100}{1200 \times \frac{7}{8} \times 37} = 2.42$ cm² per meter strip.

Use 13ϕ bars at 30 cm c/c = 4.42 cm²

unit shear = $\frac{2030}{100 \times \frac{7}{8} \times 32} = .73$ kg/cm² ok

unit bond = $\frac{2030}{\frac{4.08}{.3} \times \frac{7}{8} \times 32} = 5.33$ " ok.

At section 1m above bottom of wall.

Reinforcements say = $\frac{30 \times 2.6}{1.6} = 48.8$ cm c/c use 50 cm spacing

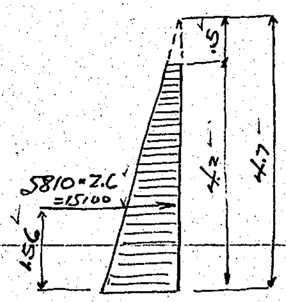
Use same reinforcements for both sides of wall.

Column under pedestal. Section assumed 1.3 × 1.3m height 4.20m

Earthpressure at top = $\frac{1}{3} \times 1600 \times 0.5 = 267$ kg/m²

" " bottom = $\frac{1}{3} \times 1600 \times 4.7 = 2503$

$2770 \div 2 = 1385$ kg/m² average.



Total earthpressure = 1385 × 4.2 = 5810 kg. width = 2.6m assumed.

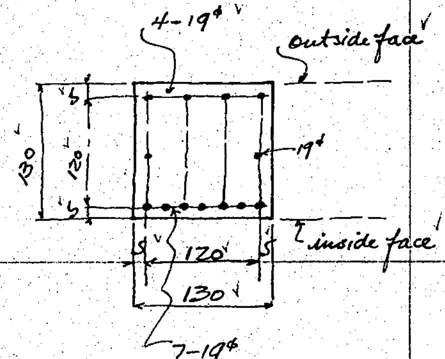
moment on column = 5810 × 1.56 × 2.6 = 23600 kgm at bottom.

use 7-19mmϕ bars = 19.84 cm²

~~Steel area reqd~~ = $\frac{23600 \times 100}{1200 \times \frac{7}{8} \times 125} = 18.0$ cm² ok.

unit shear = $\frac{5810 \times 2.6}{130 \times \frac{7}{8} \times 125} = 1.06$ kg/cm² ok

unit bond = $\frac{5810 \times 2.6}{5.97 \times 7 \times \frac{7}{8} \times 125} = 3.31$ kg/cm² ok.



Earth pressure during earthquake = $0.480 \times 1600 \times 4.2 \times \frac{4.2}{2} = 6780$ kg per meter strip.

Total earth pressure = 6780 × 2.6 = 17630 kg < 15100 × 1.6 ok

moment at bottom = $17630 \times \frac{4.2}{3} = 24700$ kgm < 23600 × 1.6 ok.

Assumed section of column is ample for earthquake stresses.

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY K. Inaba DATE 5-1-25 FILE NO
CHECKED BY M. Jinda DATE 5-2-24 PAGE NO 70

CALCULATIONS FOR

Shinobu Bashi for Fukushima Ken.

Center of gravity of superstructure. Span no 1.

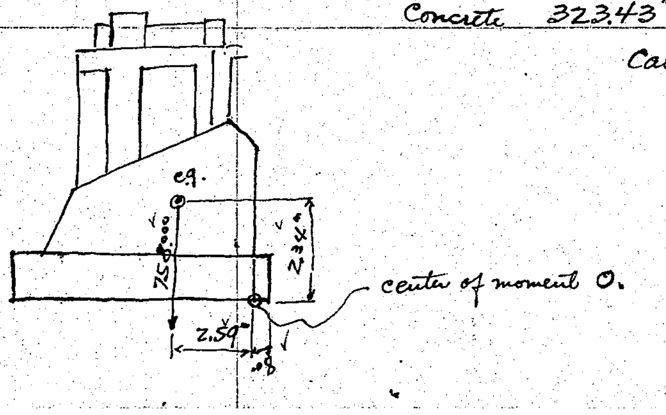
					Moment at crown of Roadway.
Handrails	11.52 × 2	@ 353 =	8,120 kg	× −0.50 =	−4,060
Copings	11.52 × 2	@ 256 =	5,900	× 0.15 =	885
Pavement	11.52 ×	@ 1614 =	18,580	× 0.08 =	1,485
Concrete slab	11.52	@ 4350 =	50,100	× 0.20 =	10,020
Cross beam	2	@ 3890 =	7780	× 0.47 =	3,655
"	1	@ 4240 =	4,240	× 0.41 =	1,740
"	1	@ 620 =	620	× 0.60 =	370
Spandrel walls	1.66	@ 3460 =	5740	× 0.75 =	4,305
fascia girder	8	@ 227 =	1820	× 0.45 =	820
Solid wall	0.41	@ 5980 =	2460	× 0.83 =	2040
walls outside + inside			1300	× 0.41 =	530
Sand fill			7580	× 0.41 =	3110
Arch ring 0			1350	× 0.59 =	800
" 1			8150	× 0.58 =	4730
" 2			8350	× 0.62 =	5170
" 3			8570	× 0.68 =	5830
" 4			8770	× 0.78 =	6840
" 5			9200	× 0.92 =	8460
" 6			9780	× 1.10 =	10,750
" 7			10,400	× 1.31 =	13,600
" 8			11,400	× 1.57 =	17,900
" 9			12,750	× 1.89 =	24,100
" 10			14,500	× 2.23 =	32,300
" 11			12,000	× 2.64 =	31,700
" 12			6650	× 2.89 =	19,200
			236,100 kg	× 0.874 m =	206,280

moment about O. in sketch below

Weight and center of gravity of abutment.

					Hor. arm	Hor. moment	vert. arm	vert. moment
granite Light pedestal.	1.1 × 1.1 × 1.4 × 2 =	3.39	@ 2600 =	8810 kg	3.67 m	32,330	8.00	70,500
" pedestal	.7 × .7 × .9 × 2 =	.88	" =	2290	.67	1,540	7.75	17,750
" handrail	.15 □m × 2.0 × 2 =	.60	" =	1,560	2.12	3,310	7.70	12,000
Light pole.	.4 × .4 × 2.3 × 2 =	.74	" =	1930	3.67	7,080	9.90	19,100
projection	.7 × .5 × 1.0 × 2 =	.70	" =	1820	4.50	8190	7.80	14,200
	granite	6.31						
Rear wall	.4 × 2.6 × 11.0 =	11.45	@ 2400 =	27,500	.52	14,300	6.00	165,000
column	.9 × .9 × 2.8 × 2 =	4.54	" =	10,900	.77	8,390	5.95	64,900
"	1.3 × 1.3 × 4.2 × 2 =	14.20	" =	34,100	3.67	125,100	5.10	174,000
wall	.35 × 1.8 × 3.0 × 2 =	3.78	" =	9,070	2.12	19,220	5.40	49,000
"	.48 × .37 × 1.8 × 2 =	~~6.40~~ .64	" =	1,540	2.12	3260	7.15	~~15,150~~ 11,000
"	.35 × 4.3 × .4 × 2 =	1.20	" =	2880	4.52	13,020	4.90	14,120
"	.48 × .37 × .4 × 2 =	.14	" =	340	4.52	1,540	7.15	2430
Body	1.8 × .37 × 11.6 =	7.72	@ 2200 =	17,000	.50	8,500	4.25	72,200
"	3.26 × 2.23 × 11.6 =	84.20	" =	185,300	1.80	333,000	3.13	580,000
"	5.42 × 1.30 × 11.6 =	81.80	" =	180,000	2.70	486,000	1.83	329,200
wall	.72 × 3.2 × 1.2 =	2.76	@ 2400 =	6610	.36	2,380	2.90	19,160
Base	6.8 × 1.2 × 13.6 =	111.00	" =	266,200	3.36	895,000	0.60	159,700
	Concrete	323.43 m³		757,850		1,962,160		1,774,260

Call this 758,000 kg × 2.59 m × 2.34 m



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CALCULATIONS FOR

Shinobu Bashi for Fukushima ken.

Stability of abutment.

Superimposed Loads on abutment.

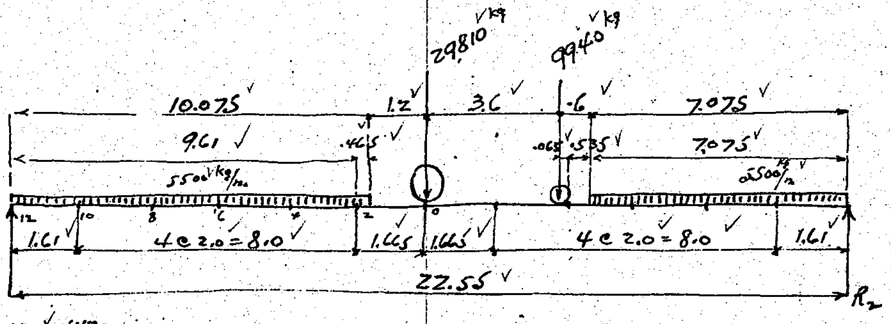
Dead Load.

vertical load on springing = 236100 kg
horizontal thrust = 492900 in round no.

Live Load.

Motor truck rear wheel concentration with impact for 4 rows. 29810 kg
" front " " 9940 "
Uniform live load. 11.0 m @ 500 = 5500 kg per lin m.

Max. Horizontal thrust.



4430 4430
5500 11000 11000 11000 5500
2200 3601 320 9620
29810 2950 5100
5500 11000 5500
4430 4430

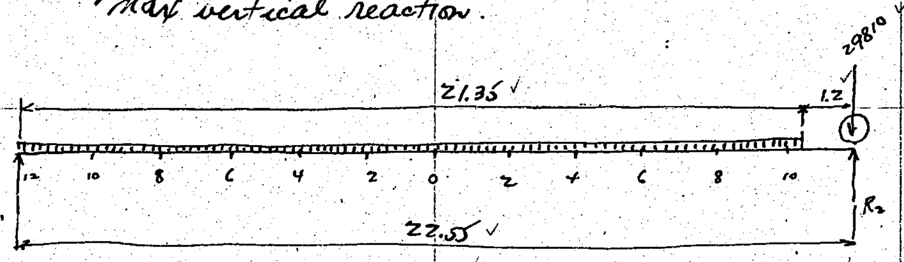
4430 9930 11000 11000 11000 7700 30170 320 12570 10600 11000 9930 4430

	vert. reaction Rz.	H unit	Hor. thrust H.
12	4430 × 0 = 0	0.000	0
10	9930 × 1.61 = 16000	0.091	904
8	11000 × 3.61 = 39700	0.466	5120
6	11000 × 5.61 = 61700	1.086	11950
4	11000 × 7.61 = 83700	1.788	19,650
2	7700 × 9.61 = 74000	2.318	17850
0	30,170 × 11.275 = 340000	2.462	74200
2	320 × 12.94 = 4100	2.318	742
4	12,570 × 14.94 = 187,800	1.788	22,480
6	10,600 × 16.94 = 179500	1.086	11,510
8	11,000 × 18.94 = 208400	0.466	5120
10	9930 × 20.94 = 208000	0.091	904
12	4430 × 22.55 = 99900	0.000	0
	134080 1502800		$H_{max.}$ = 170,430 kg.

$R_2 = \frac{1502800}{22.55} = 66700$ kg

$R_1 = 134080 - 66700$
$= 67380$ kg

max vertical reaction.



4430 9930 11000 11000 11000 10080 9170 10080 11000 11000 11000 7470 290
29810
30100

	vert. reaction R_2	H unit	Hor. thrust H.
12	4430 × 0 = 0	0.000	0
10	9930 × 1.61 = 16000	0.091	904
8	11,000 × 3.61 = 39700	0.466	5120
6	11,000 × 5.61 = 61700	1.086	11950
4	11,000 × 7.61 = 83700	1.788	19650
2	10080 × 9.61 = 97000	2.318	23380
0	9170 × 11.275 = 103300	2.462	22560
2	10080 × 12.94 = 130500	2.318	23380
4	11000 × 14.94 = 164400	1.788	19650
6	11,000 × 16.94 = 186300	1.086	~~19650~~ 11650
8	11,000 × 18.94 = 208400	0.466	5120
10	7470 × 20.94 = 156200	0.091	676
12	30,100 × 22.55 = 679000	0.000	0
	147260 1926200		H = 144,340 kg.

$R_2 = \frac{1926200}{22.55} = 85500$ kg

$R_1 = 147260 - 85500 = 61760$

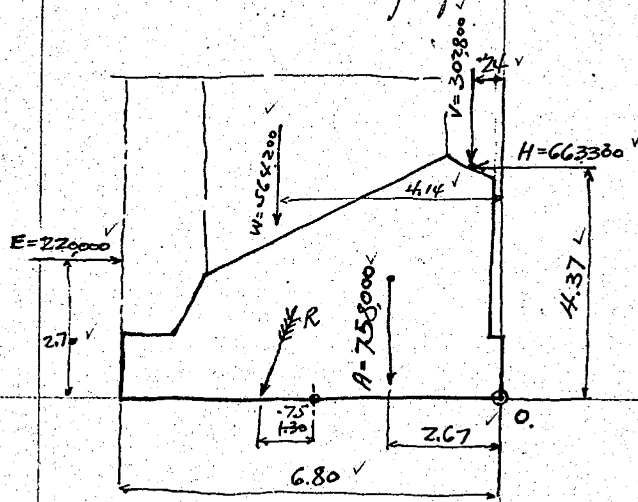
Summary of Superimposed Dead + Live Load -

	H	V.
Dead Load	492900	236,100
Live Load	170430	66,700
	663,330 kg	302,800 kg

Dead Load	492900	236,100
Live Load	144340	85500
	637,240 kg	321,600 kg.

Shinobu Bashi for Fukushima Ken.

Case 1. Stability of abutment at normal state.



weight of Earth fill on rear. Surcharge assumed 0.5m for Live Load

4.3 × 3.5 × 11.5 @ 1600 = 277000 × 2.65 = 734000 × 5.8 × 1606000
1.4 × 6.0 × 13.6 @ 1600 = 182700 × 5.45 = 995000 × 4.8 × 877000
0.6 × 6.6 × 13.6 @ 1600 = 86200 × 6.50 = 560000 × 4.5 × 488000
3.4 × 5.6 × 1.2 ÷ 2 @ 1600 = 18300 × 2.60 = 47500 × 2.4 × 43900
564200kg × 4.14m = 2336500 5.34m = 3014900

Earth pressure at normal state.

$\frac{1}{3} \times 1600 \times 0.5 = 267$
$\frac{1}{3} \times 1600 \times 7.8 = 4160$
$4427 \div 2 = 2214$ kg/m² average.

Earth pressure on abutment = 2214 × 7.3 × 13.6 = 220000 kg

Taking moment about toe O.

	Hor. forces	Vert. forces	Lev. arm	moment
V		302800	× 0.24 =	72600
H	663330		× 4.37 =	2900000
A		758000	× 2.67 =	2024000
W		564200	× 4.14 =	2336000
E	−220000		× 2.70 =	−594000
	443330	1625000	× 4.15m =	6738600

max. Bearing pressure

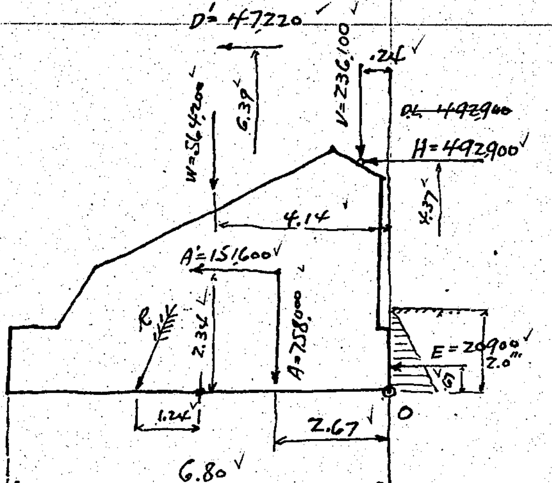
$= \frac{1625000}{6.8 \times 13.6} \times (1 \pm \frac{6 \times .75}{6.8}) = 29220$ kg/m² (2.67 tons/□)
or 5940

max. load on one pile = 29.22 × 1.05 × 1.05 = 32.2 kg tons.
If 11 tons/□m be allowed on bed 11 × 1.05 × 1.05 = −12.1
20.1 kg tons net

Resultant force applicate at 4.150m from O.
4.150 − 3.4 = ~~1.30~~ 0.75 eccentricity
Resultant force ~~outside~~ within of middle third

Case 2. Stability during Earthquake k=0.2 Seismic force backward.

Earth pressure $= 0.48 \times 1600 \times \frac{2^2}{2} = 1535 \times 13.6 = 20900$ kg



	Hor. forces	Vert. forces	lev. arms	moments
V		236100	× ~~4.37~~ 0.24 =	56600
H	492900		× 4.37 =	2154000
A		758000	× 2.67 =	2023000
A'	151600		× 2.34 =	354500
W		564200	× 4.14 =	2335000
E	20900		× 0.67 =	14000
D'	47220		× 6.39 =	302000
	712620	1558300	× 4.64 ×	7239100

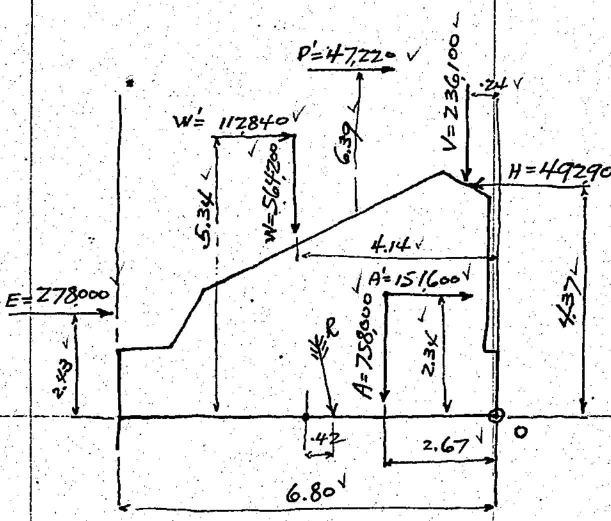
Eccentricity = 4.64 − 3.4 = 1.24m 6.8 − 4.64 = 2.16
Resultant force outside of middle third.
Pressure area = 2.16 × 3 × 13.6 = 88.1 □m
max. bearing pressure $= \frac{1558300 \times 2}{88.1} = 35400$ kg/m² or 3.24 tons/□

max. load on one pile = 35.4 × 1.05 × 1.05 = 39.0 kg.tons
12.1
26.9 net

Case 3. Stability during Earthquake Seismic force forward.

Earth pressure during earthquake
$= 0.48 \times 1600 \times \frac{7.30^2}{2} = 20450 \times 13.6 = 278000$ kg $= E$

Shinobu Bashi for Fukushima Ken



Taking moment about O.

		Hor. forces	Vert. forces		lever arm		moment
V	+		236,100 ✓	×	.24 ✓ =	+	56600 ✓
H	+	492900 ✓		×	4.37 ✓ =	+	2154000 ✓
A	+		758000 ✓	×	2.67 ✓ =	+	2023000 ✓
A'	-	151600 ✓		×	2.34 ✓ =	-	354500 ✓
D'	-	47220 ✓		×	6.39 ✓ =	-	302000 ✓
W	+		564200 ✓	×	4.14 ✓ =	+	2335000 ✓
W'	-	112840 ✓		×	5.34 ✓ =	-	603000 ✓
E	-	278000 ✓		×	2.43 ✓ =	-	675000 ✓
		-96,760	1558300 ✓	×	2.98 m ✓ =	+	4634100 ✓

Eccentricity = 3.40 - 2.98 ✓ = 0.42 m ✓

Resultant force within middle third

$$\text{max. Bearing pressure} = \frac{1558300}{6.8 \times 13.6}\left(1 \pm \frac{6 \times .42}{6.8}\right) = 23100\ \text{kg/m}^2 \sim (2.11\ \text{tons/□'})$$
$$\sim 10620$$
.37

max. load on one pile = 23,100 × 1.05 × 1.375 = $\underline{\underline{33.3}}$ ~~kg~~ tons

Curtain wall. span length = 1.2 m ✓

Earth pressure at bottom

$= \frac{1}{3} \times 1600 \times 6.6 = 3510\ \text{kg/m}^2$ ✓

moment $= \frac{3510 \times 1.2^2}{12} = 421$ ✓ kgm per meter strip.

Steel required $= \frac{42100}{1200 \times \frac{7}{8} \times 75} = .54\ \text{cm}^2$ ✓ per meter strip.

use 19 mmφ bars at 50 ~ 60 c to c.

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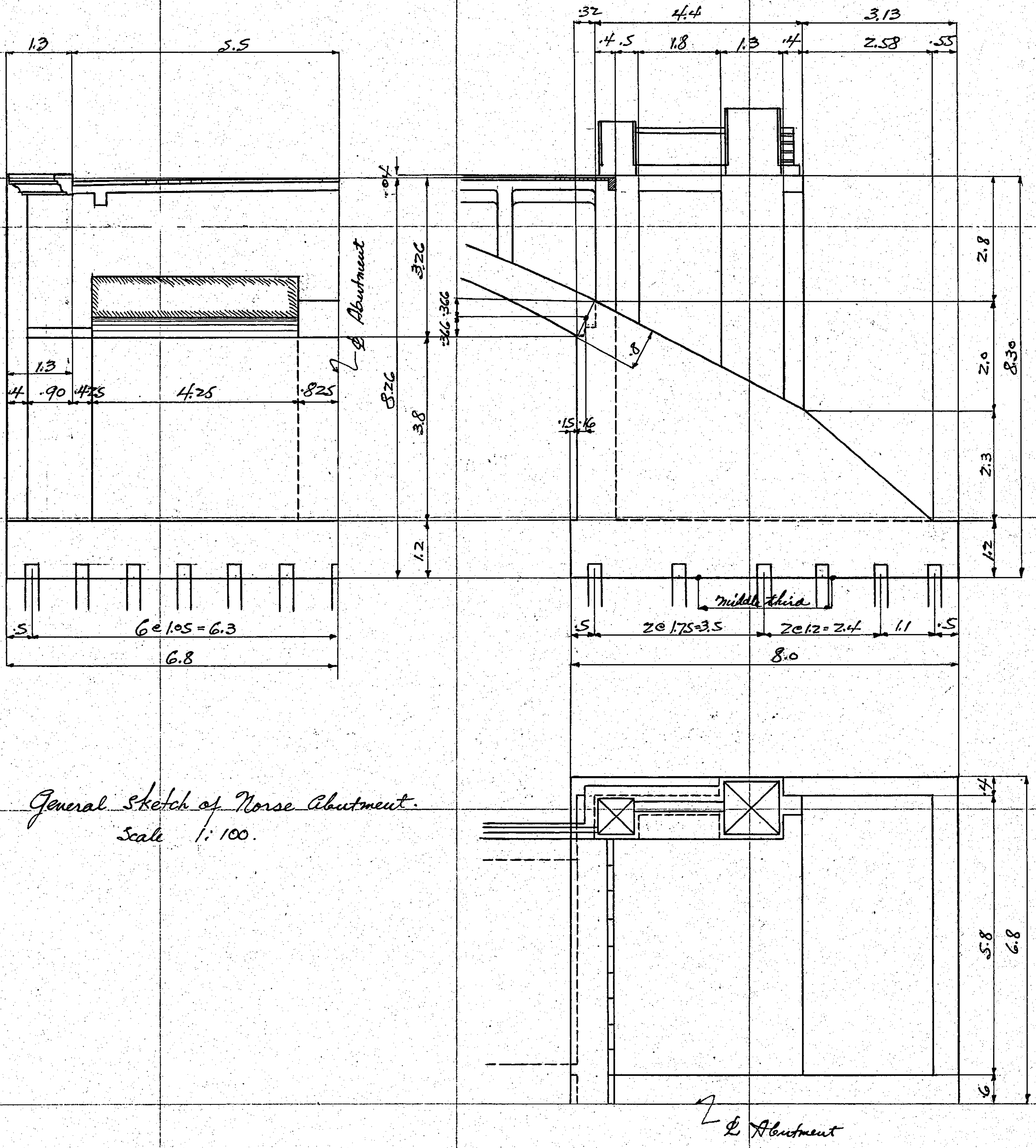
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.

Design of Norse abutment. (A2)

General dimensions are as shown on sketch below:-



General sketch of Norse abutment.
Scale 1:100.

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.

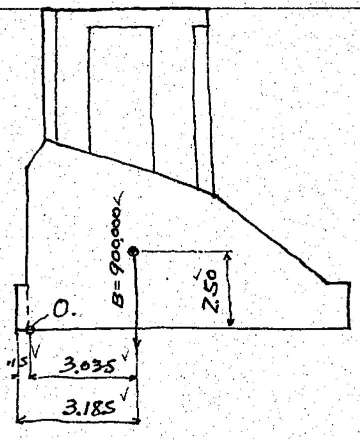
The structure of Abutment including Rear wall, ~~wall~~ wing wall, and Column.
Use same details as for South abutment.

Center of gravity of Super structure in span no 1.
weight 236,100 kg = D. Seismic force 236100 · .2 = 47,220 kg = D'
Arm 0.874 m below crown of roadway.

Moment about O. in sketch below.

Weight and center of gravity of abutment.

		kg	Hor. arm	Hor. moment	Vert. arm	Vert. moment
granite light pedestals	1.1·1.1·1.4·2 = 3.39 c 2600 =	8810	3.67	32,330	9.00	79,300
〃 pedestals	.7·.7·.9·2 = .88 c 〃 =	2290	.67	1,540	8.75	20,050
〃 handrail	.15 cm·2.0·2 = .60 c 〃 =	1,560	2.12	3,310	8.70	13,580
Light poles	.4·.4·2.3·2 = .74 c 〃 =	1,930	3.67	7,080	10.90	21,040
Projection	.7·.5·1.0·2 = .70 c 〃 =	1820	4.50	8,190	8.80	16020
	Granite = 6.31 m³					
Rear wall	.4·2.6·11.0 = 11.45 c 2400 =	27,500	.52	14,300	7.00	192,500
Column	.9·.9·2.8·2 = 4.54 c 〃 =	10,900	.77	8,390	6.95	75,700
〃	1.3·1.3·4.2·2 = 14.20 c 〃 =	34,100	3.67	125,100	6.10	208,000
wall	.35·1.8·3.0·2 = 3.78 c 〃 =	9,070	2.12	19,220	6.40	58,000
〃	.48·.37·1.8·2 = .64 c 〃 =	1,540	2.12	3,260	8.15	12,650
〃	.35·4.3·.4·2 = 1.20 c 〃 =	2,880	4.52	13,020	5.90	17,000
〃	.48·.37·.4·2 = .14 c 〃 =	340	4.52	1,540	8.15	2,770
Body	1.80·.37·11.6 = 7.72 c 2200 =	17000	.50	8500	5.25	89,200
〃	3.26·1.27·11.6 = 48.00 c 〃 =	105,500	1.75	184,600	4.15	438,000
〃	6.01·2.3·11.6 = 160.20 c 〃 =	352,500	3.10	1,093,000	2.75	793,000
wall.	.72·4.5·1.2 = 3.89 c 2400 =	9,330	.36	3,360	2.30	21,450
Base	8.0·1.2·13.6 = 130.50 c 〃 =	313,200	3.85	1,206,000	0.60	188,000
	Concrete = 386.26 m³	900,270				
	call this	900,000 kg	3.035 m	2,732,740	2.50 m	2,246,260



Seismic force 900,000 · .2 = 180,000 kg = B'

Superimposed Dead and Live Load on Abutment. Same as for South abutment.

	H	V.
Dead Load	492,900	236,100
Live Load	170,430	66,700
	663,330 kg	302,800 kg
Dead Load	492,900	236,100
Live Load	144,340	85,500
	637,240 kg	321,600 kg

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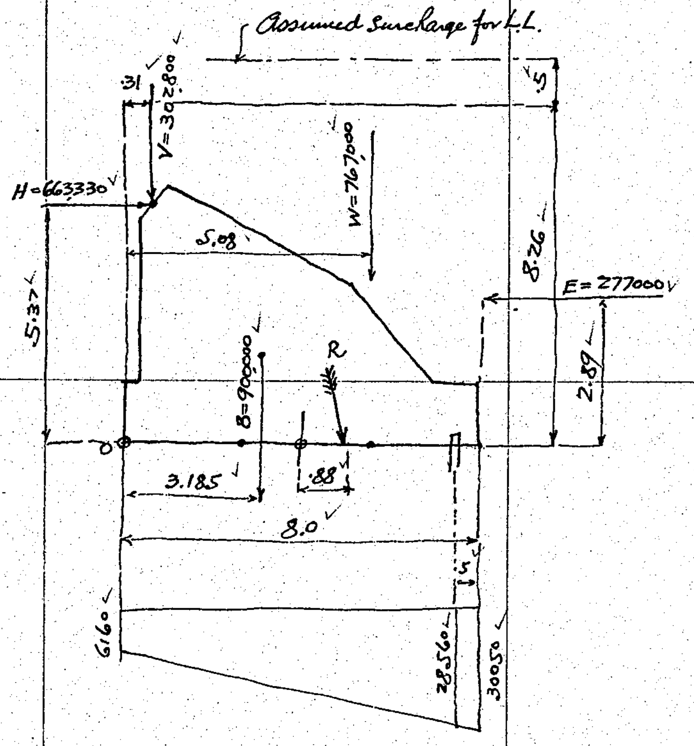
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.

Case 1. Stability of abutment at normal state



weight of earth fill on rear. Surcharge assumed 0.5m for Live Load -

$\overset{4.3}{4.0 \times 3.8} \times 11.50 \times 1600 =$ 316,500 × 3.02 956,000 6.75 2,137,000

$\overset{6.41}{5.91} \times 2.58 \times 13.6 \times$ " = 360,000 × 6.22 2,240,000 5.50 1,981,000

$7.56 \times 0.55 \times 13.6 \times$ " = 90,500 × 7.725 699,000 4.98 451,000

W = 767,000 kg 5.08m 3,895,000 5.96m 4,569,000

Earth pressure at normal state.

$\frac{1}{3} \times 1600 \times 0.5 =$ 267

$\frac{1}{3} \times 1600 \times 8.76 =$ 4665

4932 ÷ 2 = 2466 kg/m² average.

Earth pressure on abutment = 2466 × 8.26 × 13.6 = 277,000 kg = E

Taking moment about O.

Loads	Hor. forces	Vert. forces		Lev. arms	Moments.
V		302800	×	.31 =	(+) 94000
H	663,330		×	5.37 =	(+) 3,560,000
B		900,000	×	3.185 =	(+) 2,865,000
W		767,000	×	5.08 =	(+) 3,895,000
E	−277,000		×	2.89 =	(−) 800,000
	386,330	1,969,800	.	4.88m =	9,614,000

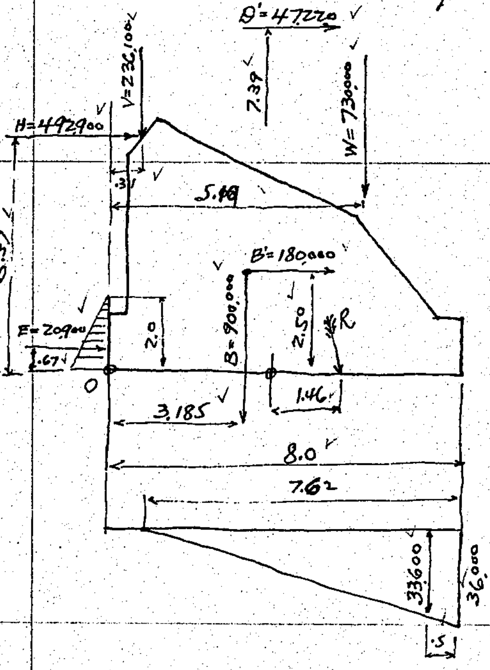
Eccentricity = 4.88 − 4.0 = 0.88m right

Resultant force within middle third

max. bearing pressure = $\frac{1969800}{8.0 \times 13.6}\left(1 \pm \frac{6 \times \overset{.66}{.88}}{8}\right) = 30050$ kg/m² or (2.75 tons/ft²)
or 6160

max. load on one pile = 28.16 × 1.05 × 1.05 = 31.0 kg tons.
If 11 kg tons/m² be allowed on bed less 11 × 1.05² = 12.1
18.9 net

Case 2. Stability during Earthquake. k = 0.20 assumed. (Seismic forces backward)



weight of earth fill on rear with no surcharge for Live Load -

767,000 × 5.08 3,895,000 5.96 4,569,000

Less surcharge 4.0 × 11.5 × .5 × 1600 = − 37,000 × 2.87 − 106,000 8.01 − 296,000

730,000 5.19 3,789,000 5.85 4,273,000

Taking moment about O.

Loads	Hor. forces	Vert. forces		Lev. arms	Moments.
V		236,100	×	.31 =	73,200
H	492,900		×	5.37 =	2,645,000
D'	47,220		×	7.39 =	348,700
W		730,000	×	5.19 =	3,790,000
B		900,000	×	3.185 =	2,865,000
B'	180,000		×	2.50 =	450,000
E	20,900		×	.67 =	14,000
	741,020	1866100		5.46	10,185,900

Eccentricity = 5.46 − 4.0 = 1.46 meters.

Resultant force outside of middle third, neglecting tension.

Pressure area = 3 × 2.54 × 13.6 = 34.55 or m³ = 103.75

max. bearing pressure = $\frac{1866100 \times 2}{3 \times 34.55} = \frac{108000}{3} = 36,000$ kg/m² (3.29 tons/ft²)

max. load on one pile = 33.6 × 1.05 × 1.05 = 37.00 kg tons
12.1
24.9 net.

Case 3. Stability during earthquake k. = 0.20 assumed (Seismic forces forward).

Earth pressure during Earthquake

$= 0.48 \times 1600 \times \frac{8.26^2}{2} = 26,200 \times 13.6 = 356,000$ kg. = E.

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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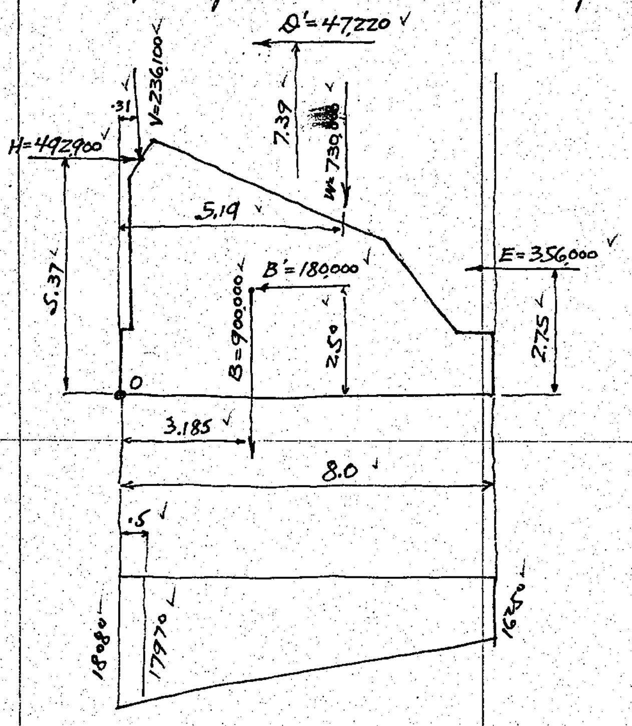
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima ken.



Taking moment about point O.

Loads	Hor. forces	Vert. forces		Lev. arms		Moments
V		236,100	×	.31	=	73,200
H	492,900		×	5.37	=	2,645,000
D'	− 47,220		×	7.39	=	− 348,700
W		730,000	×	5.19	=	3,790,000
B		900,000	×	3.185	=	2,865,000
B'	− 180,000		×	2.50	=	− 450,000
E	− 356,000	~~356000~~	×	2.75	=	− 979,000
	− 90,320	1,866,100		4.07m		759,5500

Eccentricity = 4.07 − 4.0 = 0.07m

Resultant force within middle third.

max. bearing pressure

$$= \frac{1866100}{8.0 \times 13.6}\left(1 \pm \frac{6 \times .07}{8.0}\right) = \begin{matrix} 18,080 \text{ kg/m}^2 \\ 16250 \text{ "} \end{matrix} \quad (1.65 \text{ tons/□'}).$$

.053

max. load on one pile = 17.97 × 1.375 × 1.05 = <u>25.9</u> kg tons.

Curtain wall.

Span length = 1.2 meter say.

Earth pressure at bottom.

$= \frac{1}{3} \times 1600 \times 7.56 = 4030$ kg/m²

moment $= \frac{4030 \times 1.2^2}{12} = 484.0$ kgm per meter strip.

Steel area required $= \frac{484.0 \times 100}{1200 \times \frac{7}{8} \times 7.5} = 0.614$ cm² "

Use 19mmφ bars at 50~60 c to c.

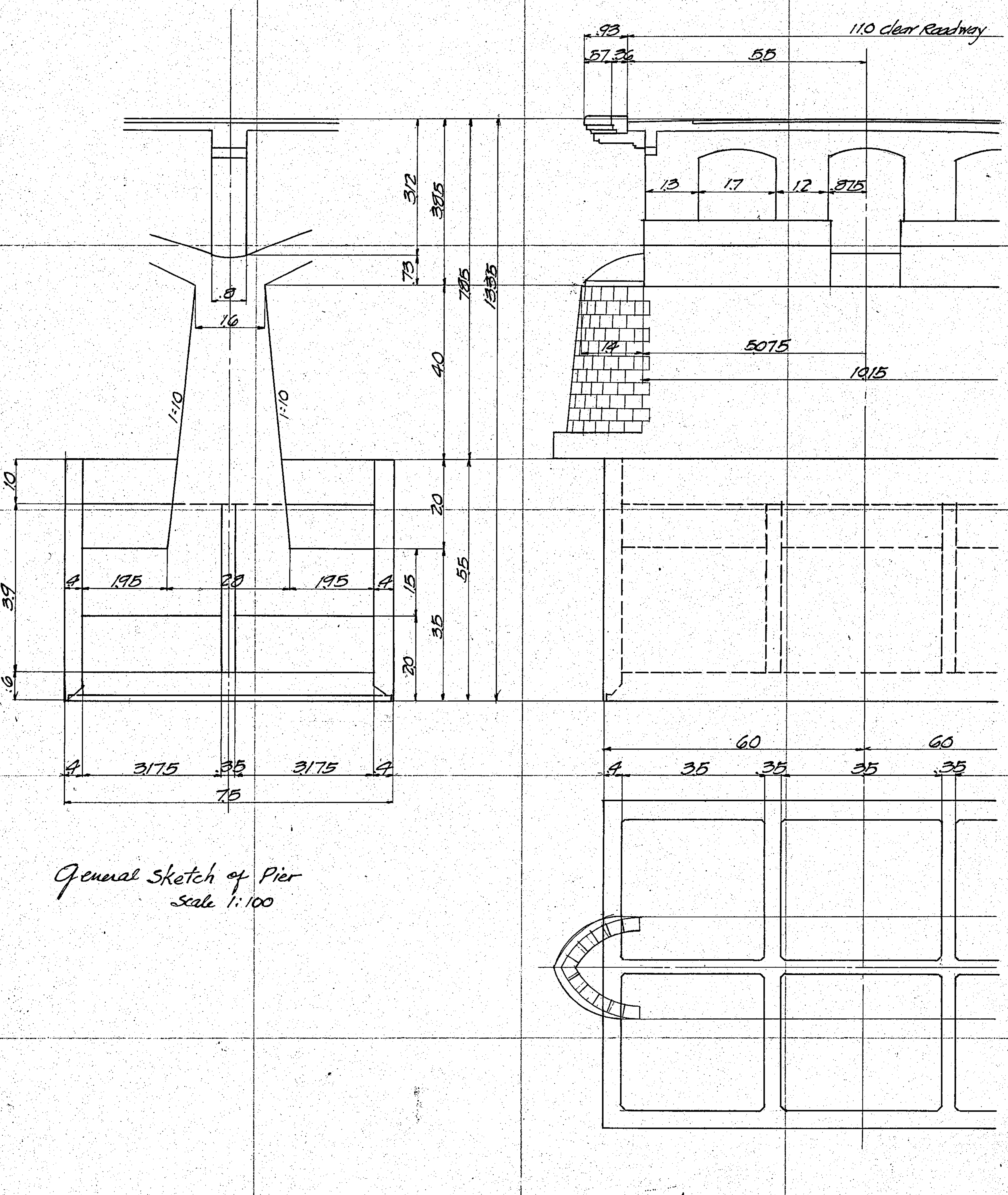
Design of Shinobu Bashi for Fukushima Ken

Design of Pier

Horizontal thrust and vertical shear due to Dead Load.

Span no.	Ho	Difference	V	Difference	Pier no.
4	587,740 kg ✓	} -- 10752 ✓	284,030 kg ✓	} -- 6630 ✓	---- P3
3	576,988 ✓	} -- 45,348 ✓	277,400 ✓	} -- 21460 ✓	--- P2
2	531,640 ✓	} -- 38,778 ✓	255,940	} -- 26,180 ✓	--- P1
1	492,862 ✓		229,760 ✓		

Let us design pier P2 between span no. 2 + 3 which will be the most unstable to dead load. General dimensions are as shown on sketch below



General Sketch of Pier
Scale 1:100

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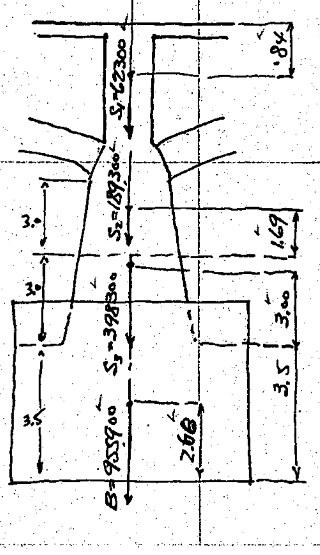
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken

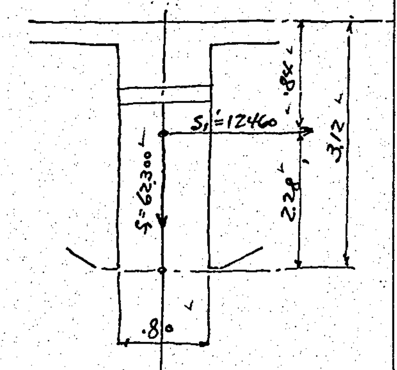
Weight and center of gravity of pier.

			Moment about crown of roadway	
			arms	moments
Pier Structure.				
Handrails	1.8×2 @ 353✓ =	1,270✓	−0.50✓	− 635✓
Light pedestals	2 @ 1500✓ =	3,000✓	−0.54✓	− 1620✓
Light poles	2 @ 250✓ =	500✓	−2.80✓	− 1,400✓
Copings	2×3.0 @ 256✓ =	1,540✓	0.15✓	230✓
Projections (slab)	.4×.25×.165×2 @ 2400✓ =	80✓	0.04✓	3✓
Brackets	.8×.35×.9×2 @ " ✓ =	1210✓	0.48✓	581✓
Pavements	2.5 @ 1614✓ =	4030✓	0.08✓	322✓
Slab	2.5 @ 4350✓ =	10 880✓	0.20✓	2178✓
Fascia beams	1.7×2 @ 454✓ =	1,540✓	0.45✓	693✓
Cross beam	8/3 × 3890 ✓ =	10,370✓	0.47✓	4 870✓
walls	.8×5.0×2.9 @ 2400✓ =	27860✓	1.69✓	47 050✓
		62,280✓	0.84m✓	52,272✓
	Call this	62,300✓kg = S_1		
Pier Shaft. upper 3 meter shaft.				
Top.	1.28✓×.73✓×10.15=9.47✓@ 2400✓ =	22,720✓	3.28✓	74,500✓
Shaft	1.90✓×3.0✓×10.15✓=57.83✓@ " =	138,900✓	1.42✓	197,300✓
end cap.	1.3✓×.6×1.4×2✓= 2.18✓@ " =	5,230✓	3.35✓	17,530✓
water cut nouse	1.6✓×.65×2×3.0✓= 6.22✓@ " =	14,930✓	1.30✓	19,400✓
"	3.2✓×.15✓×3.0✓×2 = 2.88✓@ 2600✓=	7490✓	1.40✓	10,480✓
		189270✓	1.69m✓	319,210✓
	Call this	189,300✓kg = S_2		
Whole shaft 6.0m heigh				
upper 3m shaft		189,300✓	4.69✓	888,000✓
lower 3m "	2.50✓×3.0✓×10.15=76.10✓@ 2400✓=	182,500✓	1.44✓	262,800✓
water cut nouse say	1.94✓×0.9×.4×2= 1.40✓@ " =	3,360✓	2.80✓	9400✓
"	3.4✓×.15×.4×2= .41✓@ 2600✓=	1,060✓	2.80✓	2970✓
"	2.34×.6×1.33×2=3.73✓@ 2400✓=	8950✓	2.30✓	20,590✓
"	2.6×2.0×.525×2=5.46✓@ " =	13,100✓	1.00✓	13,100✓
		398,270✓	3.00m✓	1,196,860✓
Concrete for shaft = 162.39✓ m³.	Call this	398,300✓kg = S_3		
Weight and center of gravity of Base.				
Caisson				
Side walls	.4×5.5×12.0×2✓= 52.80✓@2400✓=	126,800✓	2.75✓	349,000✓
"	.4×5.5×6.7×2✓= 29.50✓@ " =	70,800✓	2.75✓	194,800✓
Cross walls	.35×3.9×6.7×2✓= 18.28✓@ "	43,850✓	2.55✓	111,800✓
longitadinal wall	.35×~~4~~3.9×10.5✓= 14.34✓@ " 114.92m³	34,400✓	2.55✓	87,700✓
Filling concrete	06×6.7×11.2✓= 45.04✓@ 2200✓	99,000✓	0.30✓	29,700✓
"	3.5×3.175×29.6✓= 193.25✓@ " 238.29m³	425,000✓	2.55✓	1,084,000✓
Rubbles	2.05×2.0×11.2×2✓= 91.80✓@ 1700 =	156,000✓	4.52✓ ~~5.02~~	705,000✓
		955,850kg✓	2.68m✓	~~2,640,000~~ 2,562,000✓
	Call this	955,900✓kg = B.		



Design of Shinobu Bashi for Fukushima Ken.

Pier Structure.



Seismic Coefficient assumed at 0.20.

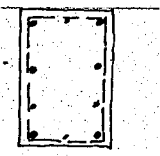
Seismic force = 62300 · .2 = 12460 kg

Seismic moment on columns = 12460 · 2.28 = 28400 kgm for 4 columns.

Effective depth say 80 - 5 = 75 centimeters

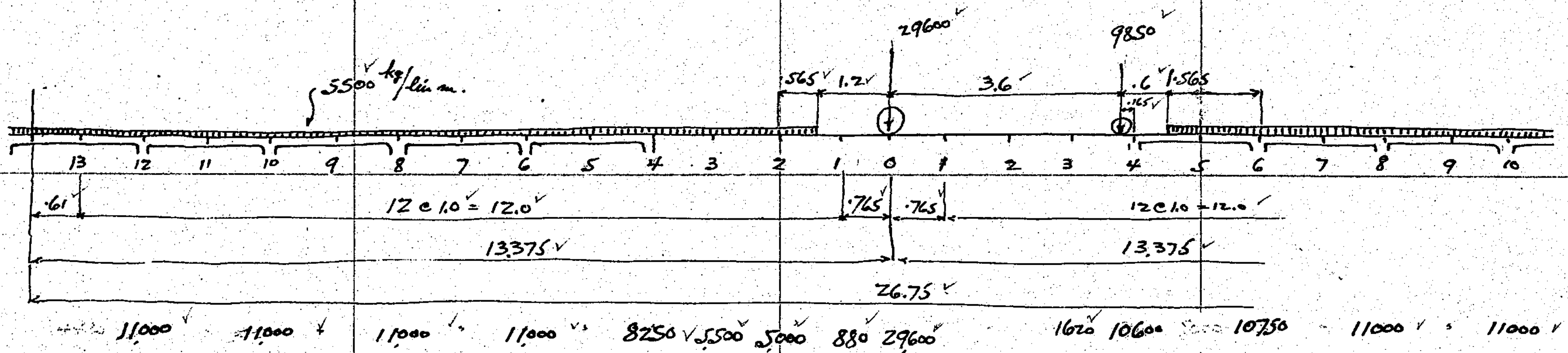
Steel area required for moment

$$= \frac{28400 \cdot 100}{1200 \cdot 1.6 \cdot \frac{7}{8} \cdot 75} = 22.50^{cm^2}$$



Use 16 - $16^{mm\phi}$ bars = 32.2^{cm^2} for 4 columns. (4 bars in 1 column)

Max. Horizontal thrust due to Live Load on 3rd span. Refer to page 39.



Panel Points.	H unit load	Load	H.	V unit load	V
0	2.427	29600	71,800	0.500	14,800
1^L	2.411	880	2,120	0.529	465
2	2.312	5,000	11,570	0.566	2,830
3	2.142	5,500	11,780	0.603	3,320
4	1.914	8,250	15,780	0.641	5,290
6	1.351	11,000	14,870	0.716	7,870
8	.775	11,000	8,520	0.790	8,690
10	.322	11,000	3,540	0.865	9,515
12	.062	11,000	680	0.940	10,350
3^R	2.142	1,620	3,480	0.397	645
4	1.914	10600	20280	0.359	3805
6	1.351	10750	14,520	0.285	3065
8	.775	11000	8,520	0.210	2310
10	.322	11000	3,540	0.135	1485
12	.062	11,000	680	0.060	660
			191,680 kg		75,100 kg.

増田淳氏関係資料
（独立行政法人 土木研究所蔵）

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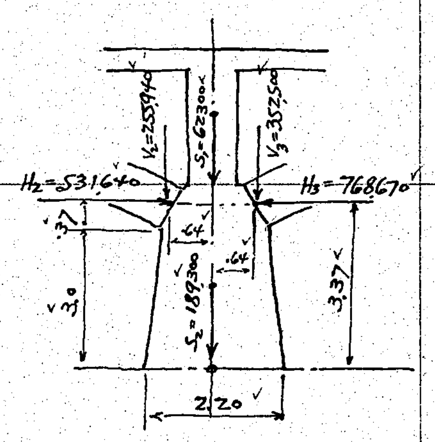
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken

Horizontal thrust and vertical load during erection.
Arch Ring for 4th span only executed.

Panel Point	Panel load	H unit load	H
0	4,610	2.411	11,100
1	8,150	2.365	19,260
2	8,350	2.254	18,830
3	8,550	2.078	17,750
4	8,560	1.847	15,800
5	8,980	1.580	14,200
6	9,370	1.292	12,100
7	9,800	1.009	9,880
8	10,400	.734	7,630
9	11,200	.495	5,540
10	11,820	.301	3,560
11	13,050	.153	1,995
12	14,500	.058	840
13	12,000	.008	95
Springing	6,650	.000	0
	145,990 = V		138,580
			138,580
			277,160 kg = H.

Stability of Shaft
Section at 3 meters below springing line.
Case 1. Live Load on one side only



Superimposed loads + thrusts

	2nd span		3rd span	
	H_2	V_2	H_3	V_3
Dead Load	531,640	255,940	576,988	277,400
Live Load.	—	—	191,680	75,100
	531,640 kg	255,940 kg	768,670 kg	352,500 kg

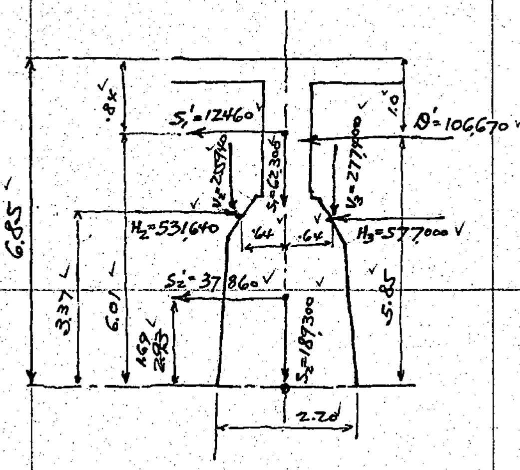
Taking moment about center of section.

Loads	Hor. forces	Vert. forces		Lev. arms		moments
S_1		62,300	× +	0	=	0
S_2		189,300	×	0	=	0
V_2		255,940	× +	.64	=	163,800
V_3		352,500	× −	.64	= −	225,600
H_2	− 531,640		×	3.37	= −	1,791,000
H_3	+ 768,670		×	3.37	=	2,590,000
	237,030 kg	860,040 kg				+ 737,200 kgm.

Eccentricity = $\frac{737200}{860040}$ = .857 m

Case 2. During Earthquake. k = 0.20

Seismic force due to Dead Load on span 0.2 (255940 + 277400) = 106670 kg = D′
Center of gravity assumed 1.0 m below crown of Roadway.



Loads	Hor. forces	Vert. forces		Lev. arm		Moments
D′	106,670		×	5.85	=	624,000
S_1		62,300	×	0	=	0
S_1'	12,460		×	6.01	=	74,900
V_2		255,940	×	0.64	=	163,800
V_3		277,400	× −	0.64	=	− 177,500
H_2	− 531,640		×	3.37	=	− 1,791,000
H_3	577,000		×	3.37	=	1,944,500
S_2		189,300	×	0	=	0
S_2'	37,860		×	~~2.93~~ 1.69	=	64,000
	202,350 kg	784,940 kg.		1.15 m	=	902,700 kgm

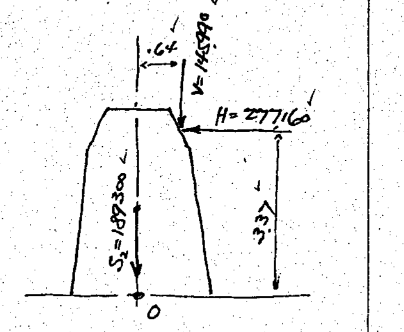
增田淳氏関係資料（独立行政法人 土木研究所蔵）

MADE BY K. Inaba DATE 5-2-20 FILE NO
CHECKED BY M. Iida DATE 5-2-28 PAGE NO 82

CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken

Case 3. Arch Ring on one side only being erected. (Span no 4).

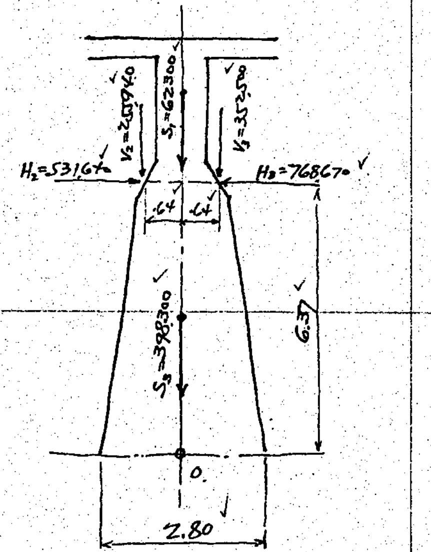


Taking moment about point O.

Loads	Hor. forces	Vert forces	Lev. arms	Moments
S_2		189,300 ✓	.00 ✓	0 ✓
V		145,990 ✓	− .64 ✓	− 93,400 ✓
H	277160 ✓		3.37 ✓	934,000 ✓
	277160 ✓ Kg	335290 ✓ Kg	2.51 m ✓	840,600 ✓ Kgm.

Section at bottom of Shaft.

Case 1. Live Load on one side only.



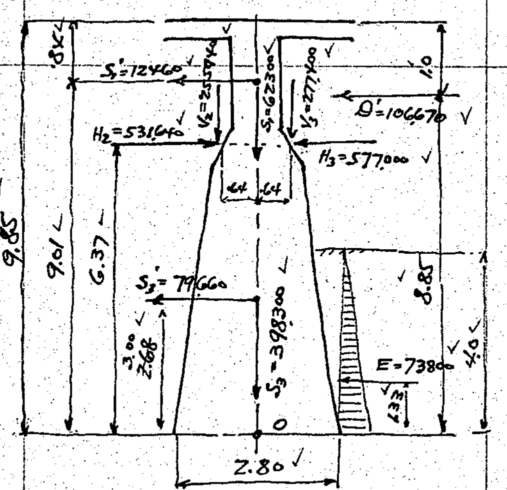
Taking moment about center of section.

Loads	Hor. forces	Vert. forces	Lev. arms	moments
S_1		62,300 ✓	0 ✓	0 ✓
V_2		255,940 ✓	.64 ✓	163,750 ✓
V_3		352,500 ✓	−.64 ✓	− 225,500 ✓
H_2	− 531,640 ✓		6.37 ✓	− 3,387,000 ✓
H_3	76,8670 ✓		6.37 ✓	4895,000 ✓
S_3		398,300 ✓	0 ✓	0 ✓
	237,030 ✓ kg	1,069,040 kg ✓	1.35 m ✓	1,446,250 ✓ kgm

Earth pressure during Earthquake for k = 0.20. width say 12.0 ✓ meters.

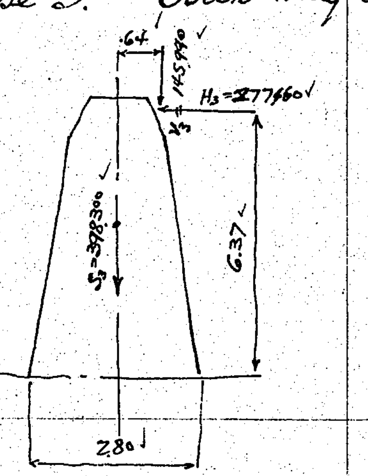
$E = 0.48 \cdot 1600 \cdot \frac{4^2}{2} \cdot 12.0 = 73,800$ kg for case 2.

Case 2. During Earthquake k = 0.20



Loads	Hor. forces	Vert. forces	Lev. arms	Moments.
D'	106,670 ✓		8.85 ✓	943,000 ✓
S_1		62,300 ✓	0 ✓	0 ✓
S_1'	12,460 ✓		9.01 ✓	112,300 ✓
V_2		255,940 ✓	.64 ✓	163,800 ✓
V_3		277,400 ✓	− .64 ✓	− 177,500 ✓
H_2	− 531,640 ✓		6.37 ✓	− 338 7,000 ✓
H_3	577,000 ✓		6.37 ✓	3675,000 ✓
S_3		398,300 ✓	0 ✓	0 ✓
S_3'	79,660 ✓		3.00 ✓	239,000 ✓
E	73,800 ✓		1.33 ✓	98,200 ✓
	317,950 kg ✓	993,940 ✓ kg	1.68 m	1,666,800 ✓ kgm.

Case 3. Arch Ring on one side only being erected. (span no 4)



Loads	Hor. forces	Vert. forces	Lev. arms	moments.
V_3		145,990 ✓	− .64 ✓	− 93,400 ✓
H_3	277,160 ✓		6.37 ✓	1765,000 ✓
S_3		398,300 ✓	0 ✓	0 ✓
	277,160 ✓ kg	544,290 ✓ kg	~~2.35 m~~ 3.07 m	1,671,600 kgm

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CALCULATIONS FOR

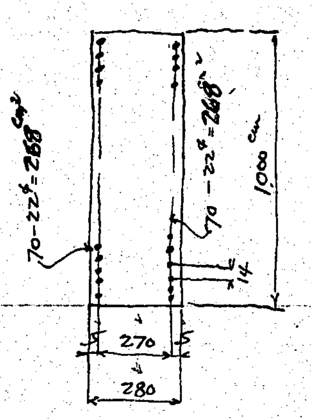
Design of Shinobu Bashi for Fukushima Ken.

Summary for moments and loads on the shaft.

		Hor. forces.	Vert forces.	Lev. arms	Moments.	Ecc. ratio	e/h.
Section at 3m below top	case 1	237,030 kg	860,060 kg	.86 m	737,200	.86÷2.2 =	.39
〃 (Earthquake)	case 2	202,350	784,940	1.15	902,700	1.15÷〃 =	.52
〃 (Erection stress)	case 3	277,160	335,290	2.51	840,600	2.51÷〃 =	1.14
Section at bottom	case 1	237,030	1,069,040	1.35	1,446,250	1.35÷2.8 =	.48
〃 (Earthquake)	case 2	317,950	993,940	1.68	1,666,800	1.68÷〃 =	.60
〃 (Erection stress)	case 3	277,160	544,290	3.07	1,671,600	3.07÷〃 =	1.095

Stresses at Bottom section

assumed section



Case 1. at normal state.

Reinforcements, try 70-22 mmφ bars = 268 cm² on both sides

Steel ratio $p_0 = 2p = \frac{268 \times 2}{1000 \times 280} = .0019$, $e/h = .48$, $d'/h = 5/280 = .018$

From the prepared diagrams of combined stress direct and bending.

we have $k = .40$, $L = .09$

$f_c = \frac{1446250 \times 100}{.09 \times 1000 \times 280^2} = 20.5$ kg/cm² ok.

$f_s = 15 \times 20.5 \left(\overset{1.455}{\frac{275}{.40 \times 280}} - 1 \right) = 447$ kg/cm² ok.

Unit shear $= \frac{237030}{1000 \times \frac{7}{8} \times 275} = 0.99$ kg/cm² ok

unit bond $= \frac{237030}{70 \times 6.91 \times \frac{7}{8} \times 275} = 2.04$ kg/cm² ok.

Case 2. During Earthquake. $k = 0.2$

$p_0 = .0019$, $d'/h = .018$, $e/h = .60$

$k = .31$, $L = .081$

$f_c = \frac{1666800 \times 100}{.081 \times 1000 \times 280^2} = 26.3$ kg/cm² ok

$f_s = 15 \times 26.3 \left(\overset{2.17}{\frac{275}{.31 \times 280}} - 1 \right) = 856$ kg/cm² ok.

unit shear $= \frac{317950}{1000 \times \frac{7}{8} \times 275} = 1.32$ kg/cm² ok

unit bond $= \frac{317950}{70 \times 6.91 \times \frac{7}{8} \times 275} = 2.73$ kg/cm² ok.

Case 3. Arch Ring on one side only be executed.

$p_0 = .0019$, $d'/h = .018$, $e/h = 1.095$

$k = .20$, $L = .075$

$f_c = \frac{1671600 \times 100}{.075 \times 1000 \times 280^2} = 28.5$ kg/cm² ok.

$f_s = 15 \times 28.5 \left(\overset{3.9}{\frac{275}{.20 \times 280}} - 1 \right) = 1665$ kg/cm² ok.

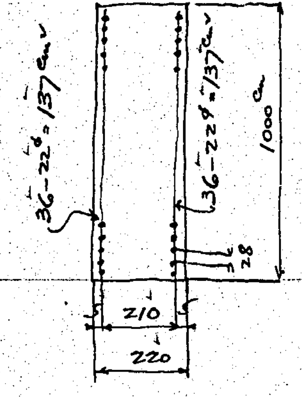
Unit shear and bond ok. In this case all stresses are temporaly and let us allow 50% over or 1200×1.5=1800 kg/cm²

Assumed section is ample for all cases.

Design of Shinobu Bashi for Fukushima Ken.

Section at 3 meter below top.

Assumed section



Case 1. at normal state

Reinforcements try $36-22^{\phi}=137^{cm^2}$ on both sides

Steel ratio $p_0=2p=\frac{137\times2}{1000\times220}=.00125$, $\frac{e}{h}=.39$, $\frac{d'}{h}=5/220=.023$

$k=.47$, $L=.090$

$f_c=\frac{737200\times100}{.09\times1000\times220^2}=17.0$ kg/cm² ok.

$f_s=15\times17\left(\frac{215}{.47\times220}\overset{1.08}{}-1\right)=276$ kg/cm² ok.

unit shear $=\frac{237030}{1000\times\frac{7}{8}\times215}=1.26$ kg/cm² ok.

unit bond $=\frac{237030}{36\times6.91\times\frac{7}{8}\times215}=5.07$ kg/cm² ok.

Case 2. During Earthquake $k=0.2$

$p_0=2p=.00125$, $\frac{e}{h}=.52$, $\frac{d'}{h}=.023$

$k=.31$, $L=.075$

$f_c=\frac{902700\times100}{.075\times1000\times220^2}=24.9$ kg/cm² ok.

$f_s=15\times24.9\left(\frac{215}{.31\times220}-1\right)=803$ kg/cm² ok.

unit shear $=\frac{202350}{1000\times\frac{7}{8}\times215}=1.08$ kg/cm² ok.

unit bond $=\frac{202350}{36\times6.91\times\frac{7}{8}\times215}=4.35$ kg/cm² ok.

Case 3. Arch Ring on one side only being erected.

$p_0=.00125$, $\frac{e}{h}=1.14$, $\frac{d'}{h}=.023$

$k=.19$, $L=.062$

$f_c=\frac{840600\times100}{.062\times1000\times220^2}=28.1$ kg/cm² ok.

$f_s=15\times28.1\left(\frac{215}{.19\times220}-1\right)=1745$ kg/cm² ok.

unit shear $=\frac{277160}{1000\times\frac{7}{8}\times215}=1.48$ kg/cm² ok.

unit bond $=\frac{277160}{36\times6.91\times\frac{7}{8}\times215}=5.93$ kg/cm² ok.

In this case (case 3), all stresses are temporaly and let us allow for steel stress 50% over or $1200\times1.5=1800$ kg/cm²
The assumed section is ample for all cases.

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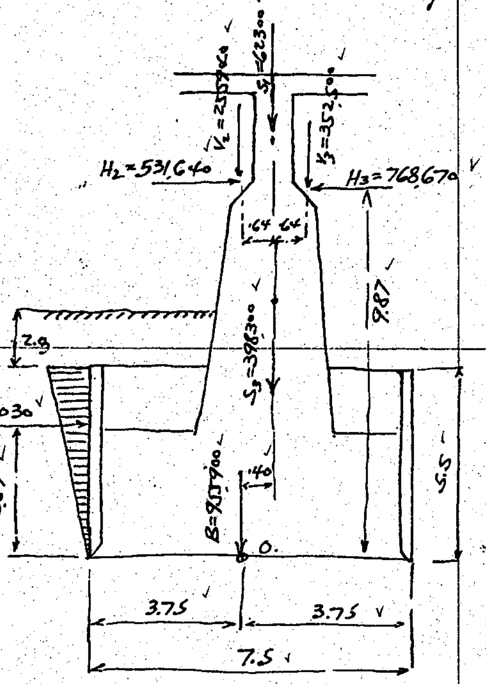
CHECKED BY M. Jindo DATE 5-4-16 PAGE NO 85

CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken

Stability of pier as a whole (pier P2)

Case 1. Stability at normal state.



Taking moment about center of base area O.

Loads	Hor. forces	Vert. forces	Lev. arms	Moments
S_1		62300 ×	-.40 =	- 24900
S_3		398300 ×	-.40 =	- 159,400
B		955,900 ×	-.0 =	0
V_2		255,940 ×	.24 =	61,400
V_3		352,500 ×	-1.04 =	- 366,500
H_2	-531,640	×	9.87 =	-5,243,000
H_3	768,670	×	9.87 =	7,590000
	237030 kg	2024940 kg		1,857,600

Average skin friction on caisson assumed 900 kg/m² (180 #/□')

frictional couple = 900×12.0×5.5×7.5 = 445,000 kgm

resisting earth moment = 237030 × 3.67 = 870000

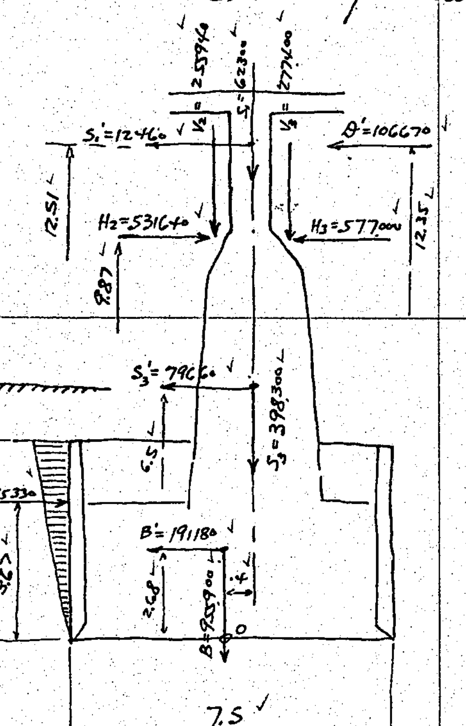
1,315,000 kgm

Resulting moment = 1,857,600 - 1,315,000 = 542,600 kgm

Eccentricity $\varepsilon = \frac{542,600}{2024940} = .268$ m

max. bearing pressure $= \frac{2024940}{7.5\times12.0}\left(1\pm\frac{\overset{.214}{6\times.268}}{7.5}\right) =$ 27320 kg/m² or (2.50 tons/□') or 17,700

Case 2. Stability during Earthquake k=0.20 assumed



Taking moment about center of bottom area O.

Loads	Hor. forces	Vert. forces	Lev. arms	Moments
S_1		62,300 ×	-.40 =	- 24,900
S_1'	12,460	×	12.51 =	155,800
S_3		398,300 ×	-.40 =	- 159,400
S_3'	79,660	×	6.50 =	518,000
B		955900 ×	~~.40~~ 0 =	0
B'	191,180	×	2.68 =	512,000
V_2		255940 ×	.24 =	61,400
V_3		277,400 ×	-1.04 =	- 288,500
H_2	-531,640	×	9.87 =	-5,245,000
H_3	577,000	×	9.87 =	5,700,000
D'	106,670	×	12.35 =	1,317,000
	435330 kg	1,949,840 kg		2,546,400

Average skin friction on caisson during earthquake assumed =900 kg/m² (or 180#/□')

frictional couple = 900×12.0×5.5×7.5 = 445000

resisting earth moment = 435330×3.67 = 1598000

2043000

$\frac{435330}{12\times5.5}\times2 = 13200$ kg/m²

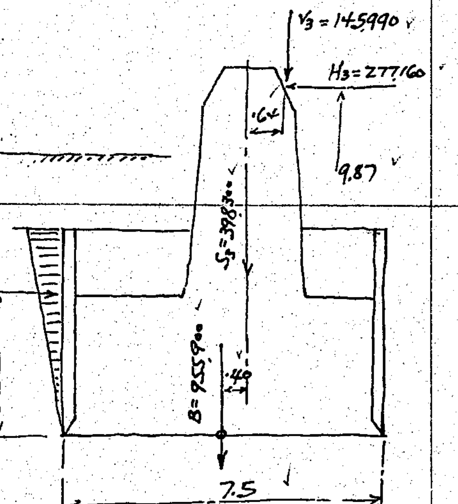
$1700\times\frac{1+.5}{1-.5}\times2.3 = 11,750$

use rubbles around the caisson

Resultant moment = 2546,400 - 2043000 = 503400 kgm Ecc = .258 m

max. Bearing pressure $= \frac{1949840}{7.5\times12.0}\left(1\pm\frac{\overset{.206}{6\times.258}}{7.5}\right) =$ 26100 kg/m² or (2.39 tons/□') or 17,200

Case 3. Arch Ring on one side only being executed.



Loads	Hor. forces	Vert. forces	Lev. arm	Moments
V_3		145,990 ×	-1.04 =	-151,800
H_3	277,160	×	9.87 =	2,738400
S_3		398,300 ×	-.40 =	- 159,400
B		955,900 ×	.00 =	0
	277,160 kg	1,500,190 kg		2,427,200

frictional couple same as case 1. 445,000

resisting earth moment 277160×3.67= 1,017,000

1462,000

- 1,462,000

965,200÷1,500,190= 0.643 m ecc.

max. bearing pressure $= \frac{1500190}{7.5\times12.0}\left(1\pm\frac{\overset{.514}{6\times.643}}{7.5}\right) =$ 25250 kg/m² or (2.31 tons/□') 8,100

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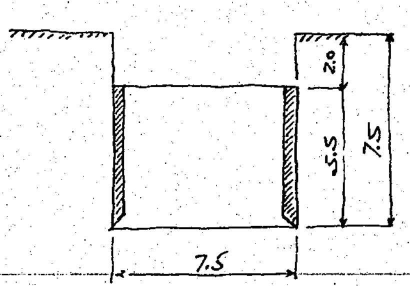
CALCULATIONS FOR

Design of Shinoku Bashi for Fukushima Ken.

Design of Reinforced concrete caission for Piers. 12.0 × 7.5 × 5.5 m

Side walls.



Bottom 1 meter strip of wall. span length 3.85 meters.

Earth pressure 7.0 × 1600 × $\frac{1}{3}$ = 3730 kg/m² average

moment on wall = $\frac{1}{10}$ × 3730 × 3.85² = 5530 kgm per meter strip

Shear = $\frac{1}{2}$ × 3730 × 3.85 = 7180 kg "

Effective depth required = $\sqrt{\frac{5530 \times 100}{100 \times 7.18}}$ = 27.7 cm

Use 37 cm eff. depth with 3 cm insulation. total depth = 40 cm.

Steel area required = $\frac{5530 \times 100}{1200 \times \frac{7}{8} \times 37}$ = 14.2 cm² per meter strip.

use 16φ bars at 14 cm ctoc = 14.37 unit shear = $\frac{7180}{100 \times \frac{7}{8} \times 37}$ = 2.22 kg/cm² ok.

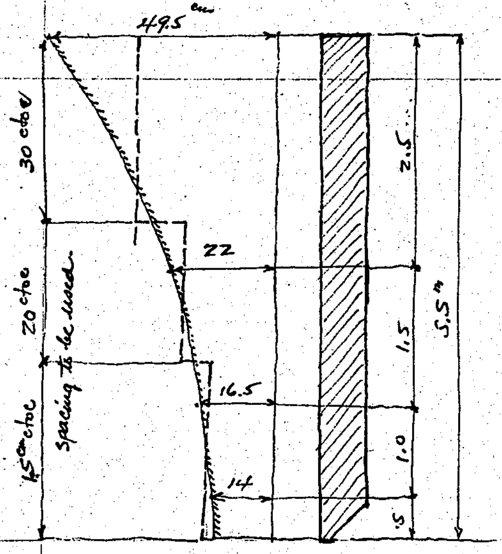
At section 1.5 m above bottom.

Earth pressure 6.0 × 1600 × $\frac{1}{3}$ = 3200 kg/m²

moment = $\frac{1}{10}$ × 3200 × 3.85² = 4740 kgm

Steel area req'd = $\frac{4740 \times 100}{1200 \times \frac{7}{8} \times 37}$ = 12.2 cm²

Use 16φ bars at 16.5 cm ctoc = 12.2 cm²



Spacing diagram.

At section 3 m above bottom.

Earth pressure = 4.5 × 1600 × $\frac{1}{3}$ = 2400 kg/m²

moment = $\frac{1}{10}$ × 2400 × 385² = 3560 kgm.

Steel area req'd = $\frac{3560 \times 100}{1200 \times \frac{7}{8} \times 37}$ = 9.17 cm²

Use 16φ bars at 22 cm ctoc = 9.17 "

At top section

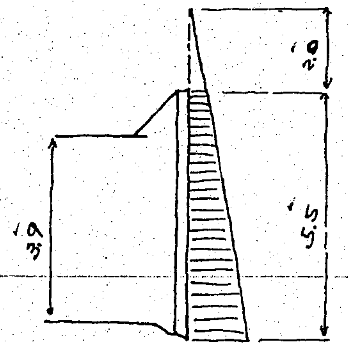
Earth pressure = $\frac{1}{3}$ × 1600 × 2 = 1067 kg/m²

moment = $\frac{1}{10}$ × 1067 × 3.85² = 1580 kgm

Steel area req'd. = $\frac{1580 \times 100}{1200 \times \frac{7}{8} \times 37}$ = 4.07 cm²

Use 16φ bars at 49.5 cm ctoc = 4.07 "

Wall struts.



Load on struts.

Earth pressure at top = $\frac{1}{3}$ × 1600 × 2.0 = 1067

" " bottom = $\frac{1}{3}$ × 1600 × 7.5 = 4000

$\frac{5067}{2}$ × 5.5 = 13950 kg

13950 × 3.85 = 53700 kg on one wall.

Average unit compression on wall = $\frac{53700}{390 \times 35}$ = 3.93 kg/cm² ok.

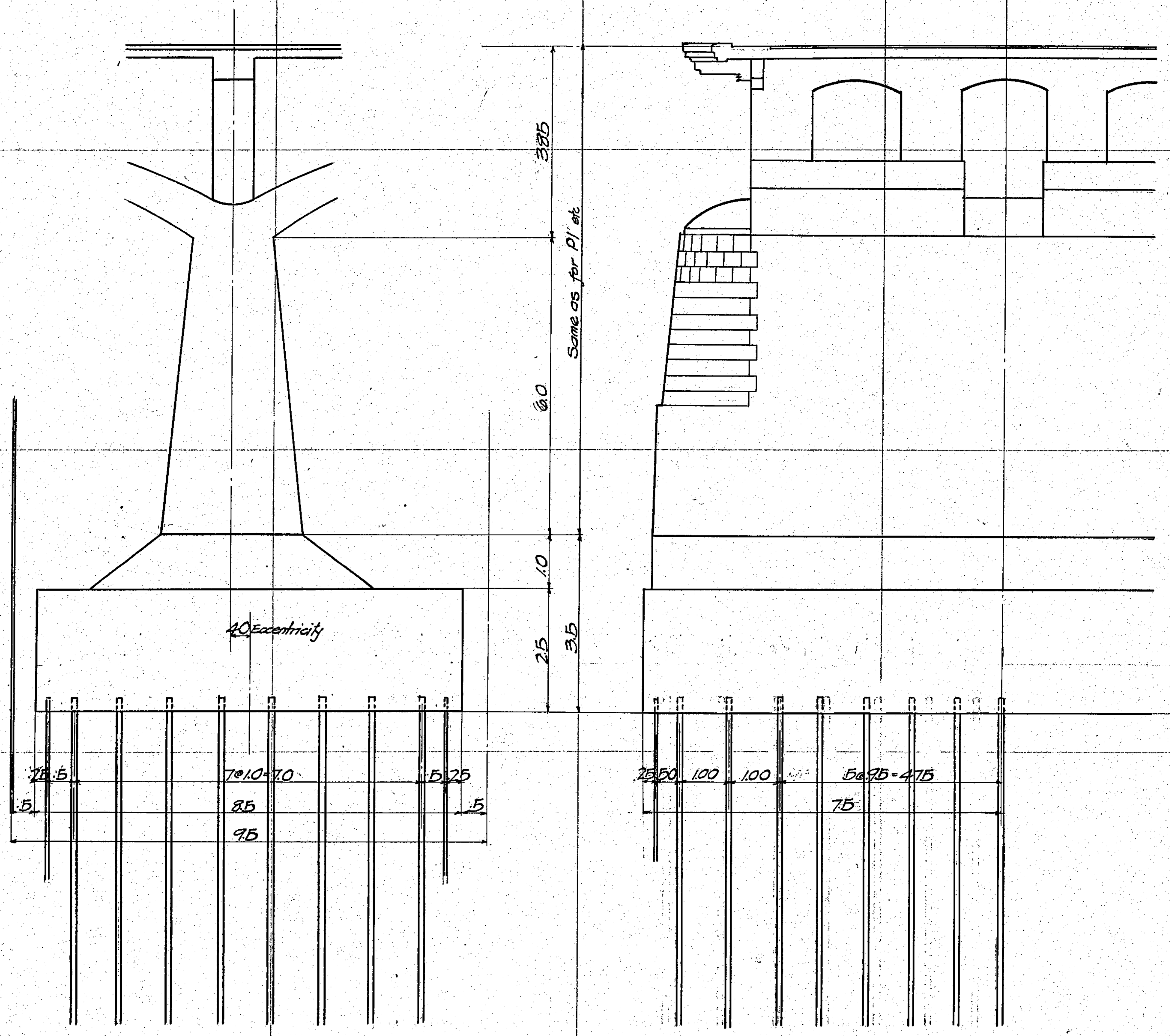
Slenderness ratio of wall l/b = 350/35 = 10. ok.

Use 13φ bars 30 ~ 45 cm ctoc on both sides.

Design of Shinobu Bashi for Fukushima Ken

Design of Pier no 3 and 5

All figures in the following calculations are for Pier no 5.



JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.

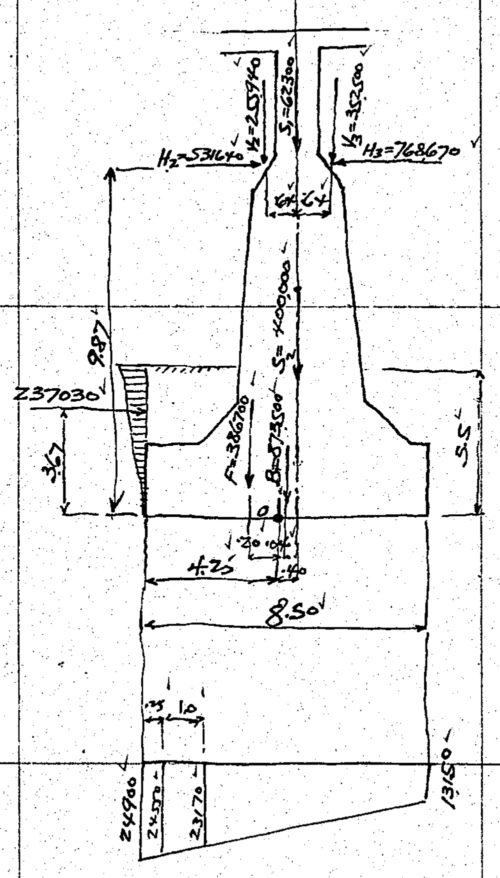
Use same detail of shaft as for Pier P1.

Case 1. Stability at normal state.

Weight of Shaft say 400,000 ✓ kg

Weight of Base — hor. — vert.

4.15 ✓ × 1.0 ✓ × 14.0 ✓ = 58.10 ✓ @ 2400 ✓ = 139,500 ✓ × .25 ✓ = 34,850 ✓ 2.94 ✓ 410,000 ✓
2.50 ✓ × 8.5 ✓ × 14.4 ✓ = 306.00 ✓ @ 2400 ✓ = 734000 ✓ × .00 ✓ = 0 ✓ 1.25 ✓ 917,000 ✓
364.10 ✓ — 873,500 ✓ kg .04 m ✓ — 34850 ✓ 1.52 m ✓ 1,327,000 ✓



Earth filling on base
3.20 ✓ × 3.0 ✓ × 1600 ✓ × 14.4 ✓ = 221,000 ✓ × -2.60 - 574,000 ✓ 4.2
2.4 ✓ × 3.0 ✓ × 1600 × 14.4 ✓ = 165,700 ✓ × +3.00 497000 ✓ 4.2
386,700 — 0.20 ✓ 77000 ✓ 4.20

Taking moment about center of base.

Loads	Hor. forces	Vert. forces	Lev. arms	Moments.
S_1		62300 ✓	-.40 ✓	- 24900 ✓
S_2		400,000 ✓	-.40 ✓	- 160,000 ✓
B		873,500 ✓	-.04 ✓	- 34,900 ✓
F		386,700 ✓	.20 ✓	77,300 ✓
V_2		255940 ✓	.24 ✓	61,400 ✓
V_3		352,500 ✓	-1.04 ✓	- 366,500 ✓
H_2	- 531,640 ✓		9.87 ✓	- 5,250,000 ✓
H_3	+ 768,670 ✓		9.87 ✓	7,590,000 ✓
	237,030 ✓	2,330,940 ✓	.81	+ ~~213,600~~ 1,892,400 ✓

max. load on pile
= 23,170 ✓ × 1.0 ✓ × .75 ✓ = 17.4 ✓ kg tons.

max load on sheet pile
= 24,550 ✓ × .5 ✓ = 12.28 ✓ kg tons/lin m

Resisting Earth moment = 237030 ✓ × 3.67 ✓ = - 870,000 ✓
1,022,400 ✓

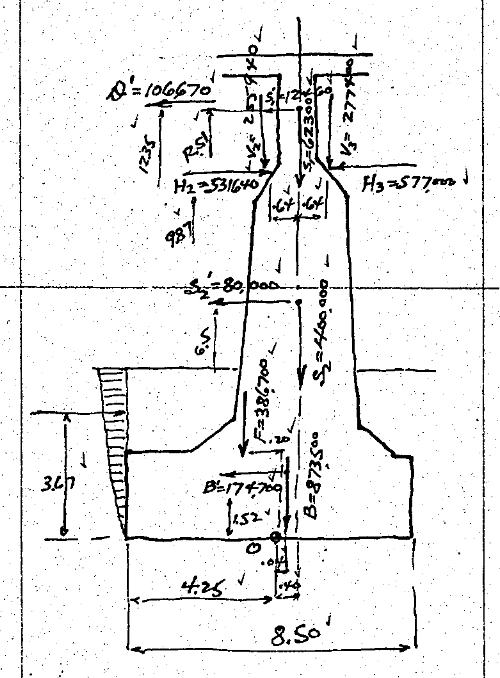
Eccentricity = $\frac{1022400}{2330940}$ ✓ = .438 m

max. bearing pressure at toe = $\frac{2330940}{8.5\times14.4}\left(1\pm\frac{6\times.438}{8.5}\right)$ (.309 ✓) = 24900 ✓ kg/m² or (2.28 tons/ft²)
13,150 ✓

Case 2. Stability during Earthquake. k = 0.20.

Taking moment about center of bottom 0.

Loads	Hor. forces	Vert. forces	Lev. arm	moment.
S_1		62300 ✓ ×	- 0.40 ✓ =	- 24,900 ✓
S_1'	12,460 ✓	×	+ 12.51 ✓ =	155,800 ✓
S_2		400,000 ✓ ×	- 0.40 ✓ =	- 160,000 ✓
S_2'	80,000 ✓	×	+ 6.50 ✓ =	520,000 ✓
B		873,500 ✓ ×	- 0.04 ✓ =	- 34,900 ✓
B'	174,700 ✓	×	+ 1.52 ✓ =	265,500 ✓
F		386,700 ✓ ×	+ 0.20 ✓ =	77,300 ✓
V_2		255940 ✓ ×	+ 0.24 ✓ =	61,400 ✓
V_3		277,400 ✓ ×	- 1.04 ✓ =	- 288,000 ✓
H_2	(-) 531,640 ✓	×	9.87 ✓ =	- 5,250,000 ✓
H_3	577,000 ✓	×	+ 9.87 ✓ =	5,700,000 ✓
D'	106670 ✓	×	+ 12.35 ✓ =	1,318,000 ✓
	419,190 ✓	2,255,840 ✓		+ 8,098,000 ✓ - 5,757,800 ✓ + 2,340,200 ✓



Resisting Earth moment = 419190 ✓ × 3.67 ✓ = - 1,539,000 ✓
+ 801,200 ✓

Eccentricity = $\frac{801,200}{2255,840}$ ✓ = .355 m ✓

max. bearing pressure = $\frac{2255840}{8.5\times14.4}\left(1\pm\frac{6\times.355}{8.5}\right)$ (.251 ✓) = 23050 ✓ kg/m² or (1.68 tons/ft²)
13800

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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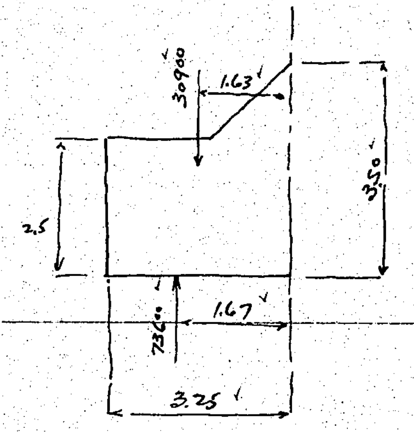
CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima ken.

Design of cantilever footing of pier.



upward pressure at toe 24900 kg/m²

" " fixed point $\underline{20400}$

45300 ÷ 2 = 22650 kg/m² average

22650 × 3.25 = 73600 kg per meter strip.

Downward pressure.

Concrete say 2.5 × 2200 = 5500

earth 2.5 × 1600 = $\underline{4000}$

9500 × 3.25 = 30900 kg

max. moment on footing =

30900 × 1.63 = − 50400

73600 × 1.67 = + $\underline{123000}$

72600 kgm.

for homogeneous section

$$\text{fibre stress} = \frac{72600 \times 100}{\frac{100 \times 350^2}{6}} = \pm 3.55 \text{ kg/cm}^2 \quad \text{ok}$$

Shear = 73600 − 30900 = 42700 kg

$$\text{unit shear} = \frac{42700}{100 \times 350} = 1.22 \text{ kg/cm}^2 \quad \text{ok}$$

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MADE BY K. Iwaba DATE 5-4-4 **FILE NO**

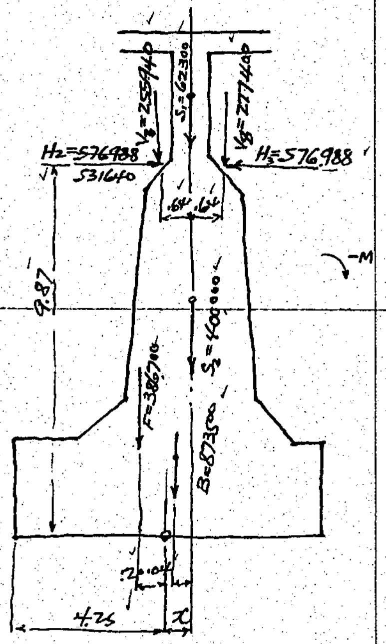
CHECKED BY M. Jinda DATE 5-4-16 **PAGE NO** 90

CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.

Eccentricity of shaft to make Dead Load moment Zero at bottom of base.

Pier no P5.



Taking moment about center of base O.

Load	Hor. forces	Vert. forces	Lev. arm	Moment.	
S_1		62300	$-x$	$-62300x$	
S_2		400000	$-x$	$-400000x$	
B		873500	−.04		−34900
F		386700	+.20	77300	+77300
H_2	531640		−9.87		−5250000
H_3	576988		+9.87		+5700000
V_2		255940	$+.64-x$	$-255940x$ +	163700
V_3		277400	$-.64-x$	$-277400x$ −	177500
		2255840 kg.		$-995640x$ +	478600 = 0

$$x = \frac{+478600}{995640} = +0.48^{m}$$

D.L. average bearing press. $= \frac{2255840}{14.4 \times 8.5} = 18400$ kg/m² ≈ (1.68 tons/□′)

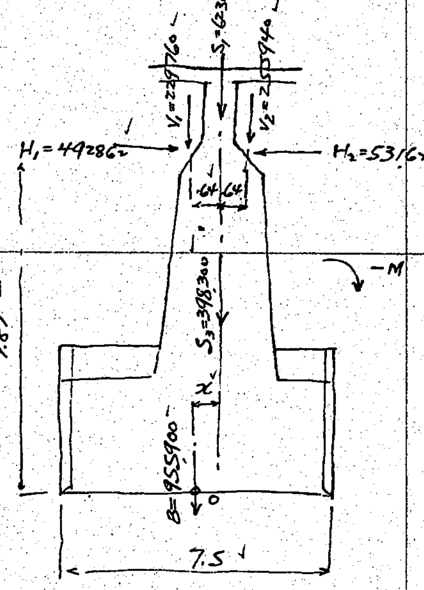
Pier no P3.

Loads.	Hor. forces	Vert. forces	Lev. arm	Moments.	
S_1		62300	$-x$	$-62300x$	
S_2		400000	$-x$	$-400000x$	
B		873500	−.01		−8735
F		386700	+.05		+19350
H_3	577000		−9.87		−5690000
H_4	587740		+9.87		+5795000
V_3		277400	$+.64-x$	− 277400 x ~~177500~~	+ 177500
V_4	————	284030	$-.64-x$	$-284030x$ −	181750
		2283930 kg		$-1023730x$ +	111365 = 0

$$x = \frac{111365}{1023730} = 0.109^{m}$$

D.L. average bearing press. $= \frac{2283930}{14.4 \times 8.5} = 18700$ kg/m² ≈ (1.71 tons/□′)

Pier no P1.



Taking moment about center of base O.

Loads	Hor forces	Vert. forces	Lev. arm	moments.	
S_1		62300	$-x$	$-62300x$	
S_3		398300	$-x$	$-398300x$	
B		955900	0		0
V_1		229760	$.64-x$	$-229760x$ +	147000
V_2		255940	$-.64-x$	$-255940x$ −	163800
H_1	−492862		9.87		−4864000
H_2	531640		9.87		+5248000
		1902200 kg		$-946300x$ +	367200 = 0

$$x = \frac{367200}{946300} = 0.388^{m}.$$

Dead Load average bearing ~~sto~~ pressure

$$= \frac{1902200}{12.0 \times 7.5} = 21150 \text{ kg/m}^2 \approx (1.93 \text{ tons/□}')$$

Friction on well surface, neglected.

Design of Shimoba Bashi for Fukushima ken.

Pier no P2.

Loads	Hor. Forces	Vert. Forces	Lev. arms	Moments
S_1		62300	$-x$	$-62300x$
S_3		398300	$-x$	$-398300x$
B		955900	0	0
V_2		255940	$.64-x$	$-255940x + 163800$
V_3		277400	$-.64-x$	$-277400x - 177500$
H_2	-531640		9.87	-5247300
H_3	576988		9.87	$+5694900$
		1949840		$-993640x + 433900 = 0$

$$x = \frac{433900}{993640} = 0.437^{m}$$

D.L. average Bearing pressure $= \frac{1949840}{7.5 \times 12.0} = 21600\ ^{kg}/_{m^2}$ or $(1.97\ ^{tons}/_{\square'})$

(Skin friction on caisson being neglected)

Pier no P4.

Loads	Hor. Forces	Vert. Forces	Lev. arms	Moments
S_1		62300	$-x$	$-62300x$
S_3		398300	$-x$	$-398300x$
B		955900	0	0
V_3		277400	$.64-x$	$-277400x + 177500$
V_4		284030	$-.64-x$	$-284030x - 181780$
H_3	-576988		9.87	-5694870
H_4	587740		9.87	$+5801000$
		1977930		$-1022030x + 101850 = 0$

$$x = \frac{101850}{1022030} = 0.100^{m}$$

D.L. average Bearing pressure

$$= \frac{1977930}{7.5 \times 12.0} = 22000\ ^{kg}/_{m^2} \text{ or } (2.00\ ^{tons}/_{\square'})$$

(Skin friction on the surface of caisson neglected.)

Dead Load on pile. 54 piles used.

Total Dead Load = 1977,930 kg

frictional resistance = 900 × 39.0 × 5.5 = 193,000 kg

$$\begin{array}{r} 1,977,930 \\ -193,000 \\ \hline 1,784,930 \text{ kg} \end{array}$$

$\frac{1,784,930}{54} = 33.0$ kg tons on one pile

If 10 kg tons/□ be allowed for earth. 10 × 7.5 × 12 = 900 tons.

total load on piles = 1870 − 900 = 970 tons.

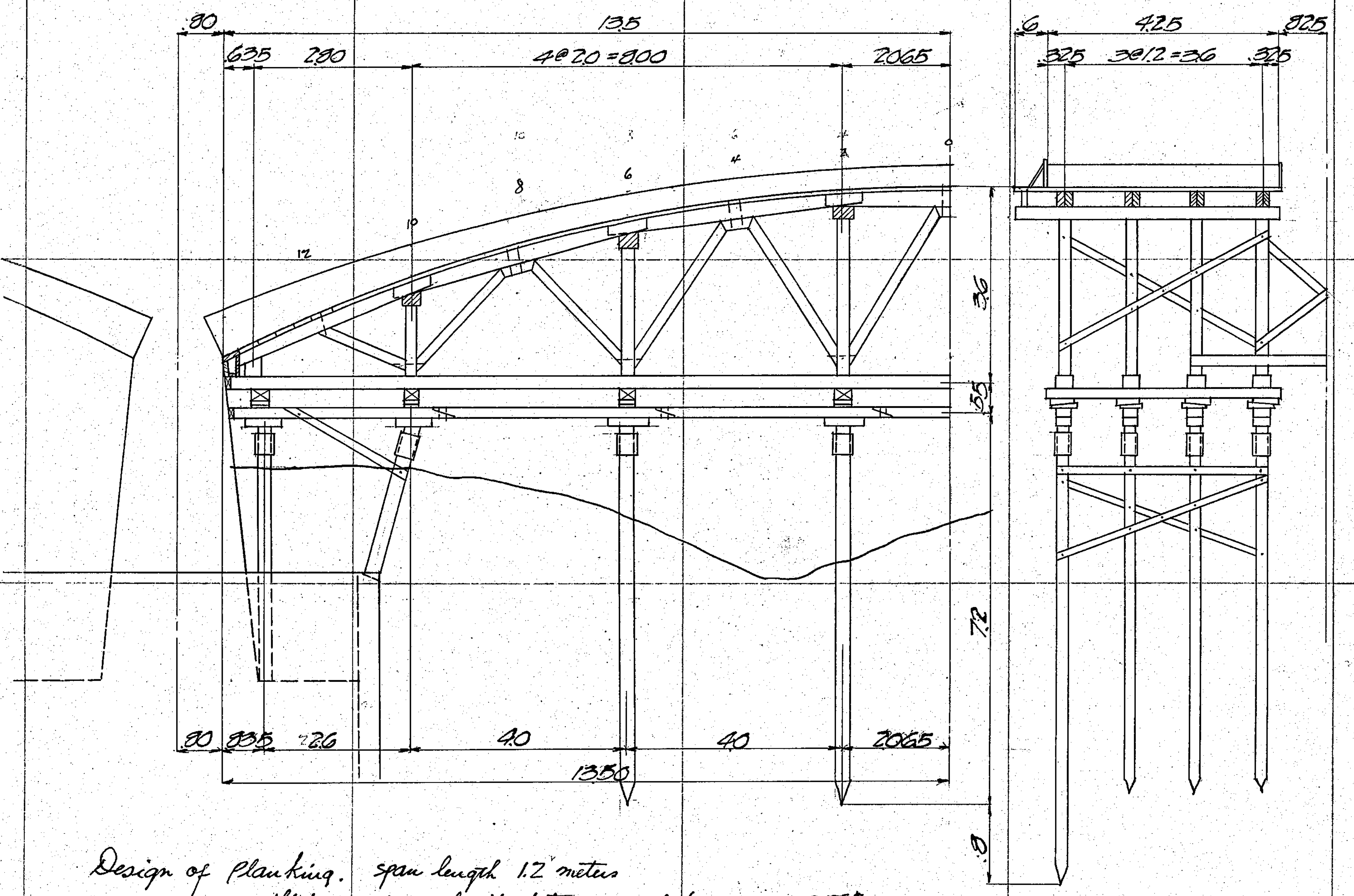
970 ÷ 54 = 18.0 kg tons per pile.

MADE BY K. Inaba DATE 5-2-20 **FILE NO**

CHECKED BY M. Jinda DATE 5-2-26 **PAGE NO** 92

CALCULATIONS FOR

Design of Shinobu Bashi for Fukushima Ken.
Design of Staging for Arch Ring.



Design of Planking. span length 1.2 meters
average thickness of arch rib between panel pts 10 + 8 = 0.55 m
weight of arch rib = .55 × 2400 = 1320 kg/m²
weight of planking .06 × 650 = 40
1360

moment = $\frac{1}{10}$ × 1360 × 1.2² = 196 kgm. per meter strip
Shear = $\frac{1}{2}$ × 1360 × 1.2 = 816 kg
allowable fibre stress due to bending assumed 50 kg/cm² (710 #/□")
Section modulus required = $\frac{196 \times 100}{50}$ = 392 cm³

use 6 cm board section modulus = $\frac{100 \times 6^2}{6}$ = 600 cm³. (正二寸板)

Design of Stringers. span length 2.1 meters, spacing 1.2 meters
Dead Load. Concrete + planking 1360 × 1.2 = 1632 kg per lin meter.
beam assumed 28
1660

moment = $\frac{1}{8}$ × 1660 × 2.1² = 914 kgm
Shear = $\frac{1}{2}$ × 1660 × 2.1 = 1742 kg
Section modulus required = $\frac{91400}{50}$ = 1828 cm³

use 15 × 30 cm (5寸 × 1.0尺)正角 Section modulus = $\frac{15 \times 30^2}{6}$ = 2250 cm³
unit shear = $\frac{1742}{15 \times 30}$ = 3.9 kg/cm² ok.

Pile load. approximate load on one pile
Concrete and planking with stringer 1660 × 4.2 = 6,970 kg
wood frame say 830
7,800 kg

Use 18 cmφ × 6.3 m Inside piles
18 cmφ × 7.1 m Outside "

MADE BY M. J. DATE 5-3-7 **FILE NO**
CHECKED BY M. K. DATE 5-3-19 **PAGE NO** 93

CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Floor Slab

Concrete 1:2:4 *mixture*

Slab .165 × 11.0 = 1.815
Coping 2 × .22 × .25 = .110
1.925 sq. m.

Slab S1 1.925 × 3.85 + $\frac{1}{2}$ × .15 × .07 × 9.55 + $\frac{1}{2}$ × .105 × .215 × 9.55 = 7.57
S2 〃 × 4.00 + $\frac{1}{2}$ × .15 × .07 × 9.55 = 7.75
TS1 〃 × 7.33 = 14.11
S3 〃 × 8.50 + 2 × .57 × 1.00 × .25 + $\frac{2}{2}$ × .15 × .07 × 9.55 = 16.72
S4 〃 × 6.00 + $\frac{1}{2}$ × .15 × .07 × 9.55 = 11.60
TS2 〃 × 5.83 = 11.22
TS3 〃 × 7.53 = 14.49
TS4 〃 × 8.13 = 15.65

Total Concrete for Slab

S1 2 @ 7.57 = 15.14
S2 4 @ 7.75 = 31.00
TS1 2 @ 14.11 = 28.22
S3 6 @ 16.72 = 100.32
S4 10 @ 11.60 = 116.00
TS2 2 @ 11.22 = 22.44
TS3 2 @ 14.49 = 28.98
TS4 1 @ 15.65 = 15.65
less const. jt 28 @ 1.925 × 0.13 = (-) .70
357.05 cub. m.

Forms *Bottom* 10.50
Coping 2 × .57 = 1.14
11.64 m.

Slab S1 11.64 × 3.85 = 44.81
less Cross beam .70 × 9.55 = (-) 6.69
fillet .15 × 9.55 = 1.43
〃 .215 × 9.55 = 2.05
41.60 sq. m

Slab S2 11.64 × 4.00 = 46.56
less cross beam .70 × 9.55 = (-) 6.69
fillet .15 × 9.55 = 1.43
41.30 sq. m

Slab TS1 11.64 × 7.33 = 85.32
less spandrel fill 2 × 3.90 × 7.33 = (-) 57.17
〃 *cross beam* 2 × .15 × 1.75 = .53
27.62 sq. m

Slab S3 11.64 × 8.50 = 98.94
less bracket 2 × .68 × .69 = (-) .94
〃 *cross beam* 1.90 × 9.55 = (-) 18.15
fillet 2 × .15 × 9.55 = 2.87
Coping bottom 2 × .15 × .80 = .24
Coping side 2 × .32 × 1.20 = .77
83.73 sq. m

Slab S4 11.64 × 6.00 = 69.84
less cross beam 1.00 × 9.55 = (-) 9.55
fillet .15 × 9.55 = 1.43
61.72 sq. m

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Slab TS2 11.64 × 5.83 = 67.86
less spandrel fill 2 × 3.90 × 5.83 = (-) 45.47
" cross beam 2 × .15 × 1.75 = (-) .53
21.86 sq.m

Slab TS3 11.64 × 7.53 = 87.65
less spandrel fill 2 × 3.90 × 7.53 = (-) 58.73
" cross beam 2 × .15 × 1.75 = (-) .53
28.39 sq.m

Slab TS4 11.64 × 8.13 = 94.63
less fascia girder 2 × 3.90 × 8.13 = (-) 63.41
" cross beam 2 × .15 × 1.75 = (-) .53
30.69 sq.m

Total Forms
Slab S1 2 @ 41.60 = 83.20
S2 4 @ 41.30 = 165.20
TS1 2 @ 27.62 = 55.24
S3 6 @ 83.73 = 502.38
S4 10 @ 61.72 = 617.20
TS2 2 @ 21.86 = 43.72
TS3 2 @ 28.39 = 56.78
TS4 1 @ 30.69 = 30.69
1,554.41 sq.m.

Reinforcements, Plain bars
Slab S1 2 @ 922.0 = 1,844.0
S2 4 @ 919.1 = 3,676.4
TS1 2 @ 1,679.7 = 3,359.4
S3 6 @ 1,915.3 = 11,491.8
S4 10 @ 1,383.3 = 13,833.0
TS2 2 @ 1,312.7 = 2,625.4
TS3 2 @ 1,717.2 = 3,434.4
TS4 1 @ 1,575.0 = 1,575.0
41,839.4 Kgs
or 41.8394 Kg.tons

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Slab S1 2 × 4.95 × 3.63 = 35.94 @ 2 = 71.88
S2 2 × 4.95 × 4.00 = 39.60 @ 4 = 158.40
TS1 2 × 4.95 × 7.33 = 72.57 @ 2 = 145.14
S3 2 × 4.95 × 7.45 = 73.76 } 89.57 @ 6 = 537.42
2 × 4.25 × 1.86 = 15.81 }
S4 2 × 4.95 × 6.00 = 59.40 @ 10 = 594.00
TS2 2 × 4.95 × 5.83 = 57.72 @ 2 = 115.44
TS3 2 × 4.95 × 7.53 = 74.55 @ 2 = 149.10
TS4 2 × 4.95 × 8.13 = 80.49 @ 1 = 80.49
1,851.87 sq.m.

Crown Fill (Sand)
Span no. 1 2 × 3.65 × .211 × 7.03 = 10.8 @ 2 = 21.6
no. 2 2 × 3.65 × .157 × 5.53 = 6.3 @ 2 = 12.6
no. 3 2 × 3.65 × .195 × 7.23 = 10.3 @ 2 = 20.6
no. 4 2 × 3.65 × .210 × 7.83 = 12.0 @ 1 = 12.0
66.8 cub. meters

Pavements Roadway asphalt block pavements 5cm thick with 2cm cement mortar cushion (1:3)
paved area 7.36m × 184.61m = 1,358.73 sq. meters
Concrete pavements 5cm ~~Soliditit block pavement with 2cm~~ cement ~~mortar~~ cushion (1:3)
paved area 3.64m × 184.61 = 671.98 sq. meters

MADE BY M.J. DATE 5-3-8 **FILE NO**

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Expansion Joints
½" carey Elastite 挿入 28 - Req'd

Drains (cast iron) @ 28.10 kgs 28 - Req'd

Fascia girders and Longitudinal Spandrel walls
Concrete 1:2:4 mixture

Span no. 1
F1 .20 × .25 × 3.40 = .17 @ 2 = .34
F2 .20 × .25 × 3.40 = .17 @ 4 = .68
TS1 .25 × .251 × 7.03 = .44 @ 2 = .88
TS1 .163 × .25 × 7.03 = .29 @ 2 = .58
F3 .20 × .25 × 3.40 = .17 @ 2 = .34
fillet .30 × .14 × .25 = .01 @ 16 = .16
2.98 cub. m

Span no. 2
F3 .20 × .25 × 3.40 = .17 @ 4 = .68
F4 .20 × .25 × 3.40 = .17 @ 4 = .68
Wall .25 × .253 × 1.70 = .11 @ 2 = .22
TS2 .119 × .25 × 5.53 = .16 @ 2 = .32
TS2 .197 × .25 × 5.53 = .27 @ 2 = .54
wall .25 × .34 × 1.70 = .14 @ 2 = .28
fillet .30 × .14 × .25 = .01 @ 16 = .16
2.88 cub. m

Span no. 3
F3 .20 × .25 × 3.40 = .17 @ 4 = .68
F4 .20 × .25 × 3.40 = .17 @ 4 = .68
wall .25 × .37 × 1.70 = .16 @ 2 = .32
TS3 .158 × .25 × 7.23 = .29 @ 2 = .58
TS3 .233 × .25 × 7.23 = .42 @ 2 = .84
wall .25 × .419 × 1.70 = .18 @ 2 = .36
fillet .30 × .14 × .25 = .01 @ 16 = .16
3.62 cub. m

Span no. 4
F3 .20 × .25 × 3.40 = .17 @ 4 = .68
F4 .20 × .25 × 3.40 = .17 @ 4 = .68
wall .25 × .433 × 1.70 = .18 @ 4 = .72
TS4 .173 × .25 × 7.83 = .34 @ 2 = .68
TS4 .249 × .25 × 7.83 = .49 @ 2 = .98
fillet .30 × .14 × .25 = .01 @ 16 = .16
3.90 cub. m

Total concrete
Span no. 1 2 @ 2.98 = 5.96
Span no. 2 2 @ 2.88 = 5.76
Span no. 3 2 @ 3.62 = 7.24
Span no. 4 1 @ 3.90 = 3.90
22.86 cub. meters

Forms
Span no. 1
Sides 32 × .20 × 1.70 = 10.88
Bottoms 16 × .25 × 2.01 = 8.04
fillets 32 × .14 × .30 = 1.34
Spandrel walls 2 × .163 × 7.03 = 2.29
" 2 × .153 × 7.03 = 2.15
" 4 × .251 × 7.03 = 7.06
31.76 sq. m.

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Span no. 2
Sides 32 × .20 × 1.70 = 10.88
Bottom 16 × .25 × 2.01 = 8.04
Fillets 32 × .14 × .30 = 1.34
Spandrel walls 4 × .253 × 1.70 = 1.72
〃 2 × .119 × 5.53 = 1.32
〃 2 × .111 × 5.53 = 1.23
〃 4 × .197 × 5.53 = 4.36
〃 4 × .34 × 1.70 = 2.31
31.20 sq.m

Span no. 3
Sides 32 × .20 × 1.70 = 10.88
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 32 × .14 × .30 = 1.34
Spandrel walls 4 × .37 × 1.70 = 2.52
〃 2 × .158 × 7.23 = 2.28
〃 2 × .15 × 7.23 = 2.17
〃 4 × .233 × 7.23 = 6.74
〃 4 × .419 × 1.70 = 2.85
36.82 sq.m

Span no. 4
Sides 32 × .20 × 1.70 = 10.88
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 32 × .14 × .30 = 1.34
Spandrel walls 8 × .433 × 1.70 = 5.89
〃 2 × .173 × 7.83 = 2.71
〃 2 × .165 × 7.83 = 2.58
〃 4 × .249 × 7.83 = 7.80
39.24 sq.m

Total Forms
Span no. 1 2 @ 31.76 = 63.52
no. 2 2 @ 31.20 = 62.40
no. 3 2 @ 36.82 = 73.64
no. 4 1 @ 39.24 = 39.24
230.80 sq.meters

Reinforcements, Plain bars
F1 2 @ 108.4 = 216.8
F2 4 @ 108.2 = 432.8
F3 6 @ 226.6 = 1359.6
F4 10 @ 109.0 = 1090.0
3099.2 Kgs
or 3.0992 Kg. tons

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Span no. 1
Sides 16 × .20 × 1.70 = 5.44
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 16 × .14 × .30 = .672
Spandrel walls 2 × .163 × 7.03 = 2.292
16.444 sq.m

Span no. 2
Sides 16 × .20 × 1.70 = 5.44
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 16 × .14 × .30 = .672
Spandrel walls 2 × .258 × 1.70 = .877
〃 2 × .119 × 5.53 = 1.316
〃 2 × .345 × 1.70 = 1.173
17.518 sq.m

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CONSULTIEG ENGINEER
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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Span no. 3 Sides 16 × .20 × 1.70 = 5.44
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 16 × .14 × .30 = .672
Spandrel wall 2 × .375 × 1.70 = 1.275
" 2 × .158 × 7.23 = 2.285
" 2 × .424 × 1.70 = 1.442
19.154 sq.m

Span no. 4 Sides 16 × .20 × 1.70 = 5.44
Bottoms 16 × .25 × 2.01 = 8.04
Fillets 16 × .14 × .30 = .672
Spandrel wall 4 × .438 × 1.70 = 2.978
" 2 × .173 × 7.93 = 2.744
19.874 sq.m

Summary Span no. 1 2 @ 16.444 = 32.888
no. 2 2 @ 17.518 = 35.036
no. 3 2 @ 19.154 = 38.308
no. 4 1 @ 19.874 = 19.874
126.106 sq. meters

Cast iron Shoe @ 9.00 Kgs 7@4 = 28 sets Required (including bolts)

Cross Beams and Spandrel walls
Concrete 1:2:4 mixture

CA1 1 @ .50 × .30 × 1.75 = .26
2 @ .626 × .30 × 1.20 = .45
2 @ .460 × .30 × 1.75 = .49
2 @ .543 × .30 × 1.20 = .39
} 1.59
4 @ 1.20 × .30 × 1.012 = 1.46
2 @ .25 × .025 × 1.527 = .02
3.07 cub.m

CA2 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × .425 = .61
2 @ .25 × .025 × .94 = .01
2.21

CA3 1 @ .50 × .30 × 1.75 = .26
2 @ .580 × .30 × 4.15 = 1.46
2 @ .25 × .025 × .505 = .01
1.73

CA4 1 @ .50 × .30 × 1.65 = .25
2 @ .296 × .30 × 4.20 = .75
1.00

CA5 1 @ .50 × .30 × 1.65 = .25
2 @ .399 × .30 × 4.20 = 1.01
1.26

CA6 1 @ .50 × .30 × 1.75 = .26
2 @ .740 × .30 × 4.15 = 1.86
2 @ .25 × .025 × .665 = .01
2.13

CA7 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × .616 = .89
2 @ .25 × .025 × 1.157 = .01
2.49

CA8 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 1.285 = 1.85
2 @ .25 × .025 × 1.80 = .02
3.46

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

Materials of Shinobu-Bashi for Fukushima-Ken

CA9 Cross beam 1.59 × 8/3 = 4.24 } 4.79
bracket 2 @ .38 × .68 × 1.06 = .55 }
4 @ 1.20 × .80 × 20.47 = 7.86
2 @ .68 × .025 × 19.62 = .07
12.72 cul. m

Total concrete for CA = 30.07 cul. meters

CB1 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 13.17 = 1.90
2 @ .25 × .025 × 18.32 = .02
3.51 cul. m

CB2. Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 7.13 = 1.03
2 @ .25 × .025 × 12.28 = .02
2.64

CB3 1 @ .50 × .30 × 1.75 = .26
2 @ .794 × .30 × 4.15 = 1.98
2 @ .25 × .025 × 7.11 = .01
2.25

CB4 1 @ .50 × .30 × 1.65 = .25
2 @ .423 × .30 × 4.20 = 1.07
1.32

CB5 1 @ .50 × .30 × 1.65 = .25
2 @ .212 × .30 × 4.20 = .53
0.78

CB6 1 @ .50 × .30 × 1.65 = .25
2 @ .269 × .30 × 4.20 = .68
0.93

CB7 1 @ .50 × .30 × 1.65 = .25
2 @ .535 × .30 × 4.20 = 1.35
1.60

CB8 1 @ .50 × .30 × 1.75 = .26
2 @ .929 × .30 × 4.15 = 2.31
2 @ .25 × .025 × 8.46 = .01
2.58

CB9 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 8.87 = 1.28
2 @ .25 × .025 × 14.02 = .02
2.89

CB10 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 15.30 = 2.20
2 @ .25 × .025 × 20.45 = .03
3.82

CB11 Same parts for CA9 = 4.79
4 @ 1.20 × .80 × 23.03 = 8.84
2 @ .68 × .025 × 22.18 = .08
13.71

Total concrete for CB = 36.03 cul. meters

CC1 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 15.52 = 2.23
2 @ .25 × .025 × 20.67 = .03
3.85

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CHECKED BY M.K. DATE 5-3-20 **PAGE NO** 99

CALCULATIONS FOR

Materials for Shinobu-Bashi for Fukushima-Ken

CC2 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 8.94 = 1.29
2 @ .25 × .025 × 14.09 = .02 cub. m
2.90

CC3 1 @ .50 × .30 × 1.75 = .26
2 @ .968 × .30 × 4.15 = 2.41
2 @ .25 × .025 × .885 = .01
2.68

CC4 1 @ .50 × .30 × 1.75 = .26
2 @ .571 × .30 × 4.15 = 1.42
1.68

CC5 1 @ .50 × .30 × 1.65 = .25
2 @ .297 × .30 × 4.20 = .75
1.00

CC6 1 @ .50 × .30 × 1.65 = .25
2 @ .335 × .30 × 4.20 = .84
1.09

CC7 1 @ .50 × .30 × 1.75 = .26
2 @ .628 × .30 × 4.15 = 1.56
1.82

CC8 1 @ .50 × .30 × 1.75 = .26
2 @ 1.045 × .30 × 4.15 = 2.60
2 @ .25 × .025 × .962 = .01
2.87

CC9 Same parts for CA1 = 1.59
4 @ .991 × .30 × 1.20 = 1.43
2 @ .25 × .025 × 1.506 = .02
3.04

CC10 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 1.663 = 2.39
2 @ .25 × .025 × 2.184 = .03
4.01

CC11 Same parts for CA9 = 4.79
4 @ 1.20 × .80 × 2.472 = 9.49
2 @ .68 × .025 × 2.357 = .08
14.36

Total concrete for CC = 39.30 cub. meters

CD1 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 1.677 = 2.41
2 @ .25 × .025 × 2.192 = .03
4.03

CD2 Same parts for CA1 = 1.59
4 @ 1.20 × .30 × 1.003 = 1.44
2 @ .25 × .025 × 1.518 = .02
3.05

CD3 1 @ .50 × .30 × 1.75 = .26
2 @ 1.059 × .30 × 4.15 = 2.64
2 @ .25 × .025 × .976 = .01
2.91

CD4 1 @ .50 × .30 × 1.75 = .26
2 @ .643 × .30 × 4.15 = 1.60
1.86

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

CD5 1 @ .50 × .30 × 1.65 = .25
2 @ .348 × .30 × 4.20 = .88
1.13 cub. m

Total Concrete for CD = 12.98 cub. meters

Summary of Concrete
Span no. 1 2 @ 30.07 = 60.14
no. 2 2 @ 36.03 = 72.06
no. 3 2 @ 39.30 = 78.60
no. 4 2 @ 12.98 = 25.96
236.76 cub. meters

Forms

CA1 2 @ .50 × 1.75 = 1.75
4 @ .626 × 1.20 = 3.00
4 @ .468 × 1.75 = 3.28
4 @ .543 × 1.20 = 2.61
less 4 @ .50 × .25 = (-) .50
3 @ .30 × 1.80 = 1.62
2 @ .30 × .54 = .32
} 12.08
4 @ 10.12 × 3.00 = 12.14
4 @ 0.025 × 15.27 = .15
24.37 sq. m

CA2 Same parts for CA1 = 12.08
4 @ .425 × 3.00 = 5.10
fillet 1 @ .10 × 9.55 = (-) .96
4 @ .025 × .94 = .09
16.31

CA3 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = 0.54
4 @ .588 × 4.15 = 9.76
2 @ .30 × .53 = .32
less 4 @ .50 × .25 = (-) .50
4 @ .025 × .505 = .05
11.92

CA4 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .296 × 3.65 = 2.16
2 @ .196 × 3.90 = 1.53
2 @ .30 × .24 = .14
4 @ .025 × .213 = .02
6.11

CA5 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .399 × 3.65 = 2.91
2 @ .299 × 3.90 = 2.33
2 @ .30 × .34 = .20
4 @ .025 × .316 = .03
7.73

CA6 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = 0.54
4 @ .748 × 4.15 = 12.42
2 @ .30 × .69 = .41
less 4 @ .50 × .25 = (-) .50
4 @ .025 × .665 = .07
14.69 sq. m

CA7 Same parts for CA1 = 12.08
4 @ .616 × 3.00 = 7.40
fillet 1 @ .10 × 9.55 = (-) .96
4 @ .025 × 1.157 = .12
18.64

CA8 Same parts for CA1 = 12.08
4 @ 12.85 × 3.00 = 15.42
4 @ .025 × 1.80 = .18
27.68

CA9 2 @ .50 × 1.75 = 1.75
4 @ .626 × 1.20 = 3.00
4 @ .468 × 1.75 = 3.28
4 @ .543 × 1.20 = 2.61
less 4 @ .50 × .25 = (-) .50
3 @ .80 × 1.80 = 4.32
4 @ .06 × .57 = .14
Bracket 4 @ .38 × 1.06 = 1.61
2 @ .68 × 1.55 = 2.11
} 18.32
4 @ 4.00 × 20.48 = 32.77
4 @ .025 × 19.62 = .20
51.29

Total Forms for CA = 178.74 sq. meters

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Materials of Shinobu-Boshi for Fukushima-Ken

CB1 Same parts for CA1 = 12.08
4 @ 1.317 × 3.00 = 15.80
4 @ .025 × 1.832 = .18
28.06 sq.m

CB2 Same parts for CA1 = 12.08
4 @ .713 × 3.00 = 8.56
less 1 @ .10 × 9.55 =(-) .96
4 @ .025 × 1.228 = .12
19.80

CB3 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
4 @ .794 × 4.15 = 13.18
2 @ .30 × .73 = .44
2 @ .30 × .196 = .12
less 4 @ .50 × .25 =(-) .50
4 @ .025 × .711 = .07
15.60

CB4 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
4 @ .423 × 3.90 = 6.60
2 @ .30 × .37 = .22
4 @ .025 × .34 = .03
9.11

CB5 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .212 × 3.65 = 1.55
2 @ .112 × 3.90 = .87
2 @ .30 × .16 = .10
4 @ .025 × .129 = .01
4.79

CB6 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .269 × 3.65 = 1.96
2 @ .169 × 3.90 = 1.32
2 @ .30 × .21 = .13
4 @ .025 × .186 = .02
5.69

CB7 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .535 × 3.90 = 4.17
2 @ .535 × 4.15 = 4.44
less 2 @ .50 × .25 =(-) .25
2 @ .30 × .48 = .29
4 @ .025 × .452 = .05
10.96

CB8 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
4 @ .929 × 4.15 = 15.42
2 @ .30 × .87 = .52
2 @ .30 × .33 = .20
less 4 @ .50 × .25 = (-) .50
4 @ .025 × .846 = .08
18.01

CB9 Same parts for CA1 = 12.08
4 @ .887 × 3.00 = 10.64
less 1 @ .10 × 9.55 = (-) .96
4 @ .025 × 1.402 = .14
21.90

CB10 Same parts for CA1 = 12.08
4 @ 1.53 × 3.00 = 18.36
4 @ .025 × 2.045 = .20
30.64

CB11 same parts for CA9 = 18.32
4 @ 4.00 × 2.303 = 36.85
4 @ .025 × 2.218 = .22
55.39

Total Forms for CB = 219.95 sq.meters

CC1 Same parts for CA1 = 12.08
4 @ 1.552 × 3.00 = 18.62
4 @ .025 × 2.067 = .21
30.91 sq.m

CC2 Same parts for CA1 = 12.08
4 @ .894 × 3.00 = 10.73
less 1 @ .10 × 9.55 =(-) .96
4 @ .025 × 1.409 = .14
21.99

CC3 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
4 @ .968 × 4.15 = 16.07
2 @ .30 × .37 = .22
2 @ .30 × .91 = .55
less 4 @ .50 × .25 =(-) .50
4 @ .025 × .885 = .09
18.72

CC4 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
2 @ .571 × 4.15 = 4.74
2 @ .571 × 3.90 = 4.45
less 2 @ .50 × .25 =(-) .25
2 @ .30 × .51 = .31
4 @ .025 × .488 = .05
11.59 sq.m

CC5 2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .298 × 3.65 = 2.18
2 @ .198 × 3.90 = 1.54
2 @ .30 × .24 = .14
4 @ .025 × .215 = .02
6.14

CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

CC6
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .335 × 3.65 = 2.45
2 @ .235 × 3.90 = 1.83
2 @ .30 × .28 = .17
4 @ .025 × .252 = .03
6.74 sq.m

CC7
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
2 @ .628 × 4.15 = 5.21
2 @ .628 × 3.90 = 4.90
less 2 @ .50 × .25 =(-) .25
2 @ .30 × .57 = .34
4 @ .025 × .545 = .05
12.54

CC8
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
4 @ 1.045 × 4.15 = 17.35
2 @ .30 × .447 = .27
2 @ .30 × .99 = .59
less 4 @ .50 × .25 =(-) .50
4 @ .025 × .962 = .10
20.10

CC9
Same parts for CA1 = 12.08
4 @ .991 × 3.00 = 11.89
less 1 @ .10 × 9.55 =(-) .96
4 @ .025 × 1.506 = .15
23.16 sq.m

CC10
Same parts for CA1 = 12.08
4 @ 1.663 × 3.00 = 19.96
4 @ .025 × 2.184 = .22
32.26

CC11
Same parts for CA9 = 18.32
4 @ 4.00 × 2.44 = 39.04
4 @ .025 × 2.357 = .24
57.60

Total Forms for CC = 241.75 sq. meters

CD1
Same parts for CA1 = 12.08
4 @ 1.677 × 3.00 = 20.12
4 @ .025 × 2.192 = .22
32.42 sq.m

CD2
Same parts for CA1 = 12.08
4 @ 1.003 × 3.00 = 12.04
less 1 @ .10 × 9.55 =(-) .96
4 @ .025 × 1.518 = .15
23.31

CD3
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
4 @ 1.054 × 4.15 = 17.50
2 @ .30 × .46 = .28
2 @ .30 × 1.00 = .60
less 4 @ .50 × .25 =(-) .50
4 @ .025 × .976 = .10
20.35

CD4
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.80 = .54
2 @ .643 × 4.15 = 5.34
2 @ .643 × 3.90 = 5.02
less 2 @ .50 × .25 =(-) .25
2 @ .30 × .63 = .38
4 @ .025 × .56 = .06
12.84 sq.m

CD5
2 @ .50 × 1.75 = 1.75
1 @ .30 × 1.70 = .51
2 @ .348 × 3.65 = 2.54
2 @ .248 × 3.90 = 1.93
2 @ .30 × .29 = .17
4 @ .025 × .265 = .03
6.93

Total Forms for CD = 95.85 sq. meters

Summary of Forms
Span no. 1 2 @ 178.74 = 357.48
no. 2 2 @ 219.95 = 439.90
no. 3 2 @ 241.75 = 483.50
no. 4 2 @ 95.85 = 191.70
1472.58 sq. meters

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

人造洗出仕上

CA1 2 @ .30 × 1.550 = .930
4 @ .25 × 1.050 = 1.050
4 @ .025 × 1.527 = .153
2.133 sq.m

CA2 2 @ .30 × .963 = .578
4 @ .25 × .463 = .463
4 @ .025 × .94 = .094
1.135

CA3 2 @ .30 × .528 = .317
4 @ .25 × .028 = .028
4 @ .025 × .505 = .051
.396

CA4 2 @ .30 × .236 = .142
4 @ .025 × .213 = .021
.163

CA5 2 @ .30 × .339 = .203
4 @ .025 × .316 = .032
.235

CA6 2 @ .30 × .688 = .413
4 @ .25 × .188 = .188
4 @ .025 × .665 = .067
.668 sq.m

CA7 2 @ .30 × 1.180 = .708
4 @ .25 × .680 = .680
4 @ .025 × 1.157 = .116
1.504

CA8 2 @ .30 × 1.823 = 1.094
4 @ .25 × 1.323 = 1.323
4 @ .025 × 1.80 = .180
2.597

CA9 2 @ .68 × 1.55 = 2.108
4 @ .38 × 1.06 = 1.611
4 @ .06 × .57 = .137
2 @ .80 × 2.048 = 3.277
4 @ .25 × 2.085 = 2.085
4 @ .025 × 1.962 = .196
9.414

Total for CA = 10.245 sq. meters

CB1 2 @ .30 × 1.855 = 1.113
4 @ .25 × 1.355 = 1.355
4 @ .025 × 1.832 = .183
2.651 sq.m

CB2 2 @ .30 × 1.251 = .751
4 @ .25 × .751 = .751
4 @ .025 × 1.228 = .123
1.625

CB3 2 @ .30 × .734 = .440
4 @ .25 × .234 = .234
4 @ .025 × .711 = .071
.745

CB4 2 @ .30 × .363 = .218
4 @ .025 × .340 = .034
.252

CB5 2 @ .30 × .152 = .091
4 @ .025 × .129 = .013
.104

CB6 2 @ .30 × .208 = .125
4 @ .025 × .186 = .019
.144

CB7 2 @ .30 × .475 = .285
4 @ .025 × .452 = .045
.330

CB8 2 @ .30 × .869 = .521
4 @ .25 × .369 = .369
4 @ .025 × .846 = .085
.975 sq.m

CB9 2 @ .30 × 1.425 = .855
4 @ .25 × .925 = .925
4 @ .025 × 1.402 = .140
1.920

CB10 2 @ .30 × 2.068 = 1.241
4 @ .25 × 1.568 = 1.568
4 @ .025 × 2.045 = .205
3.014

CB11 2 @ .68 × 1.55 = 2.108
4 @ .38 × 1.06 = 1.611
4 @ .06 × .57 = .137
2 @ .80 × 2.303 = 3.685
4 @ .25 × 2.341 = 2.341
4 @ .025 × 2.218 = .222
10.104

Total for CB = 21.864 sq. meters

CC1 2 @ .30 × 2.090 = 1.254
4 @ .25 × 1.590 = 1.590
4 @ .025 × 2.067 = .207
3.051

CC2 2 @ .30 × 1.432 = .859
4 @ .25 × .932 = .932
4 @ .025 × 1.409 = .141
1.932

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

CC3 2 @ .30 × .900 = .545
4 @ .25 × .400 = .400
4 @ .025 × .885 = .089
1.042 sq. m

CC4 2 @ .30 × .511 = .307
4 @ .25 × .011 = .011
4 @ .025 × .488 = .049
.367

CC5 2 @ .30 × .238 = .143
4 @ .025 × .215 = .022
.165

CC6 2 @ .30 × .275 = .165
4 @ .025 × .252 = .025
.190

CC7 2 @ .30 × .568 = .341
4 @ .25 × .068 = .068
4 @ .025 × .545 = .055
.464

CC8 2 @ .30 × .985 = .591
4 @ .25 × .485 = .485
4 @ .025 × .962 = .096
1.172

CC9 2 @ .30 × 1.529 = .917
4 @ .25 × 1.029 = 1.029
4 @ .025 × 1.506 = .151
2.097 sq. m

CC10 2 @ .30 × 2.207 = 1.324
4 @ .25 × 1.707 = 1.707
4 @ .025 × 2.184 = .218
3.249

CC11 2 @ .68 × 1.55 = 2.108
4 @ .38 × 1.06 = 1.611
4 @ .06 × .57 = .137
2 @ .80 × 2.440 = 3.904
4 @ .25 × 2.480 = 2.480
4 @ .025 × 2.357 = .236
10.476

Total for CC = 24.205 sq. meters

CD1 2 @ .30 × 2.215 = 1.329
4 @ .25 × 1.715 = 1.715
4 @ .025 × 2.192 = .219
3.263

CD2 2 @ .30 × 1.541 = .925
4 @ .25 × 1.041 = 1.041
4 @ .025 × 1.518 = .152
2.118

CD3 2 @ .30 × .999 = .599
4 @ .25 × .499 = .499
4 @ .025 × .976 = .098
1.196

CD4 2 @ .30 × .583 = .350
4 @ .25 × .083 = .083
4 @ .025 × .56 = .056
.489

CD5 2 @ .30 × .288 = .173
4 @ .025 × .265 = .027
.200

Total for CD = 7.266 sq. meters

Summary
span no. 1 2 @ 18.245 = 36.490
no. 2 2 @ 21.864 = 43.728
no. 3 2 @ 24.205 = 48.410
no. 4 2 @ 7.266 = 14.532
143.160 sq. meters

Reinforcements
Span no. 1 2 @ 2,603.5 = 5,207.0
no. 2 2 @ 2,899.2 = 5,798.4
no. 3 2 @ 3,148.6 = 6,297.2
no. 4 1 @ 2,449.4 = 2,449.4
19,752.0 Kgs
or 19.7520 Kg. tons

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CALCULATIONS FOR

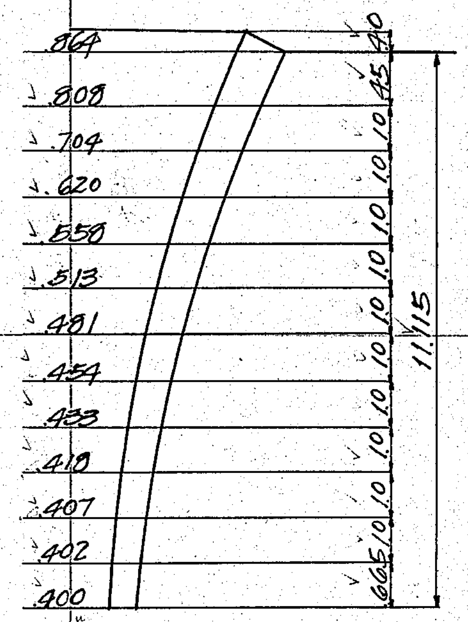
Materials of Shinobu-Bashi for Fukushima-Ken

arch Ring

Concrete 1:2:4 mixture

Span no. 1

	mean thickness		length		area
½ ×	.864	×	.40	=	.173
	.836	×	.45	=	.376
	.756	×	1.00	=	.756
	.662	×	1.00	=	.662
	.589	×	1.00	=	.589
	.536	×	1.00	=	.536
	.497	×	1.00	=	.497
	.468	×	1.00	=	.468
	.444	×	1.00	=	.444
	.426	×	1.00	=	.426
	.413	×	1.00	=	.413
	.405	×	1.00	=	.405
	.401	×	.665	=	.267

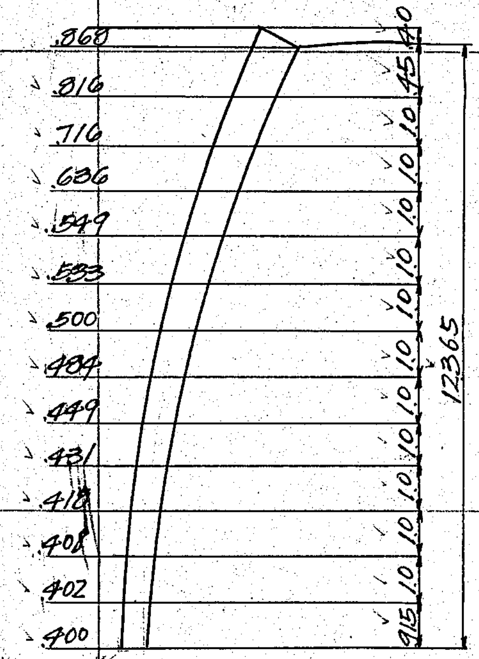


6.012 × 4 = 24.048

Concrete for Span no. 1 = 24.048 × 4.25 = 102.20 cub. meters

Span no. 2

	mean thickness		length		area
½ ×	.868	×	.40	=	.174
	.842	×	.45	=	.379
	.766	×	1.00	=	.766
	.676	×	1.00	=	.676
	.593	×	1.00	=	.593
	.541	×	1.00	=	.541
	.517	×	1.00	=	.517
	.492	×	1.00	=	.492
	.467	×	1.00	=	.467
	.440	×	1.00	=	.440
	.425	×	1.00	=	.425
	.413	×	1.00	=	.413
	.405	×	1.00	=	.405
	.401	×	.915	=	.367

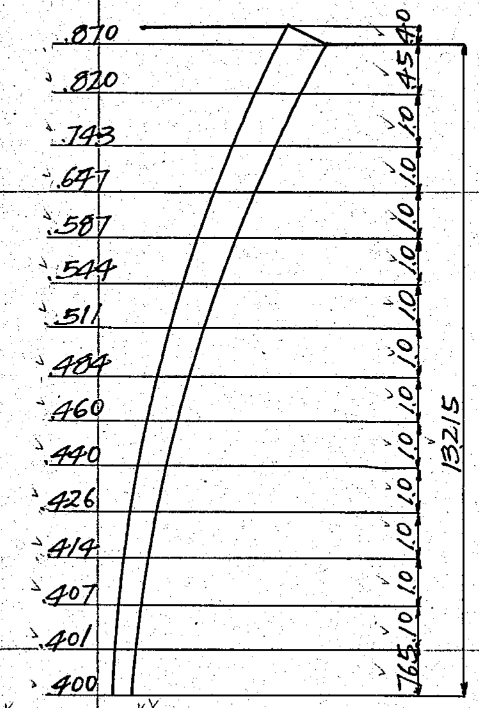


6.655 × 4 = 26.620

Concrete for Span no. 2 = 26.620 × 4.25 = 113.14 cub. meters

Span no. 3

	mean thickness		length		area
½ ×	.870	×	.40	=	.174
	.845	×	.45	=	.380
	.782	×	1.00	=	.782
	.695	×	1.00	=	.695
	.617	×	1.00	=	.617
	.566	×	1.00	=	.566
	.528	×	1.00	=	.528
	.498	×	1.00	=	.498
	.472	×	1.00	=	.472
	.450	×	1.00	=	.450
	.433	×	1.00	=	.433
	.420	×	1.00	=	.420
	.411	×	1.00	=	.411
	.404	×	1.00	=	.404
	.401	×	.765	=	.307



7.137 × 4 = 28.548

Concrete for Span no. 3 = 28.548 × 4.25 = 121.33 cub. meters

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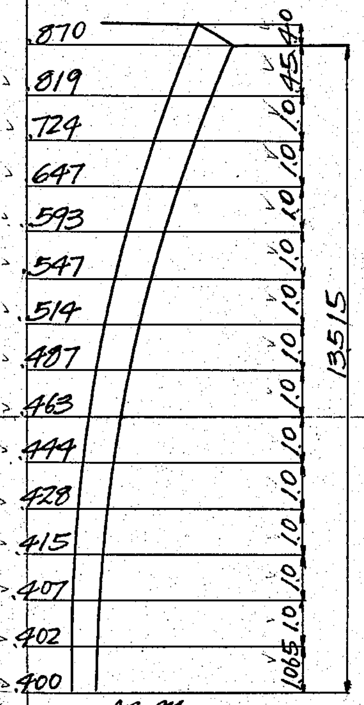
CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Span no. 4

	mean thickness		length		area
½ ×	.870	×	.40	=	.174
	.845	×	.45	=	.380
	.772	×	1.00	=	.772
	.686	×	1.00	=	.686
	.620	×	1.00	=	.620
	.570	×	1.00	=	.570
	.531	×	1.00	=	.531
	.501	×	1.00	=	.501
	.475	×	1.00	=	.475
	.454	×	1.00	=	.454
	.436	×	1.00	=	.436
	.422	×	1.00	=	.422
	.411	×	1.00	=	.411
	.405	×	1.00	=	.405
	.401	×	1.065	=	.427



7.264 × 4 = 29.056 sq. m

Concrete for Span no. 4 = 29.056 × 4.25 = 123.49 cub. meters

Total Concrete for Arch Ring

Span no. 1 2 @ 102.20 = 204.40
no. 2 2 @ 113.14 = 226.28
no. 3 2 @ 121.33 = 242.66
no. 4 1 @ 123.49 = 123.49

796.83 cub. meters

Forms

area for 1 span

Span no. 1 Same as area for concrete 8 @ 6.012 = 48.10 × 2 = 96.20
no. 2 " 8 @ 6.655 = 53.24 × 2 = 106.48
no. 3 " 8 @ 7.137 = 57.05 × 2 = 114.10
no. 4 " 8 @ 7.264 = 58.11 × 1 = 58.11

Total Forms of Arch Ring = 374.89 sq. meters

Reinforcements

Span no. 1 2 @ 10,866.2 = 21,732.4
no. 2 2 @ 12,034.6 = 24,069.2
no. 3 2 @ 12,656.2 = 25,312.4
no. 4 1 @ 12,858.8 = 12,858.8

83,972.8 Kgs

人造洗出仕上

Span no. 1 side area, same as for concrete 4 @ 6.012 = 24.048
upper face 4 @ .25 × 7.12 = 7.120
lower face 4 @ .25 × 11.61 = 11.610

42.778 @ 2 = 85.556 sq. meters

Span no. 2 side area same as for concrete 4 @ 6.655 = 26.620
upper face 4 @ .25 × 7.14 = 7.140
lower face 4 @ .25 × 12.94 = 12.940

46.700 @ 2 = 93.400 sq. meters

Span no. 3 side area same as for concrete 4 @ 7.137 = 28.548
upper face 4 @ .25 × 7.16 = 7.160
lower face 4 @ .25 × 13.82 = 13.820

49.528 @ 2 = 99.056 sq. meters

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

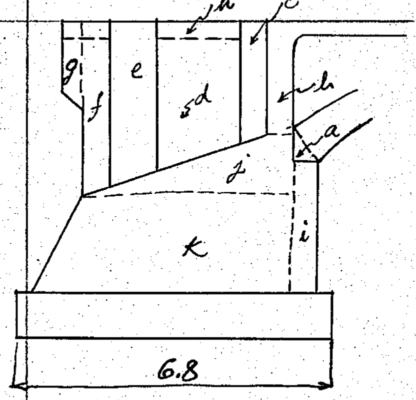
Span no. 4 side same as for Concrete	4 @ 7.264 = 29.056		
upper face	4 @ .25 × 7.19 = 7.190		
lower face	4 @ .25 × 14.13 = 14.130		
	50.376 @ 1 = 50.376	sq. meters	

人造洗出仕上合計 328.388 sq. meters

Abutment A (South side)

concrete 1:2:4 mixture

Springing a	2 × ½ × .70 × .40 × 4.25 =	1.19	
parapet b	.40 × 2.483 × 11.00 =	10.93	
front col. c	2 × .90 × .90 × 2.72 =	4.41	
wing wall d	2 × .35 × 1.70 × 3.32 =	3.95	
rear col. e	2 × 1.30 × 1.30 × 4.10 =	13.86	
wing f	2 × .40 × .75 × 4.53 =	2.72	38.82
〃 g	2 × .35 × .75 × 1.16 =	.61	
top of wall h	2 × .31 × .55 × 2.45 =	.84	
coping	2 × .09 × .25 × 3.65 =	.16	
ornaments	8 × .20 × .20 × .46 =	.15	
body i	.40 × 2.81 × 12.80 =	14.39	
〃 j	2 × 2.00 × 2.35 × 5.80 =	54.52	
〃 K	2 × 1.342 × 5.00 × 5.80 =	77.84	
Rear col. lower	2 × .40 × 1.70 × 1.87 =	2.54	
footing	1.20 × 6.80 × 13.60 =	110.98	
front wall	0.40 × 3.34 × 1.20 =	1.60	
		300.69	cub. meters



Forms

Springing a	4 × ½ × .70 × .40 =	.56	
propet b front	2 × 2.10 × 4.25 =	17.85	
less fascia	2 × .25 × .35 = (−)	.18	
propet b front	1.65 × 2.87 =	4.74	
〃	2 × .425 × 2.93 =	2.49	
〃 rear	2.60 × 11.00 =	28.60	
front col. c front	2 × .90 × 2.91 =	5.24	
〃 outside	2 × .40 × 2.37 =	1.90	
〃 inside	2 × .50 × 2.75 =	2.75	
〃 rear	2 × .55 × 2.63 =	2.89	
wing wall d outside	2 × 2.20 × 2.94 =	12.94	
〃 inside	2 × 1.70 × 3.07 -	10.44	148.13
rear col. e & f out	2 × 1.70 × 4.19 =	14.25	
〃 e outer front	2 × .40 × 3.76 =	3.01	
〃 inner front	2 × .55 × 3.41 =	3.75	
〃 〃 rear	2 × .55 × 4.08 =	4.49	
〃 〃 side	2 × 1.30 × 3.91 =	10.17	
wing f inside	2 × .40 × 4.12 =	3.30	
〃 g outside	2 × .35 × 1.16 =	.81	
〃 inside	2 × .35 × .75 =	.53	
〃 rear	2 × .75 × 5.15 -	7.73	
top wall h	2 × .82 × 2.45 -	4.02	
〃 rear	2 × .31 × .55 =	.34	
coping	2 × .39 × 3.60 =	2.81	
ornaments	8 × .45 × .75 =	2.70	
body i front	2.81 × 12.80 =	35.97	
〃 side	2 × .40 × 2.81 -	2.25	
〃 j outside	2 × 2.00 × 2.35 =	9.40	
〃 inside	2 × ½ × 2.00 × 3.90 =	7.80	

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CALCULATIONS FOR

Materials of Shinobu-Boshi for Fukushima-Ken

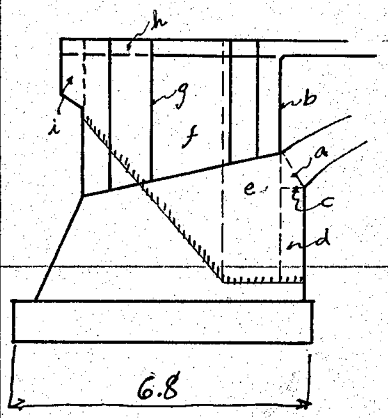
Body K outside 2 × 1.342 × 5.00 = 13.42
 〃 inside 2 × 1.342 × 4.60 = 12.35
 〃 rear 2 × 1.95 × 5.80 = 22.62
front wall rear 1.20 × 3.34 = 4.01
rear col. e 4 × .40 × 1.87 = 2.99
footing front & rear 2 × 1.20 × 13.60 = 32.64
 〃 side 2 × 1.20 × 6.80 = 16.32
307.90 sq. meters

Reinforcements plain bars 69.312 Kg tons

踏掛石 16ヶ @ .20 × .20 × .68 = .435 cub. meters

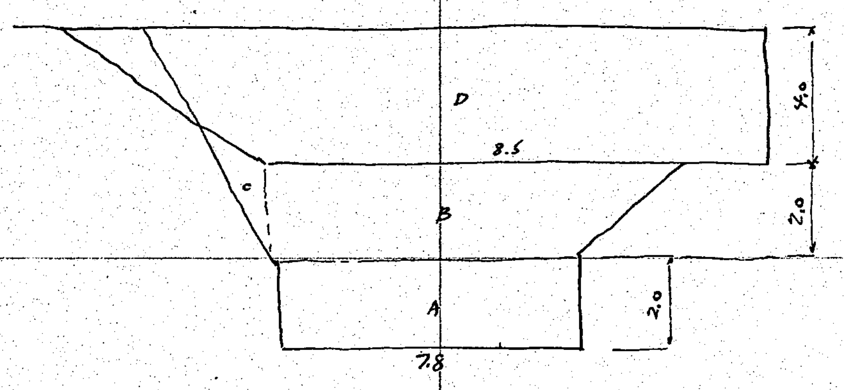
人造洗出仕上

Springing a 2 × ½ × .70 × .40 = .280
front b 2 × 1.625 × 5.100 = 16.575
less fascia girder 2 × .25 × .50 = (−) .250
 〃 haunch 2 × .30 × .70 = (−) .420
front c 2 × .40 × 1.325 = 1.060
ornaments 16 × .27 × .46 = 1.987
side d 2 × .40 × 2.81 = 2.248
 〃 e 2 × 2.10 × 5.03 = 21.126
 〃 f 2 × 3.28 × 2.20 = 14.432
Coping 2 × .39 × 3.60 = 2.808
rear col. g. front 2 × .40 × 4.35 = 3.480
 〃 upper h 2 × .25 × 1.70 = .850
 〃 i side 2 × .35 × 1.16 = .812
64.988 sq. meters



Foundation piles 21cmφ at tip 5.0m long 65 piles required

Excavation.



A 7.8 × 14.6 × 2.0 = 228.
B 8.8 × 16.6 × 2.0 = 292.
C 3.0 × .6 × 17.6 = 32
D 9.5 × 4.0 × 7.0 = 266
590
818 m³

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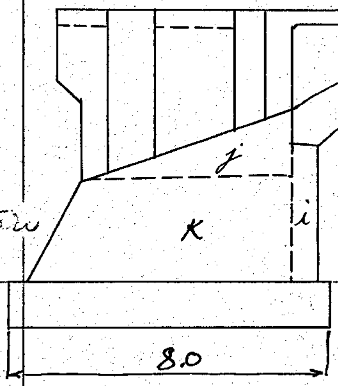
CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Abutments B (North side).

Concrete 1:2:4 mixture

Same parts for abutment A = 38.82
body i .40 × 3.81 × 12.80 = 19.51
" j 2 × 2.00 × 2.35 × 5.80 = 54.52
" K 2 × 2.342 × 5.60 × 5.80 = 152.14
Rear col. lower 2 × .40 × 1.70 × 2.87 = 3.90
footing 1.20 × 8.00 × 13.60 = 130.56
front wall 0.40 × 4.34 × 1.20 = 2.08 ~~399.45 cub. meter~~
401.53 cub. m



Forms

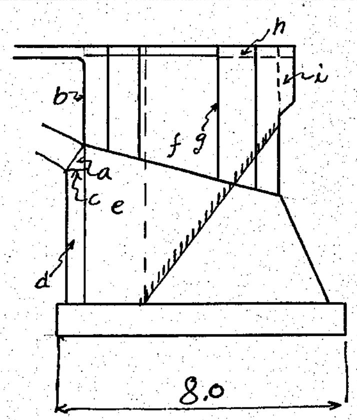
Same parts for abutment A = 148.13
body i front 3.81 × 12.80 = 48.77
" side 2 × .40 × 3.81 = 3.05
" j outside 2 × 2.00 × 2.35 = 9.40
" inside 2 × ½ × 2.00 × 3.90 = 7.80
" K outside 2 × 2.342 × 5.60 = 26.23
" inside 2 × 2.342 × 5.20 = 24.36
front wall rear 1.20 × 4.34 = 5.21
body K rear 2 × 3.52 × 5.80 = 40.83
rear col. e 4 × .40 × 2.87 = 4.59
footing front + Rear 2 × 1.20 × 13.60 = 32.64
" side 2 × 1.20 × 8.00 = 19.20
370.21 sq. meters

Reinforcements plain bars 7.7341 Kg. tons

踏掛石 16ヶ c .20 × .20 × .68 = .435 cub. meter

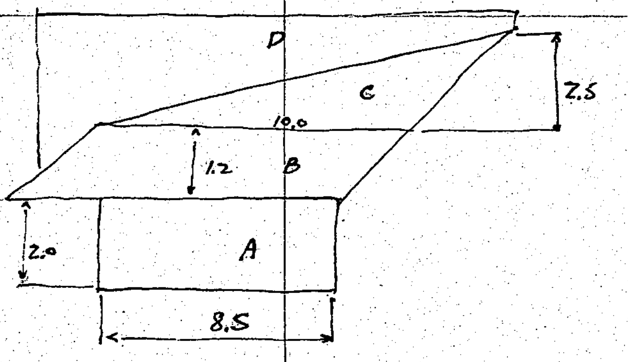
人造洗出仕上

Springing a 2 × ½ × .70 × .40 = .280
front b 2 × 1.625 × 6.715 = 21.824
less fascia girder 2 × .25 × .50 = (−) .250
" haunch 2 × .30 × .70 = (−) .420
front c 2 × .40 × 1.325 = 1.060
ornaments 16 × .27 × .46 = 1.987
side d 2 × .40 × 3.81 = 3.048
" e 2 × 1.10 × 6.715 = 14.773
" f 2 × 3.20 × 3.96 = 25.344
coping 2 × .39 × 3.60 = 2.808
rear col. g. front 2 × .40 × 4.40 = 3.520
" h 2 × .25 × 1.70 = .850
" side i 2 × .35 × 1.16 = .812
75.636 sq. meters



Foundation piles 21cmφ at tip 5.0m long 78 piles required.
捨矢板 米松厚ニ 7.5cm 長 4.5m 延長 = 29.6 meters.

Excavation. (Rough approximation)



A 8.5 × 14.6 × 2 = 248.
B 10 × 1.2 × 15.8 = 189.5
C 10 × 1.25 × 16.6 = 207.5
D 12 × 15.0 × 2.5 = 450.0
847.0
1095.0 cub. m.

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Piers no. 1, 2, & 4

Shaft Concrete 1 : 2 : 4 mixture

haunch 1.20 × .68 × .85 = 6.94
〃 1.40 × .10 × 1.65 = .23
〃 ½ × 1.40 × .25 × 1.65 = .29
ornaments 2 × .275 × 1.40 × .43 = .33
shaft 1.94 × 4.01 × 10.15 = 78.96
shaft both end 2 area 2.30 × 3.41 = 15.69
less volumes of facing stones = (−) 7.98
bottom projection 2 × .525 × 2.31 = 2.43
〃 2 area 2.53 × .60 = 3.04
shaft 2.525 × 1.70 × 11.20 = 48.08
footing 1.80 × 6.70 × 11.20 = 135.07
less partition wall 2.50 × .35 × 11.20 = (−) 9.80
〃 2 × ½ × 1.00 × .35 × 1.00 = (−) .35
〃 2 × 1.80 × .35 × 6.35 = (−) 8.00
〃 2 × .70 × .35 × 2.32 = (−) 1.14
fillet less 6 × .05 × .05 × 1.80 = (−) .03
〃 2 × .05 × .05 × 3.50 = (−) .02
〃 4 × .05 × .05 × 2.50 = (−) .03

263.71 cub. meters

Shaft Forms haunch 2 × .10 × 1.65 = .33
〃 side ½ × 4 × .25 × .50 = .25
〃 2 × 1.10 × .53 = 1.17
ornaments 2 × .10 × 3.02 = .60
shaft 2 × 4.01 × 10.15 = 81.40
less facing stone 20 × .20 × .30 = (−) 1.20
projection side 2 × .60 × 5.20 = 6.24
〃 bottom 2 × area 1.75 = 3.50
shaft bottom 2 × 1.70 × 10.50 = 35.70

127.99 sq. meters

shaft 人造洗出仕上

haunch sides 4 × ½ × .25 × .50 = .25
ornaments 2 × area 2.53 = 5.06

5.31 sq. meters

shaft Reinforcements plain bars 8.2454 Kg. tons

Facing stones 7.984 cub. meters

Well

Concrete 1 : 2 : 4 mixture

side wall 2 × .40 × 5.30 × 12.00 = 50.88
〃 2 × .40 × 5.30 × 6.70 = 28.41
partition wall .35 × 3.90 × 11.20 = 15.29
〃 2 × .35 × 3.90 × 6.35 = 17.34
〃 6 × .35 × .50 × 1.00 = 1.05
〃 6 × .35 × .10 × .50 = .11
fillets 8 × .05 × .05 × 4.90 = .10
4 × .05 × .05 × 3.90 = .04

113.22 cub. meters

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Concrete Fill (1:2:4 mixture)

7.50 × 2.00 × 12.00 = 180.00
less 2 × .40 × 1.80 × 12.00 =(-) 17.28
" 2 × .40 × 1.80 × 6.70 =(-) 9.65
" 2 × .35 × 1.40 × 6.35 =(-) 6.22
" .35 × 1.40 × 11.20 =(-) 5.49
" 6 × .35 × .10 × .50 =(-) .11
" fillet 12 × .05 × .05 × 1.60 =(-) .05
141.20 cub. meters

Forms

well shell outside 2 × 5.10 × 12.00 = 122.40
" " 2 × 5.10 × 7.50 = 76.50
" inside 6 × 3.50 × 5.35 = 112.35
" " 4 × 3.175 × 5.35 = 67.95
partition wall 6 × 3.50 × 3.90 = 81.90
" 8 × 3.175 × 3.90 = 99.06
" 6 × 1.00 × 1.00 = 6.00
" 6 × .20 × .50 = .60
" bottom .35 × 11.20 = 3.92
" 2 × .35 × 6.35 = 4.45
575.13 sq. meters

Reinforcements, plain bars 5.0342 Kg. tons

Steel for Curb shoe with anchor bolts 3.7245 Kg. tons

2.1716 ヲ訂正ス(6-12-29)

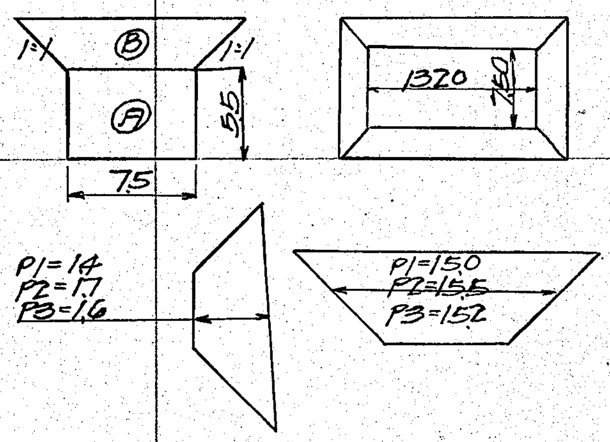
Rubble Stones (filling)

2 × 2.07 × 1.70 × 11.20 = 78.8
less partition walls 4 × .35 × .70 × 2.02 =(-) 2.0
" 2 × 1.00 × .35 × 1.00 =(-) 0.7
76.1 cub. meters

Drain hole cover (cast iron) @ 0.5923 Kgs 2-Req'd for one pier
Drain pipe 4"ϕ × 2.50 meter long 2-Req'd " " "

Excavation

volume A = 5.5 × 7.5 × 12.0 = 495.0 cub. meters



Piers no.	volume B		projection		total		volume A		
P1	8.9 × 1.4 × 15.0	+	8.0	=	194.9	+	495.0	=	689.9 cub. m
P2	9.2 × 1.7 × 15.5	+	9.6	=	252.0	+	"	=	747.0
P4	9.1 × 1.6 × 15.2	+	9.0	=	230.2	+	"	=	725.2

average of P1 & P4 = 707.6 cub. meters

Foundation piles

pier no. 2 18cmϕ at tip 5.5m long 54 piles required
no. 1 & 4 18cmϕ at tip 7.0m long " " "

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Piers no. P3. P5. & P6

Concretes 1:2:4 mixture

Haunch 1.20 × .68 × 8.50 = 6.94
" 1.40 × .10 × 1.65 = .23
" ½ × 1.40 × .25 × 1.65 = .29
Ornaments 2 × .275 × 1.40 × .43 = .33
Shaft upper 1.94 × 3.41 × 10.15 = 67.15
" " both end 2 × Area 2.30 × 3.41 = 15.69
less Volumes of facing stone = (−) 7.98
Shaft lower 2.542 × 2.60 × 10.15 = 67.08
" " both end 2 × Area 4.32 × 2.60 = 22.46
Base 4.202 × 1.00 × 14.684 = 61.70
" 8.50 × 2.50 × 15.00 = 318.75

552.64 cub. meters

Forms

Haunch 2 × .10 × 1.65 = .33
" side 4 × ½ × .25 × .50 = .25
" " 2 × 1.10 × .53 = 1.17
Ornaments 2 × .10 × 3.02 = .60
Shaft side 2 × 6.01 × 10.15 = 122.00
Facing stone less 20 × .20 × .30 = (−) 1.20
Shaft both end 2 × 2.60 × 5.25 = 27.30
Base side 2 × 1.00 × 4.20 = 8.40
" " 25 × 47.00 117.50

276.35 sq. meters

人造洗出仕上

Same as pier no. P1. P2. P4. = 7.52 sq. meters

Reinforcement plain bars = 9.9888 Kg. Tons

Facing stone (granite) = 7.984 cub. meters

捨締切 P3. P5 only 亨大桓長 3.60m = 延 45.0 米

松杭 P3. P5. 18cmφ at tip 7.0m long = 120 本
P6 18cmφ at tip 5.5m long = 120 本
鉄矢板 長八米 = 延 53.4 米

Drain pipe 4"φ × 2.50m long 2-Req'd for one pier

Excavation

Excavated area 9.7 × 16.2 = 157.1
.8 × 2.5 = 2.0
159.1

	area		average depth		
P3	159.1	×	6.33	= 1007.1	} average 1041.3 m³
P5	159.1	×	6.76	= 1075.5	
P6	159.1	×	6.67	= 1061.2	

average for One pier = 1047.9 cub. meter

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

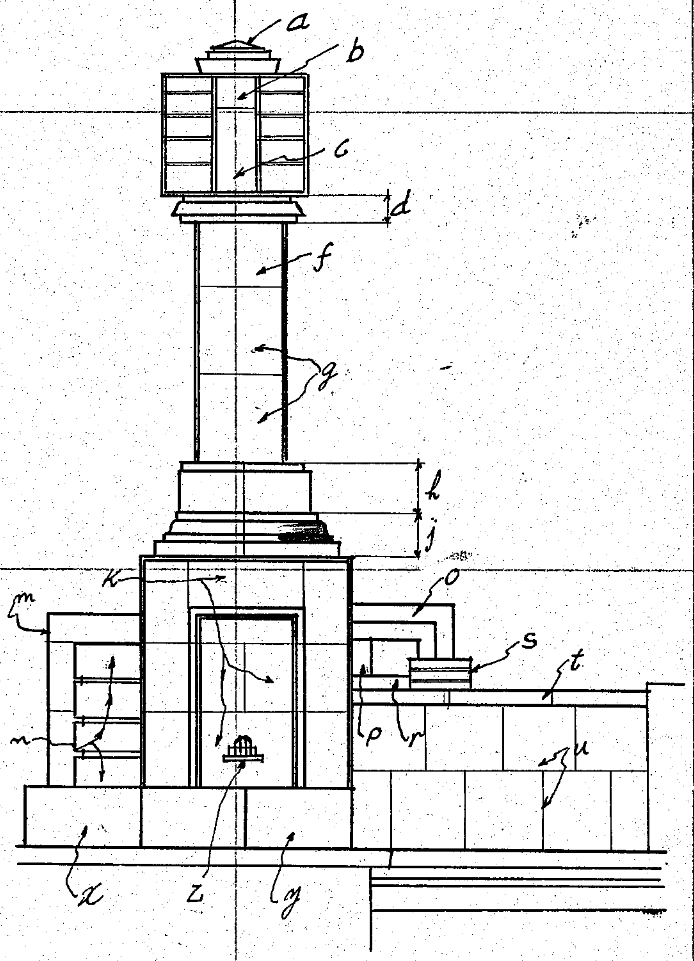
Material list of Shinobu-Bashi for Fukushima-ken

LIGHT PEDESTAL (親柱) 4 Required

Stone (花崗石)

a. 1 - 64 × 64 × 20 = .082
b. 1 - 60 × 60 × 35 = .126
c. 4 - 40 × 20 × 57 = .183
d 4 - 33.5 × 33.5 × 20 = .090
f 4 - 43 × 14 × 35 = .084
g 8 - 43 × 14 × 55 = .265
h 4 - 32 × 32 × 38 = .156
j 4 - 47.5 × 47.5 × 27 = .244
K {12 - 39 × 23 × 55 = .592
  6 - 39 × 23 × 64 = .344
m {1 - 46 × 13 × 55 = .033
  2 - 40 × 23 × 55 = .101
  2 - 37 × 27.5 × 46 = .094
n {2 - 17 × 17 × 38 = .022
  6 - 20 × 17 × 38 = .078
o 1 - 24 × 17 × 40 = .016
p 1 - 15 × 9 × 18 = .002
r 1 - 18 × 7 × 20 = .003
s 1 - 14 × 26 × 30 = .011
x 2 - 48 × 23 × 65 = .144
y {4 - 23 × 20 × 55 = .101
  2 - 23 × 20 × 70 = .064
Z 2 - 9 × 6 × 16 = .002

2.837 cub. m.



Concrete (親柱)

0.7 × 0.7 × 1.65 = .81 m^3
0.3 × 0.3 × 2.8 .25

1.06 cub. m.

Steel bar ~~(親柱)~~

4 Bars 1.6φ 1.57 × 4.5 m = 28.26
11 " .9φ .49 × .85 4.58

32.84 kgs

Gas pipe of Electric Wiring ~~(親柱)~~

1 Gas pipe 2吋φ @ 5.434 kgs × 4.1 m = 22.28 kgs
1 " " 2½吋φ @ 8.620 × 1.2 = 10.34
4 " " 1吋φ @ 2.497 × 0.25 = 2.50
1 Cast iron cross @ 1.37 = 1.37
1 Gas pipe 1吋φ @ 2.497 × 0.60 = 1.50
1 Cast iron tee @ .98 .98

38.97 kgs.

Material List of Shinobu Bashi for Fukushima ken.

Light pedestal continued.

Bronze fixture for Lamps. 4 Required.
4 Bronze fixtures @ 36.0 kgs = 144.0 kgs.
8 Steel anchor bolts .9ϕ × 20
24 Bronze screws .7ϕ × 3.5 } accessories
4 anchor " .9ϕ × 6.

Bronze ornaments at bottom of post 4 Required.
1 set of bronze frame. 24.0 Kgs.
8 Bronze anchor screws .9ϕ × 6

Bronze fixture for Bottom Lamp. 4 Required.
1 Set of bronze frame 0.74 kg

Bronze Name plate 4 Required
Show the Bridge name for 2 plates.
" " date of completion " 2 "
1 plate wt. of bronze 10.0 kgs.

Glass plates for Lamps. 4 Required.

Top Lamps.	4 milk-white plates	62cm × 50cm	bent	outside	} all 5mm thick.
	4 "	62 × 35	"	"	
	8 "	13 × 18	Straight	bottom	
	4 "	18 × 18	"	"	
	8 "	85 × 13	"	inside	
Bottom Lamp.	2 Morocco-glass plate.	14 × 12	plane		4mm thick

副柱.
Granite blocks.
2 - 23 × 15 × 54 = .037
4 - 23 × 15 × 42 = .058
1 - 75 × 19 × 84 = .120
4 - 39 × 15 × 37.5 = .088
2 - 39 × 15 × 54 = .063
4 - 36 × 15 × 42 = .091
2 - 36 × 15 × 45 = .049
2 - 7 × 5 × 15 = .001
.412 cub m.

Concrete. 1:2:4 mix.
0.45 × .55 × .95 = .240 cub m.

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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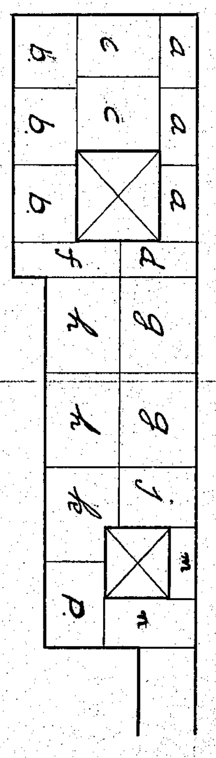
CALCULATIONS FOR

material list of Shinobu-Bashi for Fukushima-ken

袖高欄 及 コーピング 花崗石 4 Required.

3 - 35 × 13 × 62.5	=	.085	t. Handrail
7 - 36 × 20 × 47	=	.237	u.{ "
2 - 24 × 20 × 36	=	.035	"
3 - 30 × 16 × 60	=	.086	a. Coping stone
3 - 37 × 15 × 60	=	.100	b. " "
2 - 53 × 16 × 70	=	.119	c " "
1 - 37 × 16 × 65	=	.038	d " "
1 - 37 × 15 × 72	=	.040	f " "
2 - 65 × 16 × 70	=	.140	g " "
2 - 46 × 15 × 70	=	.090	h " "
1 - 40 × 16 × 65	=	.042	j " "
1 - 46 × 15 × 68	=	.047	k " "
1 - 16 × 15 × 55	=	.013	m " "
1 - 40 × 16 × 73	=	.047	n " "
1 - 38 × 15 × 66	=	.038	p " "
		1.169 cub.m.	



LAMP POST on PIER. 花崗石 12 Required

1 - 75 × 19 × 75.5	=	.107	Stone (花崗石)
~~2 - 22 × 19 × 31.0~~	~~=~~	~~.026~~	" "
8 - 37.5 × 15 × 38.5	=	.173	" "
4 - 37.5 × 15 × 44.0	=	.099	" "
1 - 7 × 5 18.0	=	.001	" "
		.38	

CONCRETE For LAMP POST ON PIER.

0.39 × 0.39 × 1.10 = 0.17 m³
.17 m³

STEEL BARS FOR LAMP POST ON PIER.

8 Bars 16φ 1.57 × 1.8m = 22.61
4 " 9φ .49 × 1.45 = 2.84
25.45 kg

GAS PIPE OF ELECTRIC WIRING FOR LAMP POST ON PIER

1 Gas pipe 2吋φ @ 5.434 × 1.3m = 7.06
1 " " 2½吋φ @ 8.620 × 1.0 = 8.62
15.68 kgs.

LAMP POST ON PIER. Casting + accessories 12 Required.

1 Cast iron post. @ 600.0 = 600.0
1 " " cap @ 60.0 60.0
4 Anchor bolts 1.3φ × 30 @ .36 1.44
4 Screws 0.7φ × 10 @ .03 0.12
661.56 kgs

4 Bronze Lamps @ 22.0 = 88.0 kgs
12 Steel screws .7φ × 10 } accessories.
24 Bronze " .7φ × 2.5

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CALCULATIONS FOR

material list of shinobu-bashi for Fukushima-ken

GLASS FOR LAMP (中間電燈柱用) 12 Required

8 乳白色厚五粍ガラス 延長 34 × 中 31
4 " 12 × 12
8 " 10 × 64

HANDRAIL & COPING STONE 石材表 (片側分) 2 Required 花崗石.

Handrail H1. 3 - 36 × 16 × 67 = .116 Coping stones
2 - 16 × 11 × 80 = .028 Bottom rails
2 - 26 × 13 × 100 = .068 Top rails.
.212 × 52 = 11.024 cub.m.

H2 3 - 36 × 16 × 61 = .105
2 - 16 × 11 × 72 = .025
2 - 26 × 13 × 92 = .062
.192 × 8 = 1.536

H3 3 - 36 × 16 × 65 = .112
2 - 16 × 11 × 77 = .027
2 - 26 × 13 × 97 = .066
.205 × 6 = 1.230

H4. 3 - 36 × 16 × 63 = .109
2 - 16 × 11 × 74 = .026
2 - 26 × 13 × 94 = .064
.199 × 8 = 1.592

H5 3 - 36 × 16 × 68 = .118
2 - 16 × 11 × 82 = .029
2 - 26 × 13 × 102 = .069
.216 × 4 = .864

H6 1 - 36 × 16 × 47 = .027
2 - 36 × 16 × 63 = .073
2 - 16 × 11 × 74 = .026
2 - 26 × 13 × 94 = .064
.190 × 12 = 2.280

H6A 3 - 36 × 16 × 53 = .092
2 - 16 × 11 × 74 = .026
2 - 26 × 13 × 94 = .064
.182 × 2 = .264

HANDRAIL POST 1 - 40 × 22 × 72 = .063 × 57 = 3.591

HANDRAIL HALF POST. 1 - 22 × 20 × 72 = .032 × 70 = 2.240

COPING STONE UNDER LAMP POST
2 - 33 × 16 × 60 = .063
2 - 33 × 15 × 53 = .052
1 - 21 × 16 × 39 = .013
.128 × 6 = .768
(片側分) 25.389 cub.m.

増田淳氏関係資料
（独立行政法人 土木研究所蔵）

MADE BY I.M. DATE 5-3-24 **FILE NO**

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CALCULATIONS FOR

material list of shinobu-bashi for Fukushima-Ken

GRATE OF HANDRAILS H1.H2.H3.H4.H5.H6 & H6A (片側分) 2 Required

52	H1	cast iron.	@	130	6,760.00	
8	H2	" "	@	122	976.00	
6	H3	" "	@	127	762.00	
8	H4	" "	@	124	992.00	
4	H5	" "	@	131	524.00	
14	H6 & 6A	" "	@	124	1,736.00	
						11,750.00 Kgs (片側分)

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Materials of Centering for Span no. 1
木材表

				unit volume	Total volume	Remarks
	115	planks	20×6×500	= 0.060	6.900	米松
	4	〃 } 箱	30×6×500	= 0.090	0.360	〃
	4	〃 } 箱	20×6×500	= 0.060	0.240	〃
					7.50 cul.m.	
	8	上弦材	30×15×350	= 0.158	1.264	米松
	16	〃	〃 ×470	= 0.212	3.392	〃
	2	〃	30×10×350	= 0.105	0.210	〃
	4	〃	30×10×470	= 0.141	0.564	〃
	8	華直材	20×20×140	= 0.056	0.448	〃
	8	〃	〃 ×100	= 0.040	0.320	〃
	8	〃	〃 ×200	= 0.080	0.640	〃
	4	〃	〃 ×220	= 0.088	0.352	〃
	4	〃	〃 ×110	= 0.044	0.176	〃
	4	〃	〃 ×50	= 0.020	0.080	〃
	4	斜材	15×15×180	= 0.041	0.164	〃
	8	〃	〃 ×230	= 0.052	0.416	〃
	8	〃	〃 ×240	= 0.054	0.432	〃
	16	〃	〃 ×280	= 0.063	1.008	〃
※	4	下弦材	25×20×335	= 0.168	0.672	〃
	4	下弦材及継木	25×20×345	= 0.173	0.692	〃
	8	〃	〃 ×380	= 0.190	1.520	〃
	16	〃	〃 ×510	= 0.255	4.080	〃
	8	〃	〃 ×440	= 0.220	1.760	〃
	8	〃	〃 ×230	= 0.115	0.920	〃
	24	肘木	25×15×60	= 0.023	0.552	〃
	4	〃	〃 ×40	= 0.015	0.060	〃
	4	〃	25×20×60	= 0.030	0.120	〃
					19.842 cul. m	
	6	筋違	15×9×175	= 0.024	0.144	米松
	12	〃	〃 ×220	= 0.030	0.360	〃
	6	〃	〃 ×205	= 0.028	0.168	〃
※	8	挟槓	15×9×160	= 0.022	0.176	〃
※	8	挟槓	15×9×255	= 0.034	0.272	〃
※	8	〃	〃 ×85	= 0.011	0.088	〃
	12	筋違(杭用)	〃 ×440	= 0.059	0.708	〃
	3	〃	〃 ×190	= 0.026	0.078	〃
	3	梁	20×20×545	= 0.218	0.654	〃
	6	〃	20×15×545	= 0.164	0.984	〃
	12	〃	〃 ×450	= 0.135	1.620	〃
※	14	挟槓及槓	15×9×450	= 0.061	0.854	〃
	36	猫木	15×10×20	= 0.003	0.108	〃
	12	楔	20×15×25	= 0.008	0.096	〃
					6.310 cul. m	
					米松材料 33.652 cul. meters	
	96	楔	20×11×40	= 0.009	0.864 cul. m	樫

米印ヲ除ク部分ハ径間第七号ト共通ナリ（共通部分合計二四七六二五方米）

杭（内地産赤松）

4	支柱	18φ	×180
8	〃	〃	×400
4	〃	〃	×270
12	杭	〃	×550
4	〃	〃	×640
5	塵芥除杭	〃	×460

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Sand Box. (附属品木部) 28 Required

1	25φ × 25	@ 0.012	.012	
2	30φ × 25	@ 0.002	.004	
2	35φ × 5	@ 0.00005	.0001	
				0.016 cub.meters

Sand Box (附属品金物部) 28 Required

1	Pl. (sand box)	400mm × 6mm × 990mm	@ 18.6517	18.6517	
4	釘 五寸釘 sand box 取付ニ使用		@ 0.0235	0.0940	
1	亜鉛鍍金鋲	90φ no. 30 B.W.G.	@ 1.9408	1.9408	
					20.6865 kgs

ボールト及鋲等

					ボールト	鋲	平鋼	釘
36	上弦材締付用	22mmφ	× 350mm	@ 1.3020 kgs	46.8720			
72	上弦材ト斜材締付用	〃	× 280	@ 1.0944	78.7968			
36	下弦材ト斜材締付用	〃	× 450	@ 1.6010	57.6360			
16	垂直材締付用	〃	× 500	@ 1.7500	28.0000			
64	垂直材ト下弦材金物ニテ締付用	〃	× 320	@ 1.2136	77.6704			
72	下弦材継手用	〃	× 250	@ 1.0050	72.3600			
32	継手金物 凸	100 × 9	× 400	@ 2.8260			90.432	
24	筋違ト垂直材締付用	19φ	× 340	@ 0.9348	22.4352			
12	〃	〃	× 430	@ 1.1346	13.6152			
62	抗ト筋違締付用	〃	× 390	@ 1.0458	64.8396			
52	〃	〃	× 470	@ 1.2234	63.6168			
9	上弦材締付用	22φ	× 250	@ 1.0050	9.0450			
28	砂箱上部締付用	19φ	× 375	@ 1.0125	28.3500			
	手違鋲長サ5寸					232		
	正 鋲					372		
820	ボールト座金(22φト19φ用)	50φ	× 3	@ .0462	37.9086			
	五寸釘			@ .0235				30.00
					601.1456 kgs	604本	90.432 kgs	30.00 kgs

arch ring 側面型枠 24.05 sq.m. see page no. 106

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Materials of Centering for Span no. 2
木材表

			Unit Volume	Total Volume	Remarks
127	Planks	20 × 6 × 500	= 0.060	7.620	米松
4	〃 } 箱	30 × 6 × 500	= 0.090	0.360	〃
4	〃	20 × 6 × 500	= 0.060	0.240	〃
				8.220 cub. meters	
8	上弦材	30 × 15 × 350	= 0.158	1.264	米松
8	〃	〃 × 470	= 0.212	1.696	〃
8	〃	〃 × 500	= 0.225	1.800	〃
4	〃	〃 × 260	= 0.117	0.468	〃
2	〃	30 × 10 × 350	= 0.105	0.210	〃
2	〃	〃 × 470	= 0.141	0.282	〃
2	〃	〃 × 500	= 0.150	0.300	〃
1	〃	〃 × 260	= 0.078	0.078	〃
8	垂直材	20 × 20 × 50	= 0.020	0.160	〃
8	〃	〃 × 110	= 0.044	0.352	〃
8	〃	〃 × 140	= 0.056	0.448	〃
8	〃	〃 × 100	= 0.040	0.320	〃
8	〃	〃 × 200	= 0.080	0.640	〃
8	〃	〃 × 240	= 0.096	0.768	〃
8	斜材	15 × 15 × 240	= 0.054	0.432	〃
8	〃	〃 × 255	= 0.057	0.456	〃
16	〃	〃 × 310	= 0.070	1.120	〃
8	〃	15 × 9 × 300	= 0.041	0.328	〃
8	下弦材	25 × 20 × 335	= 0.168	1.344	〃
8	〃	〃 380	= 0.190	1.520	〃
16	〃	〃 510	= 0.255	4.080	〃
16	〃	〃 440	= 0.220	3.520	〃
32	肘木	25 × 15 × 60	= 0.023	0.736	〃
8	〃	25 × 20 × 60	= 0.030	0.240	〃
				22.562 cub. meters	
12	筋違	15 × 9 × 195	= 0.026	0.312	米松
12	〃	〃 × 220	= 0.030	0.360	〃
6	〃	〃 × 175	= 0.024	0.144	〃
16	〃 (杭用)	15 × 9 × 440	= 0.059	0.944	〃
32	猫木	15 × 10 × 20	= 0.003	0.096	〃
				1.856 cub. meters	
18	挟槓	15 × 9 × 450	= 0.061	1.098	米松
16	〃	〃 × 160	= 0.022	0.352	〃
16	〃	〃 × 255	= 0.034	0.544	〃
16	〃	〃 × 85	= 0.011	0.176	〃
16	楔	20 × 15 × 25	= 0.008	0.128	〃
8	梁	20 × 15 × 545	= 0.164	1.312	〃
2	〃	20 × 20 × 545	= 0.218	0.436	〃
14	〃	20 × 15 × 450	= 0.135	1.890	〃
				5.936	
				米松材料合計 38.574 cub. meters	
112	楔	20 × 11 × 40	= 0.009	1.008 cub. m.	樫

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

杭 (内地産赤松)

16	支柱	18^{ϕ} cm.	× 460
8	〃	〃	× 270
4	杭	〃	× 600
12	〃	〃	× 500
6	塵芥除杭	〃	× 460

Sand Box (附属品) 木部 40 Req'd.

1	25^{ϕ} × 25	0.012	0.012	米松
2	30^{ϕ} × 2.5	0.002	0.004	〃
2	3.5^{ϕ} × 5.0	0.00005	0.0001	〃
			0.016 cub. meter.	

Sand Box (附属品) 鉄部 40 Req'd.

1	Pl. (Sand box)	400 mm. × 6 mm. × 990 mm.	@ 18.6517	18.6517
4	釘	五寸釘 sand box 取付用	@ 0.0235	0.0940
1	亜鉛メッキ鉄	90^{ϕ} no. 30. B.W.G.	@ 1.9408	1.9408
				20.6865 kgs.

ボールト及鎹等

					(ボールト及座金)	(鎹)	(平鋼)	(釘)
48	上弦材締付用	22^{ϕ} mm	× 350 mm	@ 1.3020	62.4960 kgs			
12	〃	〃	× 250	〃 1.0050	12.0600			
64	上弦材ト斜材締付用	〃	× 280	〃 1.0994	70.0416			
32	下弦材ト 〃	〃	× 450	〃 1.6010	51.2320			
16	垂直材ト 〃	〃	× 340	〃 1.3212	21.1392			
4	斜材交叉用	〃	× 430	〃 1.5894	6.3576			
16	垂直材締付用	〃	× 500	〃 1.7500	28.0000			
64	垂直材ト下弦材金物ニテ締付用	〃	× 320	〃 1.2136	77.6704			
72	下弦材継手用	〃	× 250	〃 1.0050	72.3600			
32	継手用金物 L	100 mm × 9 mm	× 400	〃 2.8260			90.432 kgs	
28	筋違ト垂直材締付用	19^{ϕ} mm.	× 340	〃 0.9348	26.1744			
16	〃	〃	× 430	〃 1.1346	18.1536			
72	杭ト筋違締付用	〃	× 390	〃 1.0458	75.2976			
88	〃 〃	〃	× 470	〃 1.2234	107.6592			
40	砂箱上部材締付用	〃	× 375	〃 1.0125	40.5000			
268	手違鎹長サ五寸					268 挺		
504	正鎹 五寸					504		
1100	ボールト座金 (22^{ϕ}, 19^{ϕ}用)	50 mmφ	× 3 mm.	@ 0.0462	50.8200			
	下弦材ニ取付用 五寸釘			@ 0.0235				35.0 kgs
					719.9616 kgs	772 挺	90.432 kgs	35.0 kgs

Arch ring 側面型枠 26.62 m² see page no. 106

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY I. M. DATE 5-4-7 FILE NO

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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

Materials of Centering for span no 3

木材表

135	Planks	20 × 6 × 500	0.060	8.100	米松
4	〃 } 箱	30 × 6 × 500	0.090	0.360	〃
4	〃	20 × 6 × 500	0.060	0.240	〃
				8.700	
8	上弦材	30 × 15 × 350	0.158	1.264	米松
8	〃	〃 〃 × 470	0.212	1.696	〃
8	〃	〃 〃 × 500	0.225	1.800	〃
4	〃	〃 〃 × 440	0.198	0.792	〃
2	〃	30 × 10 × 350	0.105	0.210	〃
2	〃	〃 〃 × 470	0.141	0.282	〃
2	〃	〃 〃 × 500	0.150	0.300	〃
1	〃	〃 〃 × 440	0.132	0.132	〃
8	垂直材	20 × 20 × 50	0.020	0.160	〃
8	〃	〃 〃 × 110	0.044	0.352	〃
8	〃	〃 〃 × 140	0.056	0.448	〃
8	〃	〃 〃 × 100	0.040	0.320	〃
8	〃	〃 〃 × 210	0.084	0.672	〃
8	〃	〃 〃 × 260	0.104	0.832	〃
8	斜材	15 × 15 × 240	0.054	0.432	〃
8	〃	〃 〃 × 260	0.059	0.472	〃
16	〃	〃 〃 × 320	0.072	1.152	〃
8	〃	〃 〃 × 325	0.073	0.584	〃
8	下弦材	25 × 20 × 335	0.168	1.344	〃
8	〃	〃 〃 × 380	0.190	1.520	〃
16	〃	〃 〃 × 510	0.255	4.080	〃
16	〃	〃 〃 × 440	0.220	3.520	〃
8	〃	〃 〃 × 215	0.108	0.864	〃
16	猫木	25 × 10 × 40	0.010	0.160	〃
32	肘木	25 × 15 × 60	0.023	0.736	〃
8	〃	25 × 20 × 60	0.030	0.240	〃
				24.364 cub. meters	
4	筋違	15 × 9 × 470	0.063	0.252	米松
12	〃	〃 〃 × 220	0.030	0.360	〃
6	〃	〃 〃 × 175	0.024	0.144	〃
18	挟横	15 × 9 × 450	0.061	1.098	〃
16	筋違	〃 〃 × 440	0.059	0.944	〃
16	楔	20 × 15 × 25	0.008	1.280	〃
16	斜材	15 × 9 × 160	0.022	0.352	〃
8	挟横	〃 × 〃 × 255	0.034	0.272	〃
8	〃	〃 × 〃 × 85	0.011	0.088	〃
8	〃	〃 × 〃 × 260	0.035	0.028	〃
8	〃	〃 × 〃 × 235	0.032	0.026	〃
8	横	20 × 15 × 545	0.164	1.312	〃
2	〃	20 × 20 × 545	0.218	0.436	〃
14	〃	20 × 15 × 450	0.135	1.890	〃
				8.482 cub. meters	
				米松材料合計	41.546 cub. meters
112	楔	20 × 11 × 40	0.009	1.008 cub. meter	樫

JIUN MASUDA
CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

MADE BY I. M DATE 5-4-7 **FILE NO**
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CALCULATIONS FOR

Materials of Shinobu-Bashi for Fukushima-Ken

杭（内地産赤松）							
4	支柱	末口 18φ cm. × 270					
8	〃	〃 〃 × 460					
12	杭	〃 〃 × 500					
4	〃	〃 〃 × 600					
4	支柱	〃 〃 × 580					
4	〃	〃 〃 × 570					
4	〃	〃 〃 × 520					
6	塵芥除椒杭	〃 〃 × 460					
Sand box（木材部）一箇分 40 Reqd.							
1		25φ × 25	0.012	0.012	赤松		
2		30φ × 2.5	0.002	0.004	〃		
2	栓	3.5φ × 5	0.00005	0.0001	〃		
				0.016 cub. meters			
Sand box（鉄部）一箇分 40 Req'd.							
1	Pls.(Sand box)	400 mm × 6 mm × 990 mm	@18.6517	18.6517			
4	釘	五寸釘 Sand box 取付用	0.0235	0.0940			
1	亜鉛メッキ鉄	90中 no. 30 B.W.G.	1.9408	1.9408			
				20.6865 Kgs.			
	ボールト及鎹等			（ボールト及座金）	（鎹）	（平鋼）	（釘）
48	上弦材締付用	22 mmφ × 350 mm.	@1.3020	62.4960			
12	〃	〃 × 250	〃 1.0050	12.0600			
80	上弦材ト斜材締付用	〃 × 280	〃 1.0944	87.5520			
40	下弦材ト 〃	〃 × 450	〃 1.6010	64.0400			
16	垂直材締付用	〃 × 500	〃 1.7500	28.0000			
64	垂直材ト下弦材金物締付用	〃 × 320	〃 1.2136	77.6704			
96	下弦材継手用	〃 × 250	〃 1.0050	96.4800			
32	継手用金物 L	100 × 9 × 400	〃 2.8260			90.432	
36	筋違ト垂直材締付用	19φ mm × 340	〃 0.9348	33.6528			
8	〃	〃 × 430	〃 1.1346	90.7680			
72	杭ト筋違締付用	〃 × 390	〃 1.0458	75.2976			
92	〃	〃 × 470	〃 1.2234	112.5528			
268	手違鎹長サ五寸				268		
504	正鎹長サ五寸				504		
1080	ボールト座金（22φ.19φ用）	50 mmφ × 3 mm.	@0.0462	49.8960			
40	砂箱上部材締付用	19φ mm × 375	〃 1.0125	40.5000			
	下弦材取付用五寸釘		〃 0.0235				35.0
				830.9656 kgs	772 挺	90.432 kgs	35.0 kgs

Arch ring 側面型枠 28.525 m² See page no. 106

MADE BY I. matano DATE 5-4-8 **FILE NO**

CHECKED BY M.J. & M.K. DATE 5-4-9. **PAGE NO** 124

CALCULATIONS FOR

material of shinobu bashi for Fukushima-ken

material of centering for span NO 4.
木材表

			Unit volume	Total volume	Remarks
140	planks	20×6×500	0.060	8.400 cub.m.	米松.
4	〃 } 箱	30×6×500	0.090	0.360	〃
4	〃	20×6×500	0.060	0.240	〃
				9.00 cub.m.	
8	上弦材	30×15×350	0.158	1.264	米松.
8	〃	30×15×470	0.212	1.696	〃.
8	〃	30×15×500	0.225	1.800	〃
4	〃	30×15×510	0.230	0.920	〃
2	〃	30×10×350	0.105	0.210	〃
2	〃	30×10×470	0.141	0.282	〃
2	〃	30×10×500	0.150	0.300	〃
1	〃	30×10×510	0.153	0.153	〃
				6.625 cub.m.	
8	垂直材	20×20×50	0.020	0.160	米松
8	〃	20×20×110	0.044	0.352	〃
8	〃	20×20×135	0.054	0.432	〃
8	〃	20×20×100	0.040	0.320	〃
8	〃	20×20×215	0.086	0.688	〃
8	〃	20×20×270	0.108	0.864	〃
				2.816 cub.m.	
8	斜材	15×15×240	0.054	0.432	米松
8	〃	15×15×265	0.060	0.480	〃
16	〃	15×15×325	0.073	1.168	〃
8	〃	15×15×345	0.078	0.624	〃.
				2.704 cub.m.	
8	下弦材	25×20×335	0.168	1.344	米松
8	〃	25×20×380	0.190	1.520	〃
16	〃	25×20×510	0.255	4.080	〃
16	〃	25×20×440	0.220	3.520	〃
8	〃	25×20×275	0.138	1.104	〃
32	肘木	25×15×60	0.023	0.736	〃
8	〃 〃	25×20×60	0.030	0.240	〃
16	猫木	25×10×40	0.010	0.160	〃
				12.704 cub.m.	
6	筋違	15×9×175	0.024	0.144	米松
12	〃	15×9×220	0.030	0.360	〃
4	〃	15×9×470	0.063	0.252	〃
8	楔	20×15×25	0.008	0.064	〃
				0.820 cub.m.	
16	筋違(杭)	15×9×440	0.059	0.944	米松.
18	〃	15×9×450	0.061.	1.098	〃
16	〃	15×9×160	0.022	0.352	〃
8	〃	15×9×255	0.034	0.272	〃
8	〃	15×9×85	0.011	0.088	〃
8	〃	15×9×260	0.035	0.280	〃
8	〃	15×9×235	0.032	0.256	〃
				3.290 cub.m.	
8	梁	20×15×545	0.164	1.312	米松
2	〃	20×20×545	0.218	0.436	〃
14	〃	20×15×450	0.135	1.890	〃
				3.638 cub.m.	
			grand summary		41.597. cub.m.
112	楔	20×11×40	0.009	1.008 cub.m.	樫.

MADE BY I. matano DATE 5-4-8 FILE NO
CHECKED BY M.J. & M.K DATE 5-4-9 PAGE NO 125

CALCULATIONS FOR

material of shinobu-bashi for Fukushima-ken

杭 (内地産赤松)

4	支柱	末口18$^{cm\phi}$ × 270
8	〃	〃 18$^{cm\phi}$ × 460
12	杭	〃 18$^{cm\phi}$ × 640
4	〃	〃 18$^{cm\phi}$ × 730
4	支柱	〃 18$^{cm\phi}$ × 520
4	〃	〃 18$^{cm\phi}$ × 580
4	〃	〃 18$^{cm\phi}$ × 570
6	塵芥除杭	〃 18$^{cm\phi}$ × 550

Sand box. (附屬品) 木部 1個分 40 Required

1	25$^{\phi}$ × 25	0.012	0.012	
2	30$^{\phi}$ × 2.5	0.002	0.004	
2	3.5$^{\phi}$ × 5.0	0.00005	0.0001	
				.0016$^{cub.m.}$

Sand box. (附屬品) 鐵部 1個分 40 Required

1	P/S(sand box)	400^{mm} × 6^{mm} × 990^{mm}	@18.6517	18.6517	
4	釘	五寸釘 sand box. 取付用	@0.0235	0.0940	
1	亜鉛鍍金板	90$^{\phi}$ no. 30 B.W.G.	@1.9408	1.9408	
					20.6865$^{kgs.}$

ボールト及鋲等

				ボールト座金	鋲	平鋼	釘
48	上弦材締付用	22$^{mm\phi}$ × 350	@1.3020	62.4960			
80	上弦材ト斜材ト締付用	〃 × 280	@1.0944	87.5520			
40	下弦材ト斜材ト締付用	〃 × 450	@1.6010	64.0400			
16	垂直材締付用	〃 × 500	@1.7500	28.0000			
64	垂直材ト下弦材金物ニテ締付用	〃 × 320	@1.2136	77.6704			
96	下弦材ト継手用	〃 × 250	@1.0050	96.4800			
32	継手用金物 ㇄	10^{mm} × 9^{mm} × 400	@2.8260			90.4320$^{kgs.}$	
36	筋違ト垂直材締付用	19$^{mm\phi}$ × 340	@0.9348	33.6528			
8	〃	〃 × 430	@1.1346	9.0768			
72	杭ト筋違締付用	〃 × 390	@1.0458	75.2976			
92	〃	〃 × 470	@1.2234	112.5528			
268	手違鋲 長サ5寸				268挺		
504	正違鋲 長サ5寸				504〃		
1,080	ボールト座金 (22$^{\phi}$ 19$^{\phi}$用)	50$^{mm\phi}$ × 3^{mm}	@0.0462	49.8960			
	下弦材ニ取付用5寸釘		@0.0235				35.0^{kgs}
12	上弦材締付用	22$^{mm\phi}$ × 250	@1.0050	12.0600			
40	砂箱上部材締付ボールト	19$^{\phi}$ × 375	@1.0125	40.5000			
				749.2744	772挺	90.4320^{kgs}	35.0^{kgs}

Arch ring 側面型枠 29.055$^{m^2}$ See page no. 106

Materials of shinobu-bashi for Fukushima-ken. 参与

materials of centering for span no. 5.
各部材全部 span no. 3ト同一.

material of centering for span no 6.

	planks	span no 2. ト同一.			8.220 cub.m.	米松
	上弦材垂直材斜材及ヒ下弦材	〃		〃	22.562	〃
	筋違及猫木	〃		〃	1.856	〃
18	梜樌	15×9×450	0.061	1.098		〃
16	〃	15×9×160	0.022	0.352		〃
16	〃	15×9×260	0.035	0.560		〃
16	〃	15×9×235	0.032	0.512		〃
16	楔	20×15×25	0.008	0.128		〃
					2.650 cub.m.	
	梁	span no 2ト同一.			7.792 cub.m.	米松
				米松材料合計		43.080 cub.m.
	楔	span no 2ト同一.			1.008 cub.m.	樫

杭 (内地産赤松)

8	支柱	末口18cmφ × 580
8	〃	〃 18cmφ × 570
8	〃	〃 18cmφ × 520
4	杭	〃 18cmφ × 600
12	〃	〃 18cmφ × 500
6	塵芥除杭	末口18cmφ × 460

Sand box (附屬品) 木部 span no 2ト同一. 0.016 cub.m. (1個分) 米松

Sand box (〃) 鉄部 span no 2ト同一. 20.0865 kgs (1個分)

ボールト及鎹等

			ボールト座金	鎹	平鋼	釘
span no 2ト同一材料			719.9616 kgs	772 挺	90.432 kgs	3.5 kgs
杭ト筋違締付用(追加)	19mmφ × 470	@1.2234	19.5744			
			739.5360 kgs	772 挺	90.432 kgs	3.5 kgs

Arch ring 側面型枠 26.62 m.² see page no. 106

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CALCULATIONS FOR

materials of Shinobu boshi for Fukushima-ken 参与

materials of Centerings for span no 7.

	planks	span no 1 ト仝一.			7.50 cub.m.	米松
	上弦材.垂直材.斜材.下弦材 筋違.梁叉猫木	〃 〃			24.762	〃
14	挟貫	15×9×450	0.061	0.854		〃
8	〃	15×9×160	0.022	0.176		〃
8	〃	15×9×260	0.035	0.280		〃
8	〃	15×9×235	0.032	0.256		〃
					1.566	
				米松材料合計	33.828 cub.m.	
12	楔	20×15×25	0.008	0.096 cub.meters		樫

杭 (内地産赤松)

4	支柱	末口18cmφ×276
12	杭	〃 18cmφ×550
4	〃	〃 18cmφ×640
4	支柱	〃 18cmφ×580
4	〃	〃 18cmφ×570
4	〃	〃 18cmφ×520
5	塵芥除杭	〃 18cmφ×400

Sand box (附屬品) 木部	span no 1 ト仝一.	.016 cub.m (1個分).	28 Req'd	米松.
Sand box (〃) 鉄部	span no 1 ト仝一.	20.6865 kgo. (1個分)	28 Req'd	

ボールト及鋲等

				ボールト座金.	鋲	平鋼	釘.
	span no 1 ト仝一材料.			601.1456 kgo.	604 挺	90.4320 kgo.	30 kgo.
8	杭ト筋違締付用(追加) 19mmφ×470	@1.2234		9.7872			
				610.9328 kgo	604 挺	90.4320 kgo.	30 kgo.

Arch ring 側面型枠 51.10 m^2 see page no. 106

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CONSULTIEG ENGINEER
JIJI BLDG, TOKYO

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CALCULATIONS FOR

昭和四年十二月

福島縣信夫橋予算設計書

16.5

23.5
9
5
41.5
79

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CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

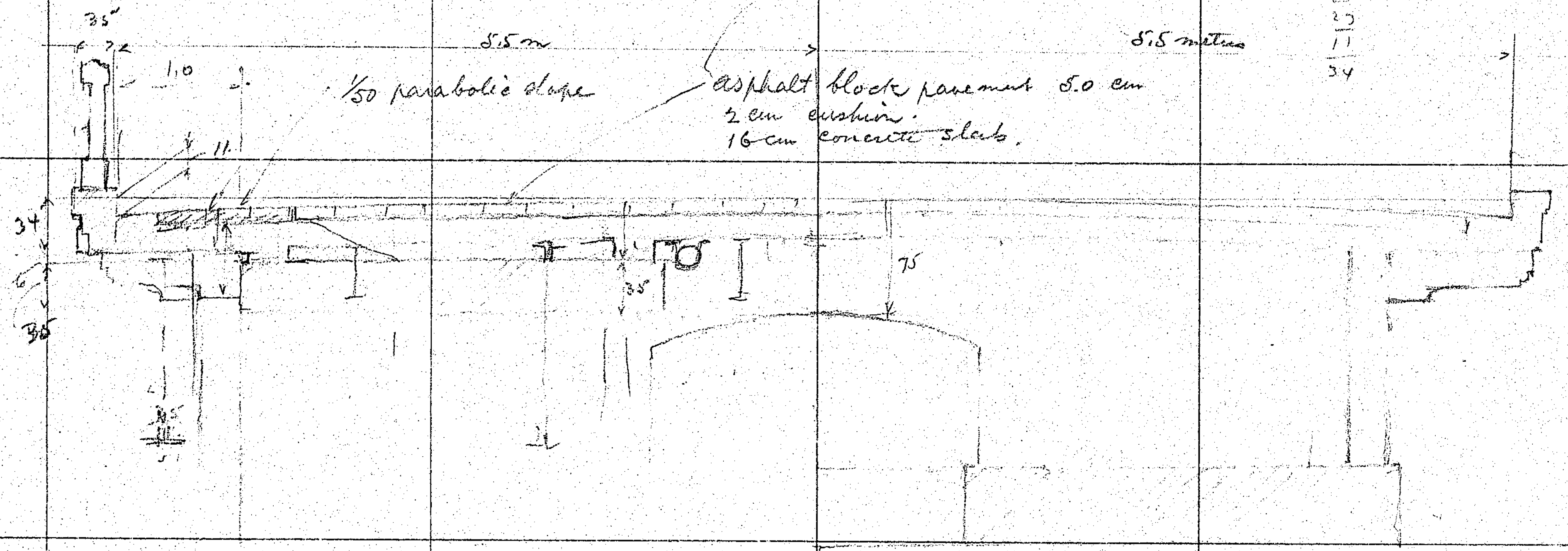
Arch span with variable spans. 22.5 25.0 26.5 27.0 meters.
Roadway 11.0 meters

Cross Section of bridge:

$\frac{11.0}{3}$

1.5m concrete pavement — 8 meter wide.

$$\begin{array}{r} 7 \\ 16 \\ \hline 23 \\ 11 \\ \hline 34 \end{array}$$

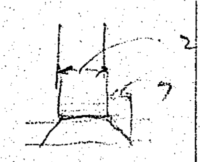


1/50 parabolic slope

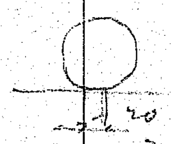
asphalt block pavement 5.0 cm
2 cm cushion.
16 cm concrete slab.

Concrete slab. span length 2.0 meter.
motor truck loading. 3000
impact 30% 900
3900 kg.

Distribution.



27 2@7= $\begin{array}{r} 27 \\ 14 \\ \hline 41 \end{array}$



$\begin{array}{r} 20 \\ 14 \\ \hline 34 \end{array}$ cm

$E = \frac{2}{3}\times 2 + \frac{41}{133} = 1.74$

3900 ÷ 1.74 = 2250 kg per lin meter

Dead Load.

5 cm	@	21	=	105
2 cm	@	17	=	34
16 cm	@	24	=	384
				523
misc say				17
				540 kg per lin meter

$d = \sqrt{\frac{1341}{71.8}} = 13.7$
2.3
16. cm

DL. m = 1/10 × 540 × 2.0² = 216.
LL m $\frac{2250}{2} \times 10$ = 1125
1341 kgm

Reinforcing Bars $\frac{134100}{\frac{7}{8}\times 13.7 \times 1200}$ = 9.35 per lin meter.

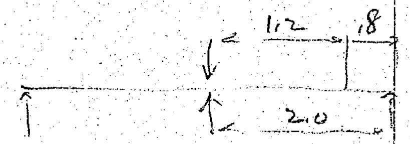
13^{d} = 1.33 $\frac{9.35}{1.33}$ = 14.0 cm centers

Cantilever Bracket projection. 1.0 meter
Uniform load say 540 × 2 = 1080 kg.
Handrail & Coping. 420 × 2 = 840

Dead Load m = 1200 × $\frac{1}{2}$ = 600
840 × 1.2 = 1000
1600

DL m = 3900 × .9 = 3500
5100

Live Load motor truck say 3900 kg.



Depth reqd = $\sqrt{\frac{510000}{.25 \times 7.18}}$ = 53

1.0
.7

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CALCULATIONS FOR

Shimo Ku- Bashi for Fukushima-Ken

Dead Load.

540 kg per sq. meter × 11.0 = 5950
coping & Handrail 2@420 = 840
Under filling 5.0 × .15 @ 1700 = 1280
Cantilever beam .2 × .1 × 1.00 @ 2400/2 = 240
cross beam 3.0 × .30 × .60 @ 2400/2 = 650
8960 kg per lin. meter.

Dead Load — Arch ring. .35 × 9.0 × 2400 = 7550
16510 kg per lin. meter.

Design of arch ring. span length 23.0 rise - 2.5 $r = \frac{2.5}{23} = .109$
approximate Dead Load thrust and moments

crown thrust 1.24 × 16510. × 23.0 = 472,000

approximate $\frac{1}{8} \times 20000 \times \frac{23^2}{2.5}$ = 530,000

V_s — .59 × 16150. × 23.0 = 220,000 kg.
axial thrust at springing line. Ts. 1.38 × 16510 × 23.0 = 512000

cross section of arch .35 × 9.0 = 3.15 $\frac{472000}{31500}$ = 15.0 kg/cm²

Live Load Stress
Live Load 500 × 11.0 = 5500 kg per lin meter.
For crown stress increase 2500
8000 kg.
400
$\frac{\text{Springing}}{\text{Crown}}$ = 2.25
.35 × 2.25 = 79 cm

Live Load + moment 0.0044 × 8000 × 23.0^2 = 18,700 kgm
" " thrust 0.60 × 8000 × 23. = 110.000 kg

Live Load - moment 0.0039 × 8000 × 23.0^2 = 16500 kgm
thrust 0.58 × 8000 × 23 = 107,000 kg

Springing
Live Load + moment 0.028 × 5500 × 23^2 = 81500 kgm
normal thrust 0.84 × 5500 × 23 = 106.000 kg

Live Load - moment 0.024 × 5500 × 23^2 = 69800 kgm
normal thrust crown Tc 0.032 × 5500 × 23 = 4050 kg 55000
Ts. 0.045 × 5500 100 × 23 7.0 5700 700

Temperature Stress
For fall of 36° crown thrust = - 30.5 $\frac{30° \times 0.0000055 \times 140,000 \times 0.0322}{2.5^2}$ = 36500 kg
0000 ~8

$I = \frac{1}{12} \times .35^3 \times 9.0 = .0322$
0.03

277,000

crown moment = + $\frac{20 \times 2.5 \times 36500}{100}$ = 18200 kgm

moment at Spring = 18200 + 2.5 × 36500 = 73000 kgm

912.000
182
73

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CALCULATIONS FOR

Shinoben-Bashi for Fukushima-Ken 3.15

crown stress. moment. thrust average.

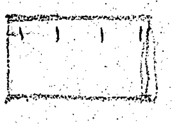
	moment	thrust	average
DL.	16000	472,000	+ 150,000
LL.	18700	106000	+ 35000
Imp.	18200	- 36500	- 11600
.04	52900	541500	173400 ÷ 277,000 625 %
	11400	- 22800	
	64300 kgm	518700	
		.2	

185
116
1734

.124 / .35 = .354

Ecc = .124 e/h = .124 / .35 = 354

Double Reinf.



6 × 3.80 = 22.8 ÷ 3500 = .65 %
6 × 4.90 = 29.4 = .84 %

19 mm 2.83 -
22 - 3.80 -
25 - 4.90

k = 76
.73
av. 75

L = .117

for 9m wide fibre stress = 64300 / (.117 × 9.0 × .35²) = 49.8.000 49.8 kg/cm²

allowable stress = 45 × 1.25 = 56.25 kg/cm²
use 22 mm bars 3 rows for 1 meter.
making 7.0 wide 58.0 kg/cm²

1646
16

Springing

	moment	thrust	aver stress
Dead Load -	-30000	+ 512300	+150,000
L L. -	69800	+ 57.000	+ 12900
Temp -	73000	- 36500	- 11600
RS. -	40,000	- 20000	
	212800	512500	

7.1
11629
116
11513
54.6 %

698
27
671

E = .415 e/h = .415 / .79 = .526

Steel %. 12 × 3.8 = 45.6 ÷ 79 ... .58 % k = 0.80 L = .110

fibre stress = 212800 / (.117 × 9 × .79²) = 344,000 344 kg/cm²

use. 7.0 meter ring. depth .79

Arch no 2. span length 25.18 rise 2.81 = .112
crown thrust. 1.2 × 16510 × 25.18 = 500,000
Springing Vs 0.59 × 16510 × 25.18 = 246.000
1.38 × 16510 575.000
normal thrust = ~~400,000~~

172
65
107

Live Load stress

crown Live Load + moment 0.0044 × 8000 × 25.18² = 22200 kgm
thrust 0.575 × 8000 × 25.18 = 116,000 kg.

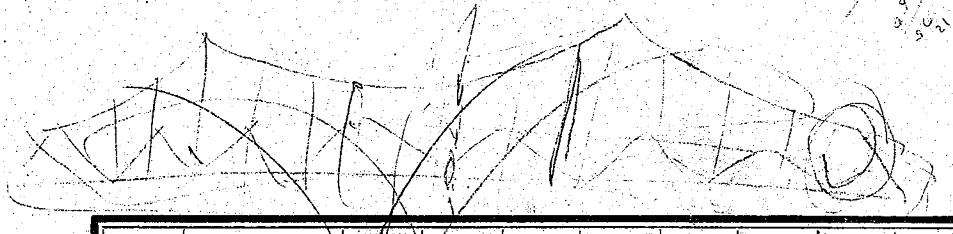
Springing Live Load - moment 0.0244 × 5500 × 25.18² = 83500 kgm
Ts thrust 0.45 × 5500 × 25.18 = 62400
Te 0.32 × 5500 × 25.18 = 44400

Temperature stress
For fall of 30° 30.5 × 30 × 0.0000055 × 140,000 × 10000 × 0.0322 / 2.81² = 28800

Me = + 20.5 × 2.81/100 × 28800 = 16600 kgm

moment at springing = 16600 - 2.81 × 28800 = 64400 kgm

.810
166
644



Electrical Page 68, 69

Civil Page 80, 85, 97

東京市麴町區丸ノ内時事新報社四階十七號室
增田淳事務所
電話丸ノ内七七七番

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CALCULATIONS FOR

Shinoku Bashi for Fukushima-Ken

crown stress.

	moment	thrust	aver stress
Dl.	+ 18500 =	- 500000	+ 159000
LL.	+ 22200	+ 116000	+ 37000
Temp.	+ 16600	- 28800	- 9100
R.S.	+ 11200	- 19500	
	68500	567200	

159
37
196
91
~~186.9~~

67.5

364
8
444
197
9240

Σee = .109 $\frac{.109}{.35}$ = .31 117

steel %. - .65 %

616
488
5672

9.0 m wide. $fc = \frac{68500}{.119 \times 9.0 \times .35^2}$ = 530000 53 kg/cm²

springing.

	moment	thrust	average stress
Dl.	40000	+575000	+ 1159000
LL	- 83500	+ 62400	+ 14100
Temp.	- 64400	- 28800	- 9200
Rib shortening	- 38200	- 17000	
	226100	591600	

71
17

1731
92
164

59.0

6374
458
5916

Σ = .38 $\frac{3}{L}$ $\frac{.38}{.79}$ .48

fibre stress - $\frac{226100}{.11 \times 9 \times .79^2}$ = 370000 37.0 kg/cm²

Arch no 3. span length 26.78 rise 3.01 r = .112

crown thrust 1.2 × 16510 × 26.78 = 530.000
Vs. 0.59 × " × 26.78 = 261.000
Ts. 1.38 × " 26.78 = 610.000

32
6
1800

Live Load Stress

crown Live Load + moment 0.0044 × 8000 × 26.78² = 25,200
thrust 0.575 × 8000 × 26.78 = 123.000

Springing Live Load - moment 0.024 × 5500 × 26.78² = 94500
Ts. 0.45 × 5500 × 26.78 = 66200
0.32 × 5500 × 26.78 = 47000

Temperature stress
For fall of 30° 30.5 × $\frac{30 \times 0.000055 \times 140.000.000}{3.01^2}$ × 0.0322 = -25,000

Me = $\frac{20.5 \times 3.01 \times 25000}{100}$ = 15500 kgm

Ms = 15500 - 3.01 × 25000 = 60,000 kgm

75,500
155
60000

Crown stress

	moment	thrust	average stress
Dl.	20000	+ 530,000	168000
LL	25.200	+ 123000	39000
Temp	15500	- 25000	- 8000
Rib shortening	11100	- 18000	
	71800	610,000	

207
8
199

72 %

653
43

Σ = .117 $\frac{Σ}{L}$ = $\frac{.117}{.35}$ = .336 L = .116

$fc = \frac{71800}{.116 \times 9 \times .35^2}$ = 56.2,000 56.2 kg/cm²

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken.

Springing	Moment	Thrust	Average	
DL.	-45000	+610.000	168000	1826 8 1746 2770
LL	-94500	+66200	14600	63%
Temp	-60.000	-25000	-8000	
Rib short	-38000	-16000		6762 41 6352
	237500	635200		

Σ = .373 $\Sigma/h = \frac{.373}{.79}$ = .474

fibre stress $= \frac{237500 \times}{.111 \times 9.0 \times .79^2}$ = 380.000 38.0 kg/cm²

Span No 4 span length 27.38 Rise 3.08 .1128

crown thrust 1.2 × 16500 × 27.38 = 540.000
V_s 0.59 × 16500 × 27.38 = 266.000
T_s 1.38 × 16500 × 27.38 = 621.000

Live Load Stress
crown Live Load + moment 0.0044 × 8000 × 27.38² = 26300
Thrust 0.575 × 8000 × 27.38 = 126.000

springing Live Load - moment 0.024 × 5500 × 27.38² = 98500 kgm
T_s 0.45 × 5500 × 27.38 = 67600
T_e 0.32 × 5500 × 27.38 = 48000

Temperature Stress.
For fall of 30° 30.5 × 30 × $\frac{0.0000055 \times 140.000 \times 1000 \times 0.0322}{3.08}$ = 23900

$Mc = 20.5 \times \frac{3.08 \times 23900}{100}$ = 15100

Ms = 15100 - 308 × 23900 = 5840

735
151

Crown Stress.	moment	thrust	average stress	
DL.	21000	540.000	172.000	212 8 204
LL	26.300	126.000	40.000	73.8%
Temp.	15500	-25000	-8000	
Rib short	.11500	-18500		666 435 6225
	74300	62250		

Σ = .119 $\Sigma/h \frac{.119}{.35}$ = .34 .115

$fc = \frac{74300}{.115 \times .90 \times \boxed{.35^2}}$ 40 $= \frac{588000}{454}$ 58.8 kg/cm²

Springing	Moment	Thrust	Average Stress	
DL.	50,000.	610.000	172000	187 8 179
LL	98500	67600	15000	64.6%
Temp	58400	-23900	-8000	
RS.	37800	-15500		6776 394 6382
	244700	638200		

Σ = .383 $\Sigma/h = \frac{.383}{.79}$ = .483 .108

$fc = \frac{244700}{.108 \times 9.0 \times .79^2}$ = 400,000 40 kg/cm²

for 9.0 51.5 kg/cm² -

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CALCULATIONS FOR

Shinobu-Bashi for Fukushima-Ken

approximate concrete in arch span
arch span no. 4
Concrete slabs.

.16 × 11 = 1.76

Coping 2 - .35 × .35 = .25

2.01 × 28.2 = 56.3 cubic meter.

27.4
.8
28.2

wall. 2 - ~~3.3~~ × .3.0 = 2.00 × 13.6 = 27.2 cubic meters.

2.5
3.0
1.4
.9
6.8 × 2 = 13.6

7B. 2.6 × .30 × .80 = .62 × 13 = 8.1

56.3
27.2
8.1
3.7
95.3 cubic meters.

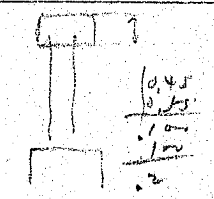
Cantilever Brackets 1.2 × .30 × .40 = .144 × 26 = 3.7

Concrete on pier
slab beam. .70 × .80 × 11 = 6.2
wall. 2 × 1.23 × 3.0 = 7.4
13.6 cubic meters

2 - .80 × .30 = .48
2.5 × .30 .75
1.23

volume of concrete in arch ring. 7.0 meter wide.
.55 × 7.0 × 28.0 = 108 cubic meters

18 3 77



.15
.18
.33
15 × .166
.15 @ 2400
360 8

Dead Load floor slab pavement & HR
slab & pavement 540 × 11 = 5940
coping: 500
Handrails. 800
7240

wall = 27.2
cantilever 3.7
7B. 8.1
39.0
108.
147
27.4 = 5.36 cubic m/m @ 2400 = 12900 kg.

Sand fill at center
.40 × 2.5 × ~~40~~ 6 = 10.0 cubic meter. 12 @ 1700 = 20400

20400 / 28 = 730

Summary slab &c 7240
arch ring & wall 12900
Sand fill. 730
20870

vertical reaction = 20800 × 27.4/2 = 285,000

Horizontal Thrust. 1/8 × 20800 × 27.4²/3.08 = 635,000
- 63
10%
572000

Concrete in super structure.
95.3
10.8
203.3 × 7 = say 1400 cubic meters

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CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

Design of piers

Load on pier from arch spa 285,000 × 2 = 570,000
on pier! 35,000
$\boxed{605000}$
12

605,000
310,000
543,000
1,458,000

concrete in pier.

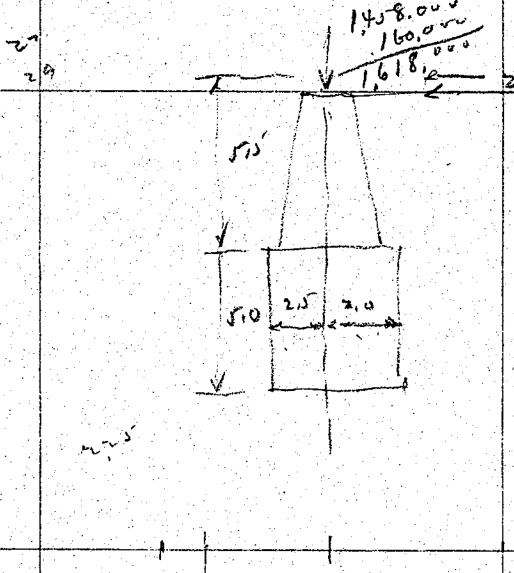
2.6
1.6
4.2 – 2.1 × 5.8 × 12.0 = 141.0 cubic meters
wt = 141 @ 2200 = 310.000 kg.

Caisson 4.5 × 11.0 × 5.0 = 247. cubic meters
wt = 247 @ 2200 = 543000

Live Load 5500 × $\frac{29}{2}$ = $\frac{160.000}{2}$ = 80,000

Horizontal Thrust = $\frac{1}{8}$ × 5500 × $\frac{27.38^2}{3.08}$ = $\boxed{168,000}$ kg.
unbalanced dead load. 572000 × .15 = 85000
253 000

168,000
12000
180000



moment at base 253 000 × 10.5 = 2,660,000
Ecc = $\frac{2660.000}{1,618,000}$ = 1.65 m

2.25
1.65
.60 × 3 = 1.8

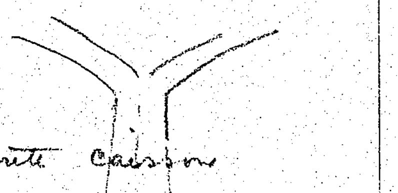
1.8 × 11. = 19.8 sq meters

Unit load. $\frac{1618,000 \times 2}{19.8}$ = 163,000 kg/m² 15.2 tons/□'

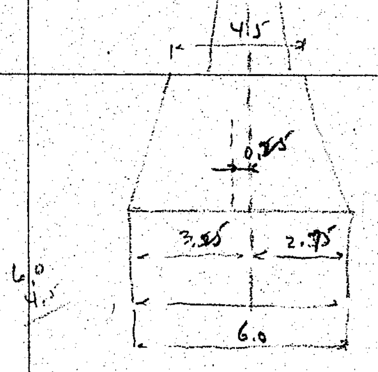
168 000 × 10.5 = $\frac{1760.000}{1618.000}$ = 1.10

2.50
1.65
.85 × 3 = 2.55 × 11 = 28.05

Soil P = $\frac{1618,000 \times 2}{28.05}$ = 116 000 kg/m² 10.8 tons/□'



Concrete Caisson



6 × 2 × 11.0 = 132.0
5.25 × 3 × 11.0 = 173.0
305.0 @ 2200 = 670.000
310.000
605,000
1585 000
160 000
1745 000

moment = $\frac{266.0000}{1745,000}$ = 1.52

3.25
1.52
1.73

$\frac{1745,000 \times 2}{1.73 \times 11. \times 3}$ = 61,000 5.7 tons/□'

Concrete in pier

13.6
141.0
305
459.6 – 77.47

141
299
440

.8
616
230
850

234 –

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CALCULATIONS FOR

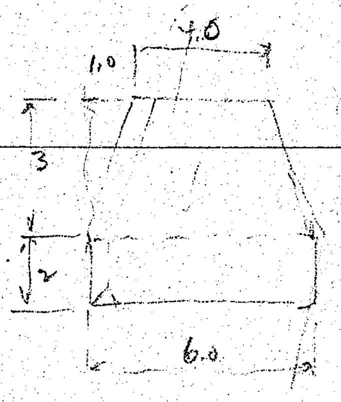
Shinobu Bashi for Fukushima-Ken

310.000
605.000
915.000
80
995.000
670.000
1665.000

$85000 \times 10.5 = \frac{893.000}{1665.000} = .535$

893.000

15



concrete $6. \times 2 \times 11 = 132.0$
" $5 \times 3 \times 11 = 165.0$
297 @ 2200 = 654000

$3 \times 11 =$ 33 @ 1700 = 56100
$6 \times 1.0 \times 11$ 66 @ 1700 = .112000
822100

995000
822100
Total load 1817,100 on base

moment. $253000 \times 10.5 = 2,660,000$
$- 80.000 \times .85 = - 68,000$
$915000 \times .25 = - 220,000$
2372,000

266.0
288
2372

$1700 \times 22 = 37400 \times 6 =$ 224,000
2148,000

$\Sigma ee = \frac{2148.000}{1817.100} = \frac{3.000 \atop 1.185}{1.815} \times 3 =$

$\frac{1817,100 \times 2}{3 \times 1,815 \times 11} = 6070.0$ kg/m² 5.65 ton/□'

253000×8.0 1960.000
$-$ 228 000
1,732,000
224.000
1.508 000

3.00
.83
2.17 ×

$\Sigma = \frac{1508 000}{1817100} = .83$

$\frac{1817100 \times 2}{2.17 \times 3 \times 11} = 5070.0$ kg/m² = 4.72 ton/□'

$\frac{181.000}{\cancel{253000}} \times 8.0 = 2020,000$
$- 80.000 \times 1.15 = 92.000$ $- 550 000$
$915.000 \times 0.5 = 458.000$ 1470 000
550 000
friction couple $-$ $- 224,000$
1246 000

1450,000
550,000
900,000
224,000
676 000

$\Sigma = \frac{1246.000}{1817100} = \frac{3.00 \atop .685}{2.315}$ $\frac{676000}{1817100} = .37$

$\frac{1817100}{11 \times 6}\left(1 \pm \frac{6 \times .685}{6 \atop 1.315}\right) = 4620.0$ kg/m² 4.30 ton/□'

$\frac{1817100}{11 \times 6}\left(1 \pm \frac{6 \times .37}{6}\right) = 3770.0$ 3.5 ton/□

増田淳氏関係資料
（独立行政法人 土木研究所蔵）

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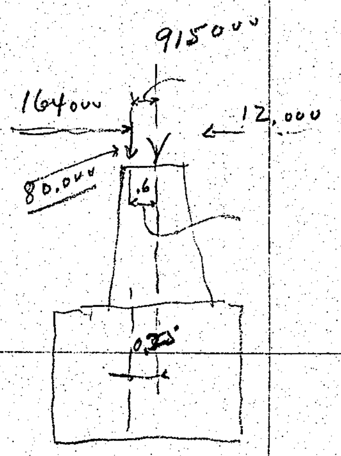
CALCULATIONS FOR

Shimoku Bashi for Fukushima-Ken.

From span no. 3.
Hor. thrust.

$\frac{1}{8} \times 5500 \times \frac{26.78^2}{3.01} = 164.000$ kg.



$\frac{1}{8} \times 208.000 \times \cancel{243} = 632.000$

$238 = 620.000$

$12\ 000$

$$\begin{array}{r} 164000 \\ 12000 \\ \hline 152000 \end{array}$$

moment $= 162.000 \times 8 =$ 1,220.000

$915000 \times 0.25 =$ 236.000

$- 80000 \times 0.35$ $-\ 28.000$

1,428.000
224.000
1,204.000

$\frac{1,204.000}{1817.000} = {}^{3}.662$

$f_s = \frac{1817.000}{6 \times 11} \times (1.1.662 = 45700$ 4.25 ton/□

$$\begin{array}{r} 1450.000 \\ -\ 288.000 \\ \hline 1,162,000 \end{array}$$

$$\begin{array}{r} 168000 \\ 12000 \\ \hline 180000 \end{array} \times 8 =$$ 1,440.000
224.000
1,216.000

$\frac{1,216.000}{1817.000} = .67$

$\frac{1817.000}{11 \times 6} \times (1.67) = 460.00$ 4.28 ton/□

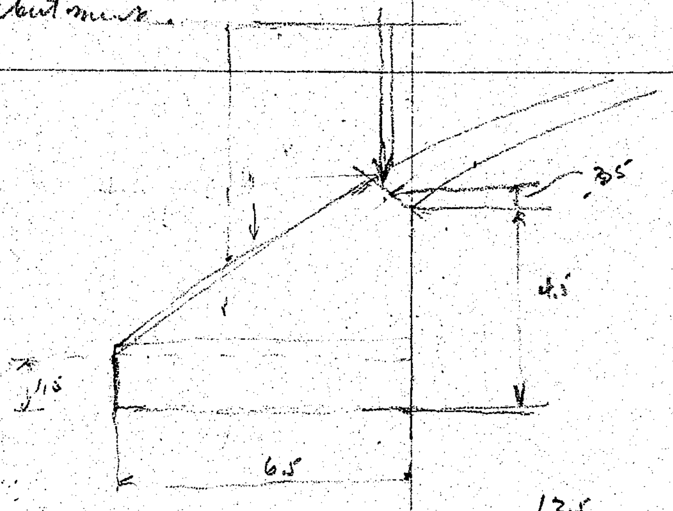
Span no. 2

$\frac{1}{8} \times 5500 \times \frac{25.18^2}{2.81} = 155.000$

unbalance of LL. $\frac{1}{8} \times \overset{20600}{\cancel{5500}} \times 21 = 54.000$

$$\begin{array}{r} 155000 \\ 54000 \\ \hline 209000 \end{array} \times 8 = 1670.000$$

abutment.



Dead Load $\frac{1}{8} \times 20600 \times \frac{22.58^2}{2.5} = 525.000$ $\begin{array}{r} 525.000 \\ 140.000 \\ \hline 665.000 \end{array}$

vertical $20600 \times 11 = 226,000$

Live Load $\frac{1}{8} \times 5500 \times$ H. 140,000 $\begin{array}{r} 226000 \\ 60000 \\ \hline 286000 \end{array}$

V_s. 60,000

weight of concrete.

$1.5 \times 6.5 \times 12.5 = 122.$

$6.5 \times \frac{4}{2} \times 12.5 = 162.$

$$\begin{array}{r} 12.5 \\ 8.0 \\ \hline 20.5 \end{array}$$

$.50 \times 4.0 \times 20.5 = 41$

325 @ 2200 = 715,000

Earth fill. $12.0 \times 5.5 \times 4.5 = 300$ @ 1700 = 51,000 54.27

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CALCULATIONS FOR

Shinobu - Bashi for Fukushima - Ken.

Point of Resultant.
Total load.

Super - 286.5^00
concrete - 715.000
Earth fill. 510.000
1511.5^00

moment, thrust. 665.000 × 4,85 = 3.230.000
3840.000
7,070.000

270.000 × 3,25 = 880.000
357000 × 2.2 = 785.000
90.000 × 1.5 = 135.000
510.000 × 4.0 = 2040.000
3840.000

80.000
20.000
12.000
1.8
3
1.62
1.8

$\frac{7,070.000}{1.511.500}$ = 1. 6.50
4.67
1.83

$\frac{1,511,500 \times 2}{3 \times 12.5 \times 1.83}$ = 44200 41.0 tons/□'

22.0
4
88

265
141
406

concrete 82 @ 55^00 = 66.
sand. ~~47^00~~ 7.
gravel 18
18
109/tsubo 18^00/m^3

115.000
42
380

Estimate of Cost.

pier. Concrete 440 @ 18^00 = 7920
Reinf. 8 tons @ 135^00 = 1000
forms. 450 □m @ 3^00 = 1350
excavation - 462 @ 8^00 = 3700
curb shoe - 2.5 @ 200 = 500
stone facing. 600 sqm @ = 2000
16470 × 6 = 99000

5000
1000
3

abutment.

concrete 325 @ 18^00 = 5850
Reinf 1000
forms 220 @ 500
exc. 230 @ 1^50 350
filling 700 @ 1^50 = 1050
piling 72 @ 4.5^0 20^0 = 1440
10410 × 2 = 20800
5000
25800
99000
124800
125000

298
398
358

sheet piling 30 @ 50 = 1500
extra 1500
3000
1000
4000

super structure.

Concrete 1500 @ 18^00 = 27.000
Reinf. 180^t @ 130^0 = 23.000
forms. 7400 @ 2^50 = 18.500
Staging. 2200 @ 10^00 = 11000
finish 800 @ 4^50 = 3600
Handrail. 185^0m @ 50^00 = 9300
pavement - 2040 @ 5^00 = 10200
Pedestals + wiring 4000
misc.
106600
3400
125000
231600

110.000
125.000
235.000

30
10

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CALCULATIONS FOR

Shinoben Bashi for Fukushima-Ken

4 girders. 26.3 0.9 @ 610 = 540 tons

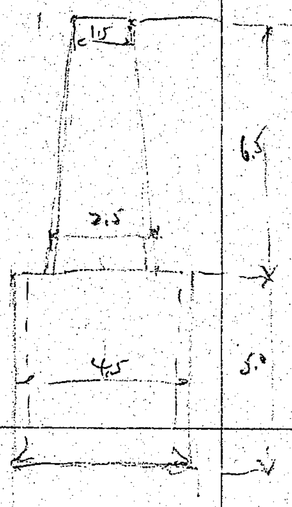
Estimate of superstructure 1.85

Deck. Concrete	2.0	@ 18^{00}	=	36^{00}
Reinf.	.22	@ 130 =		28^{60}
forms.	12	@ 2^{00}	=	24^{00}
pavement	11	@ 5^{00}	=	55^{00}
fence.	2	@ 4^{50}	=	9.00
HR.				58^{00}
				210.00

210.0 × 185 = 39000
curing & Pedestals. 4000
43000
540 @ 220^{00} = 119000
162000

Substructure

11.0 × 2. × 6.5 = 143.00
4.5 × 5.0 × 12 = 270
413 cubic metres



170.0
5.00

2
4
2
2 6
8
4 24
32
6.0

concrete	413	@ 18^{00}	=	7430
Reinf.	5 tons	@ 125^{00}	=	625
forms.	470	@ 2^{50}	=	1175
curb shoe	2 tons	@ 200	=	400
excavation.	350	@ 8^{00}	=	2800
				12430 =

6 @ 12400 = 74300
2 @ 12000 = 24000
98300
162000
260300^{00}

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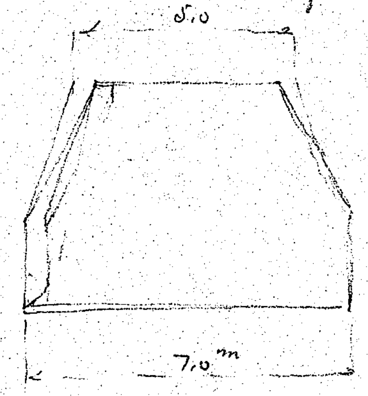
CALCULATIONS FOR

Shinobu Bashi for Fukushima-Ken

Revised Estimate of pier.



14
1.8
18
19.8

7×2 × 11 = 154
6×3 × 11 = 198
382 @ 2200 = 775.000
33 @ 1700 = 56000
77 @ 1700 = 131000
962 000

352
141
493

Horizontal thrust 168000
12000
180,000 × 8.0 = 1440,000
friction couple 37400 × 7 = 262.000
1,178,000

995 000
962 000
1957 000

$$\Sigma = \frac{1178000}{1957000} = .60$$

$$\frac{1957000}{11\times7}\left(1 - \frac{6.6}{7}\right) = 384\,00 \qquad 3.57 \text{ tons}/\square'$$

1.513

Estimate of cost one pier.

concrete	493 m³	@ 18.00	=	8900
Reinf.	8 tons	@ 125	=	1000
forms	480 □	@ 2.50	=	1200
excavation	580	@ 7.00	=	4060
curb shoe	2.5	@ 200	=	500
stone facing				2000
				17660 × 6 =

106.000
26000
132 000
110000
242 000

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CALCULATIONS FOR

Shinobu Bashi Approach for Fukushima-Ken

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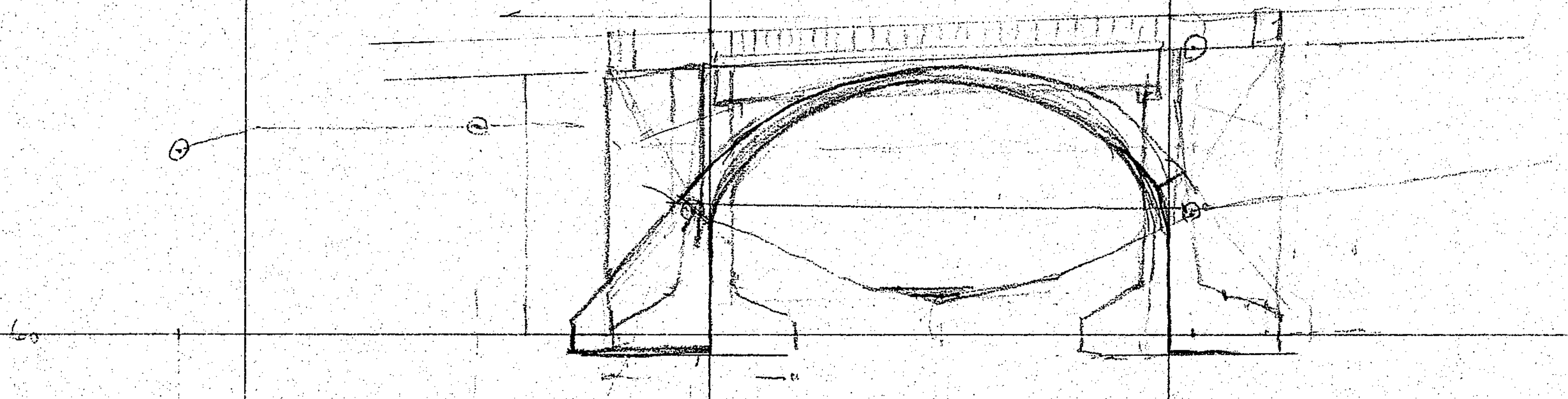
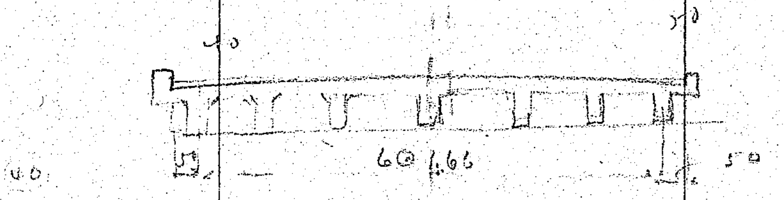




15 cm slab. 360
5 cm pavement 105
2 cm cement mortar 17 34

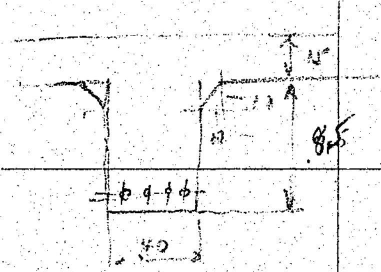
499
11

510 kg per sq meter

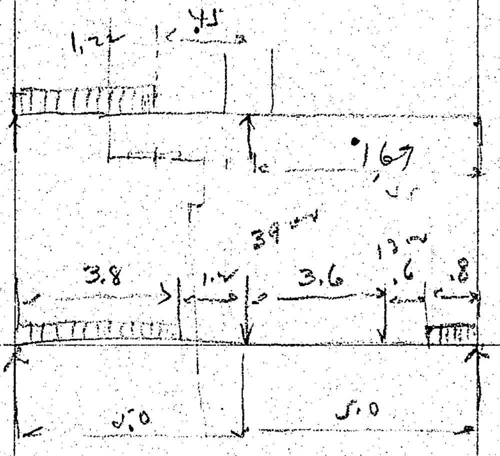
main beam.

510 × 1.67 = 865
.40 × .85 @2400 = 815

1680 kg.



$m = \frac{1}{8} \times 1680 \times 10^2 = 21,000$ kgm.



$\frac{500 \times 1.22^2}{2 \times 1.67} = 223$ kg

full unif. 500 × 1.67 = 835
223

612 kg.

moment = $1300 \times \frac{1.4}{10.0} = 182$
1950

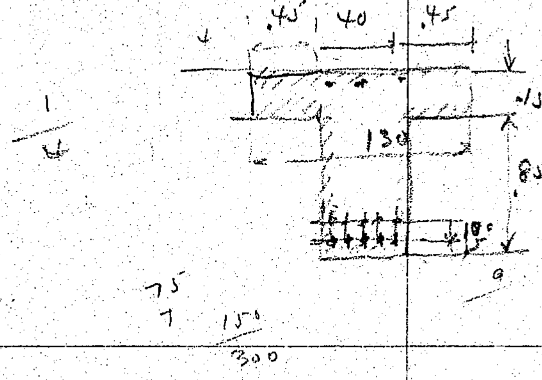
2132 × 5 = 10600

$\frac{3.8^2 \times 612}{2 \times 10} = 441 \times 5 =$ 2200
2800

15600 kgm

$\frac{1}{8} \times 223 \times 10^2 =$ 21,000

36,600 kgm.



$\frac{.15}{.90} = .166$

Reinf. bars $\frac{36,600}{.95 \times 7/8 \times 1200} = 36.5$

10 - 22 mm bars = 38.0

$\frac{38}{130 \times 90} = .00324$

1,0000
38

k = .29

j = .925

stress in concrete

$fc = \frac{Mc}{\frac{1}{2} bt (d - \frac{1}{2}t)} = \frac{3660000}{65 \times 15 (90 - 7.5)} = 45.5$ kg/cm²

82.5

1800000
800000

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CALCULATIONS FOR

Shinobu Bashi Approach for Fukushima-Ken.

Concrete in slab & beam

Slab. .15 × 11 = .165

.20

1.85

7 .4 × .85 = 2.38

7 .01 .07

2.45 × 10.4 = 25.6 cubic meters

Reinforcing Bars 10.4 × 11 @ 22 = 2500

beam 13 @ 3. kg = 39. 4900

lap + 25% .10 7.400

49.

18

7 × 67 × 10.4 =

abutment height 7.0 meters. 5000 2 @ 5000 = 10000

3600

13600

Estimate of Cost	Concrete.	26.0	@	18^{00}	=	468
	Reinf.	7.4	@	130	=	960
12 12	forms.	250	@	3^{50}	=	880
	pavement	114.	@	4^{50}	=	515
104 10	H.R.	15 m	@	50	=	750
						3573

6. 34 77 400

Arch Design. Span 11.0 rise. 2.95

Concrete in arch. .50 × 12 × 14.5 = 87.0

213

300 @ 18^{00} = 5400

2 − 9 × 12