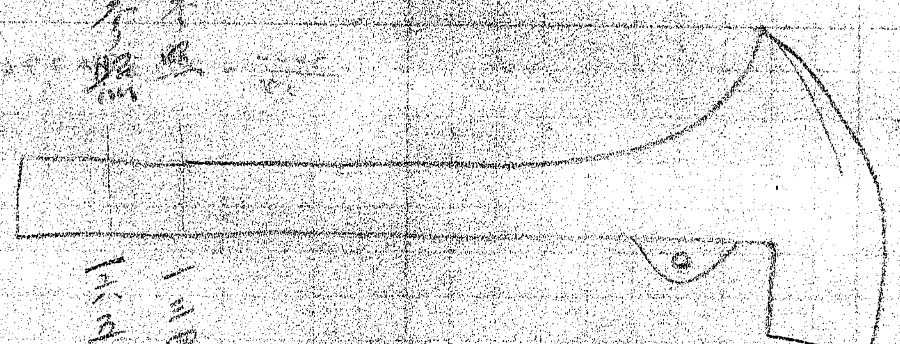
（會社原稿）

山口縣宇部市

沖ノ山炭鑛可動橋

十八米ハ豫算ノ第十三頁参照

廿一米ハ豫算ノ第十六頁参照



一三四、七〇〇。

一六五、六〇〇。

18— 55,700

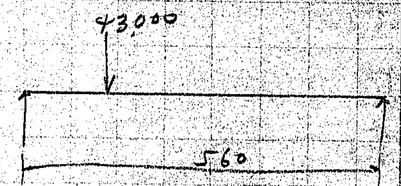
21— 76,500

Load on main trunnion

due to moving leaf	104640		
due to counter-weight	226000		
		330640 kgs	
main trunnion shaft		2100	
		332740 kgs	
load on one trunnion		166,370 kgs	
load on one bearing		83,185	say 84,000 kgs

Design of trunnion guide

load on one guide due to moving leaf	42000	
bearing	1000	
		43,000 kgs



$\frac{[illegible]}{[illegible]} \times 21.35 = 7760$

増田淳氏関係資料
(独立行政法人 土木研究所蔵)

JIUN MASUDA
CONSULTING ENGINEER
SHOWA BLDG, TOKYO

MADE BY J. Masuda DATE 10-3-2 **FILE NO** ____

CALCULATIONS FOR

CHECKED BY ____ DATE ____ **PAGE NO** 1

Okinoyama Coal mine Bascule Bridge

18 m/ Bascule Span.

Flooring 10cm thick, nailing piece - 12cm × 16cm - 800 kgs./per cubic meter

at curb line - 2 - 15cm × 20 - on one side.

stringer 250 × 125 × 7.5 @ 38.3 kgs D.L. Impact 30%.

weight of timber. 9.80 × .10 = .98

13 × .12 × .16 = .25

4 × .15 × .20 = .12

1.35 @ 800 = 1080 kg.

Stringer. 10 @ 40kg = 400

Center. 4L's 40.

1Pl. 55

95

25% 20

120 — 120 — 520 —

I 250×125×38.3

floor beam say 1.90 ton @ 6 = 11.40/19 = 600 —

Lateral Bracing 8L's 125×75×9 @ 13.5 × 5.5 = 595

on main girder 2Pls. 700×9 @ 49.4 × .90 = 89

on floor beam 1Pl. 900×9 @ 63.6 .90 = 57

Center connection 1Pl. 400×9 @ 28.3 .70 = 20

misc. 20

781 ÷ 3.8 = 297 300

520
600
300
1720
3140
1080
4220

Horizontal girder

2L's 2L's 130×130×9 @ 17.9 = 35.8

1Pl. 900×9 @ 63.6

misc. say 25.0

124.4

125 × 9.8 = 1230

main girder.

1Pl. 2000 × 16 @ 251.2

4L's 150×150×19 @ 167.6

4Pls. 400×19 @ 238.0

656.8

30% 200.0

856.8

say 860 × 2 = 1720

4220 say 4300 kg/per lin meter

Design of main girder. 2150 per lin. meter per girder

at 8 meter	$m = 2150 \times \frac{8^2}{2}$	= 68800 kgm, 30% 20600, 89400	89400
12 "	$m = 2150 \times \frac{12^2}{2}$	155,000, 46500, 201500	201500
15.5	$m = 2150 \times \frac{15.5^2}{2}$	258,000, 775, 335500	335500
19.5	$m = 2150 \times \frac{19.5^2}{2}$	410,000, 123000, 533000	533000
21.7	$m = 2150 \times \frac{21.7^2}{2}$	507,000, 152000, 659000	659000

JIUN MASUDA
CONSULTING ENGINEER
BLDG, TOKYO
SHOWA

CALCULATIONS FOR

MADE BY J. Masuda DATE ______ **FILE NO** ______

CHECKED BY ______ DATE ______ **PAGE NO** 2

Okinoyama Coal Mine Bascule Bridge

main section of girder at trunnion

d = 2500 web area = 2500 × 16 = 400.0 1/8 web = 50.

flange area $\frac{659000}{2.20 \times 1200}$ = 249.0
 50.
 199.-

272
50
222

2Ls 150×150×19 = 106.76 − 19.0 = 87.76

53.38
2
106.76
4

2P/s 360×16 = 116.00 − 16.0 100.00
 222.76
1 P/s 360×16 = 58.00 − 8 = 50.0
 280.76 237.76

106.76
19
87

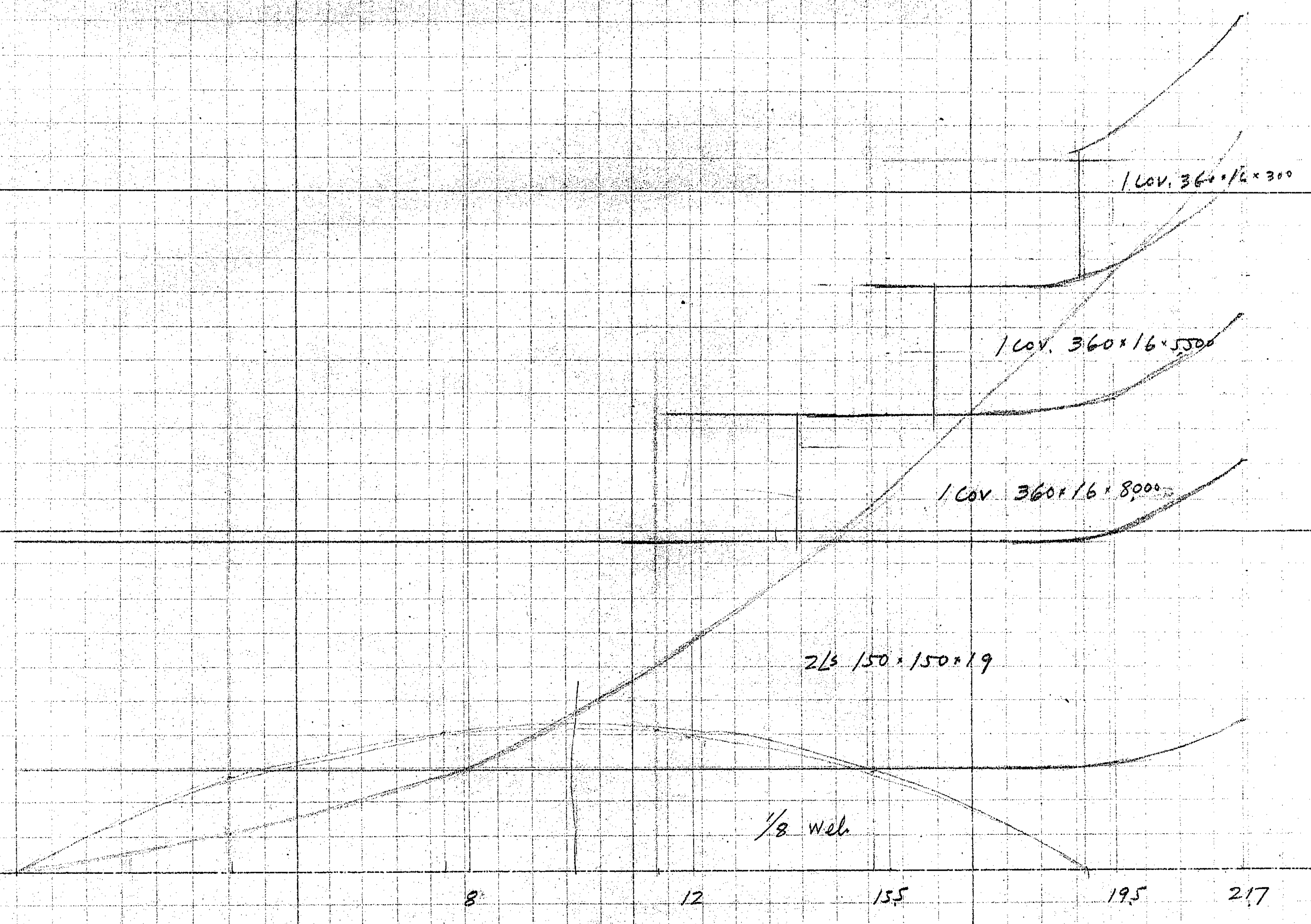
at 19.5 m m = 533000

d = 2050 web area = 2050×16 = 3280 1/8 web area = 410

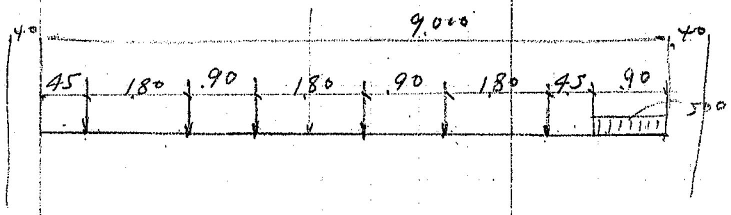
flange area $\frac{533000}{195 \times 1200}$ = 2280
 410
 1870

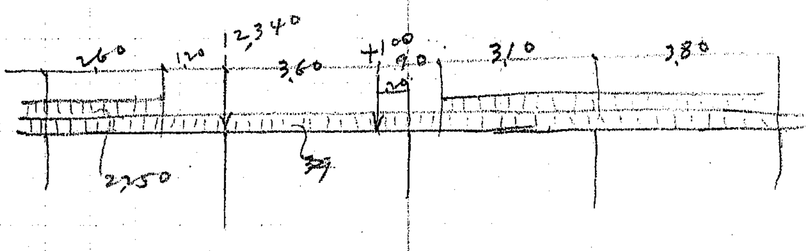
2Ls 150×150×19 = 106.76 − 19.0 = 87.76

3P/s 360×16 = 174.0 150.00
 280.76 237.76



Line load moment





load on girder $3000 \times 6 \times \frac{5.35}{9.80} = 9840$

impact $\frac{20}{60 \times 19} = 25.4\%$ 2500

12,340

12,340   216   3884

~~148~~   ~~148~~   ~~148~~   ~~148~~   ~~148~~

uniform load $\frac{500 \times 9 \times 8.5}{9.80} = 39^{kg}/m$

3,850   4280

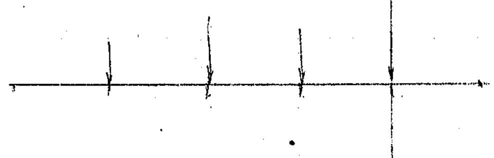
2,000   14,556   8,550   6,000 — concentration

2,850   6,734

4,150   4280   8,430

8,550   8,550

$500 \times 4.50 = 2250$,



moment at 3.80

$17,100 \times 3.80 = 65,000$

$6,000 \times \frac{4}{5} \times 3.80 = 18,250$

83,250 Kgm.

moment at 7.60

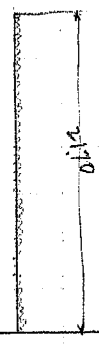
$17,100 \times 7.60 = 130,000$

$8550 \times 3.80 = - 32,500$

$6000 \times \frac{3}{5} \times 7.60 = 27,400$

124,900 Kgm.

Design of horizontal rib



load $2150 \times .15 = 322$ kg/m

moment $\frac{322 \times 217^2}{2} = 76000$ Kgm   38,000 for one rib

$d = 80^{cm}$ web area $80 \times 9 = 720$ 1/8 web = 90

flange area $= \frac{38000}{.70 \times 1100} = 49.5\ cm^2$

−9

40.5

use 2Ls 130×130×9 = 45.48 cm²

approximate weight of main girder

main section

flange	4 Ls	150×150×19	@ 41.9'	×	2700 (−350)	=	4530 ·	3940
,	1 Pl	360 × 16	@ 45.2'	×	1450' (−350)	=	655 ·	497
,	1 ,	,	@ ,	×	1150' (−350)	=	520 ·	362
,	1 ,	,	@ ,	×	900'	=	410 ·	249
,	1 ,	,	@ ,	×	1560' (−400)	=	705 ·	524
,	1 ,	,	@ ,	×	1290' (−400)	=	585 ·	402
,	1 ,	,	@ ,	×	1140' (−400)	=	515 ·	335
web	1 ,	2000 × 16	@ 251.2'	×	920'	=	2315 ·	2315
,	1 ,	,	@ ,	×	770'	=	1935 ·	1935
,	1 ,	,	@ ,	×	750' (500)	=	1885 ·	1255
,	1 ,	3000 × 16	@ 376.8	×	550'	=	2070 ·	

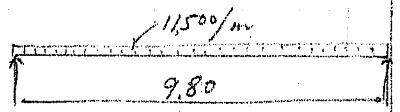
11814

Web	1 Pl	3000 × 16	37.68 ×	620 =	2340	
under rack	2 Ls	150 × 150 × 19	41.9 ×	810 =	680	
〃	1 Pl	360 × 16	45.2 ×	810 =	370	(6,700)
					19,515 ✓	
Details						
stiffener	4 Ls	125 × 90 × 13	20.6 ×	1962 =	162	
〃	28 〃	125 × 75 × 9	13.5 ×	2000 =	755	
〃	2 Ls	125 × 90 × 10	16.1 ×	2,300 =	74	
〃	4 Ls	150 × 150 × 19	41.9 ×	2800 =	470	235
〃	2 Ls	125 × 90 × 10	16.1 ×	3,800 =	123	
〃	2 Ls	〃	〃	3,000 =	97	
〃	2 Ls	150 × 150 × 12	27.1 ×	2800 =	152	
splice	8 Pls	250 × 19	37.3 ×	850 =	255	
〃	4 Pls	350 × 19	52.2 ×	1200 =	250	
〃	8 Ls	150 × 150 × 19	41.9 ×	1400 =	470	
〃	4 Pls	360 × 16	45.2 ×	1,000 =	181	
side plate	2 〃	260 × 19	38.8 ×	3900 =	305	
splice	2 〃	300 × 9	21.2 ×	3,600 =	153	
〃	2 〃	300 × 9	〃	3,000 =	127	
filler (stiff)	4 Pls	90 × 19	13.4 ×	1,700 =	91	
〃	8 〃	75 × 19	11.2 ×	1,700 =	152	
〃	2 〃	90 × 19	13.4 ×	4100 =	110	
〃	2 〃	〃	〃	2,900 =	78	
stiffener (C.W.T)	4 Ls	125 × 75 × 9	13.5 ×	1,400 =	76	700
rib	14 Pls	150 × 25	29.4 ×	500 =	210	
shelf L	1 L	100 × 75 × 10	13.0 ×	19,400 =	252	
horiz. girder	4 Ls	130 × 130 × 9	17.9 ×	8000 =	573	329
〃 〃	4 Ls	100 × 100 × 10	14.9 ×	7,200 =	430	245
〃 〃	2 web	700 × 9	49.5 ×	7,200 =	713	406
stiffener	16 Ls	100 × 75 × 10	13.0 ×	700 =	146	
rain cover	1 Pl	150 × 9	10.6 ×	7,700 =	82	(4,571) (5,100)
					6,487	34
trunnion					1,000	
					7,487	
~~misc~~					1,000	43.5%
					8,487	
					28,000	
~~rivet head 3.5%~~ 5%					980	
for one girder					28,980 kgs	
for one bridge		2 × 28,980 =			57,960 kgs	

Center of gravity of moving leaf

			hor. arm		
timber flooring	1,080 × 19.70 =	21,300 ×	12.25	=	261,000
stringers	520 × 19.70 =	10,200 ×	12.25	=	125,000
floor beams	600 × 19.70 =	11,800 ×	12.25	=	144,500
lateral bracings	215 × 19.70 =	4,230 ×	12.25	=	51,800
horizontal ~~girder~~ strut	=	1230 ×	2.85	=	3500
main girder (front)	=	34,000 ×	10.00	=	340,000
〃 〃 (rear)	=	20,000 ×	−2.80	=	−56,000
floor break	2 × 640 =	1280 ×	11.70	=	15000
shoe	=	600 ×	11.70	=	6700
		104,640 kgs			891,500 ÷ 3.95 = 226,000 kgs
trunnion shaft + misc		5,360			
		110,000			$\frac{891,500}{110,000}$ = 8.10 m

Design of Counterweight girder



uniform load $\frac{226000}{2} \div 9.80 = 11{,}500$ kg/m

moment at center $\frac{11500 \times 9.80^2}{8} = 138{,}000$ kgm

flange area $\frac{138000 \times 100}{192 \times 1200} = 60.00$ cm² ×1.3 = 78.0

use 2 Ls 150×150×15 = 85.48 − 15.0 = 70.00
2 L 125×90×9 = 37.00 − 9 = 28.00
122.5 — 98.00

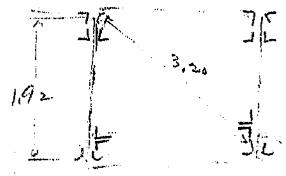
web × 1.3 = 27.

Diagonal shear $\frac{11500 \times 9.8}{2} = 56{,}400$

stress 56,400 × 1.3 = 73,300 kg

$\frac{73300}{1200} = 61.00$

Approximate weight of counter weight girder & framing



138000 × 2 = 276,000
30% 82,800
358,800 kg

flg. stress = $\frac{358{,}800}{3.2} = 111{,}0$

side							
flange	8 Ls	150×150×15	@	33.6	× 9.80	=	2,630
end connection	8 Ls	150×100×12	@	22.4	× 2.00	=	358
〃 〃	4 P/s	1,650 × 9	@	116.6	× 2.00	=	934
vertical	12 Ls	150×90×9	@	16.4	× 2.00	=	394
diagonal	32 Ls	125×90×9	@	14.6	× 1.80	=	840
gusset	10 P/s	700 × 9	@	49.5	× .80	=	396
top web	6 P/s	400 × 9	@	28.3	× 1.00	=	170
horiz. Ls	16 Ls	125×90×9	@	14.6	× 9.80	=	2,290
top & bottom							
end connection	8 Ls	150×100×12	@	22.4	× 2.40	=	430
〃	4 P/s	1,650 × 9	@	116.6	× 2.40	=	1,120
vertical	6 Ls	150×90×9	@	16.4	× 2.40	=	236
diagonal	32 Ls	150×90×9	@	〃	× 3.40	=	1,780
gusset	8 P/s	500 × 9	@	35.3	× .85	=	240
horiz. strut	4 Ls	150×90×9	@	16.4	× 9.80	=	642
〃	1 Pl	400 × 9	@	28.3	× 9.80	=	277
longi. strut	12 Ls	125×75×10	@	14.9	× 4.50	=	805
〃	3 P/s	400 × 9	@	28.3	× 4.50	=	382
bracing	16 Ls	150×90×9	@	16.4	× 3.30	=	865
end connect.	2 P/s	800 × 9	@	56.5	× 2.10	=	237
gusset	3 P/s	850 × 9	@	60.1	× 1.00	=	180
〃	10 P/s	500 × 9	@	35.3	× .85	=	300
〃	8 P/s	400 × 9	@	28.3	× .65	=	147
stiffener	46 Ls	125×75×9	@	13.5	× .40	=	248
end connection	4 Ls	150×100×9	@	17.1	× 2.10	=	144
Cross framing							
	12 Ls	150×100×9	@	17.1	× 3.10	=	636
	12 P/s	500 × 9	@	35.3	× .50	=	212
	3 P/s	500 × 9	@	〃	× .50	=	53
							16,946
rivet		3½ %					594
							17,540
misc.							260
							17,800 kg

Counterweight required

226,000
17,500
208,500 kg

unit weight of scrap concrete

$\frac{208500}{2.4 \times 2.0 \times 9.8} = 4{,}430$ kg/m³

$7850 \times x + 1700 \times (1-x) = 4430$

7,850x 4430
1700x 1700
6,150x 2,730

$x = 0.444$

weight of punch scrap

2.4 × 2.0 × 9.8 × .444 × 7,850 = 164,000
17,800
145,200 kg

JIUN MASUDA
CONSULTING ENGINEER
~~1111~~ SHOWA BLDG, TOKYO

CALCULATIONS FOR

MADE BY ____ DATE ____ FILE NO. ____
CHECKED BY ____ DATE ____ PAGE NO. 6

Flooring ~~over~~ machinery room
Stringer
Dead load

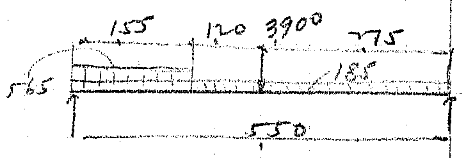
3.8 asphalt block pavement @ 21 kg = 79.8
2.2 cement mortar cushion @ 17 kg = 37.4
17.0 concrete slab @ 24 = 40.8
misc 12.0
170.0 kg/m²

moment $\frac{170 \times 5.5^2}{8}$ = 642 kgm × 1.50 = 965 kgm ✓

moment due to beam 1 I 350 × 150 @ ~~87.2~~ 58.5
$\frac{90 \times 5.5^2}{8}$ = 340 kgm ✓

Live load

uniform load 500 × 1.50 = 750 kg/m $\frac{500 \times 1.05^2}{1.5 \times 2}$ = 185
motor truck 3,000 kg 185
impact 30% 900 565
3,900 kg for rear wheel
1,300 kg for front wheel



moment 2,074 × 2.75 = 5,700 kgm
$\frac{185 \times 5.5^2}{8}$ = 700
6,400 kgm

$\frac{565 \times 1.55^2}{5.5 \times 2}$ 1950
124
2,074

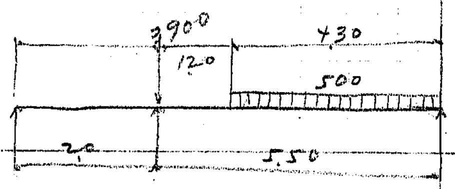
summary of moment
965
340
6400
7,705

required section modulus
$\frac{7705 \times 100}{1,100}$ = 700 cm³

use 1 I 350 × 150 @ 58.5 kg Sm. = 870 cm³

Cross beam
Dead load
pavement & slab 170.0
stringer 60/1.5 40.0
210.0 × 3.75 = 788 kg/m

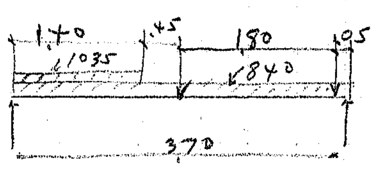
Dead load moment $\frac{788 \times 3.7^2}{8}$ = 1,350 kgm



moment due to own weight $\frac{110 \times 3.7^2}{8}$ = 188 kgm

Live load
moment

$\frac{500 \times 4.3^2}{2 \times 5.5}$ = 840



$\frac{3,900 \times 1.90}{3.70}$ × 1.85 = 3,710
$\frac{1,035 \times 1.40 \times 3.00}{3.70}$ × 1.85 = 2,175
1,035 × 1.40 × 1.15 = - 1,665
$\frac{840 \times 3.7^2}{8}$ = 1,440
5,660 kgm
7,198 kgm

$\frac{500 \times 7.5}{2}$ = 1875
840
1,035

web area 40.0 × 9 = 36.0 1/8 web = 4.5
flange area
$\frac{7,198}{.31 \times 1,100}$ = 21.1
4.5
16.6 cm²

use 2L 75 × 75 × 9 = 25.38 cm²

増田淳氏関係資料
(独立行政法人 土木研究所蔵)

approximate weight of floor framing over machinery room

stringer	7 I's	350 × 150	c 58.5	× 5.60	= 2,300
shelf L's	12 L's	125 × 75 × 9	c 17.19	× 5.60	= 1,155
coping	2 Pls	450 × 9	c 31.8	× 7.70	= 490
"	2 L's	75 × 75 × 9	c 9.96	× 7.70	= 154
cross beam	8 L's	75 × 75 × 9	"	× 9.80	= 780
"	2 Pls	400 × 9	c 28.3	× 9.80	= 555
"	4 L's	75 × 75 × 9	c 9.96	× 14.80	= 590
"	1 Pls	400 × 9	c 28.3	× 14.80	= 419
stringer conn	28 L's	150 × 90 × 9	c 16.4	× .40	= 184
"	14 Pls	150 × 9	c 10.6	× .60	= 89
stiffener	14 L's	75 × 75 × 9	c 9.96	× .40	= 56
stringer bearing	7 Pls	150 × 16	c 18.8	× .25	= 33
"	7 Pls	180 × 22	c 31.1	× .30	= 65
shelf L's	2 L's	125 × 75 × 9	c 17.19	× 11.50	= 395
columns	12 L's	100 × 100 × 10	c 14.9	× 1.30	= 233
"	12 L's	125 × 75 × 9	c 13.5	× .60	= 97
"	6 Pls	250 × 9	c 17.7	× .60	= 64
"	8 I's	200 × 90	c 30.3	× 3.45	= 835
" lacing	8 Pls		6.4	× 3.45	= 177
"	16 L's	150 × 90 × 9	c 16.4	× .55	= 145
"	16 Pls	300 × 9	c 21.2	× .55	= 187
"	8 Pls	400 × 22	c 69.1	× .45	= 249
rivet heads	3½ %				322
					9,574
misc					226
					9,800 kgs

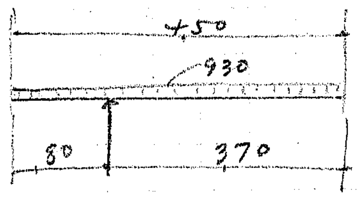
Load on main trunnion

due to moving leaf 104,640
countrweight 226,000
330640
trunnion shaft 2100
332740
load on one trunnion 166,370
one bearing 83,185 say 84,000 kgs

Design of Trunnion girder

load on one girder due to moving leaf 42000
bearing 1,000
43,000 kgs ✓

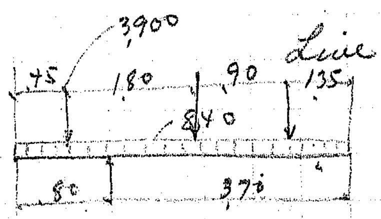
load on girder due to flooring



Dead load
pavement, slab & stringer 788
floor beam 110
column & misc 32
930 kg/m

load on girder

$\frac{930 \times 4.5 \times 2.25}{3.70} = 2,550$ kgs ✓



Live load on girder

uniform load $\frac{840 \times 4.50 \times 2.25}{370} = 2300$

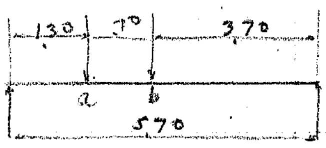
motor truck $\frac{3900 \times 7.65}{370} = 8060$

10,360 kgs ✓

12,910 kgs

moment

due to moving leaf



moment at a $\frac{43000 \times 4.4}{5.70} \times 1.30 = 43150$ kgm   shear 33200

moment at b $\frac{43000 \times 1.30}{5.70} \times 3.70 = 36300$ kgm

due to flooring & motor truck

moment at a $\frac{12910 \times 3.7}{5.70} \times 1.30 = 10900$ kgm   8380

~~moment at b $\frac{12910 \times 2.0}{5.70} \times 3.70 = 16750$ kgm~~

due to own weight assumed 290 kg/m

moment at a

$\frac{290 \times 5.70}{2} = 826$ kg   826

$826 \times 1.30 = 1075$

$\frac{290 \times 1.30^2}{2} = -245$

830 kgm

moment at b

$826 \times 2.00 = 1650$

$\frac{290 \times 2.00^2}{2} = -580$ 1070 kgm

summary of moment

a	b
43150	36300
10900	16750
830	1070
54880 kgm	54120 kgm

shear 42406

unit shear $\frac{42406}{150 \times 9} = 314$ kg/cm²

d = 150 web area = 150 × 9 = 135 cm² 1/8 web area = 16.9 cm²

flange area

$\frac{54880}{1.40 \times 1100} = 35.7$
16.9
18.8 cm²

use 2 Ls ~~125 × 75 × 10~~ 150 × 150 × 11 = ~~38.0~~ 64.0 cm²

approximate weight of trunnion girder

flange	4 Ls	150 × 150 × 11	c 25.1	× 12.80	=	1285
web	1 Pl	1500 × 9	c 106.0	× 12.70	=	1345
stiffener	4 Ls	125 × 75 × 9	c 13.5	× 1.50	=	81
"	36 Ls	125 × 75 × 10	c 14.9	× 1.50	=	805
"	8 Ls	125 × 75 × 10	c "	× 1.00	=	119
"	4 Ls	75 × 75 × 9	c 9.96	× 1.35	=	54
"	4 Ls	75 × 75 × 9	c "	× 1.15	=	46
filler	8 Pls	75 × 11	c 6.5	× 1.35	=	70
"	16 Pls	150 × 11	c 13.0	× 1.35	=	280
"	4 Pls	150 × 11	c "	× .85	=	44
						4129
						2
						8258

280

diaphragm	10 Pls	600 × 9	c 42.4	× 1.50	=	636
	2 "	"	c "	× 1.00	=	85
	40 Ls	90 × 75 × 9	c 11.0	× .60	=	264
under bearing	2 Pls	1100 × 22	c 190.0	× 2.30	=	875
sole plate	2 "	750 × 12	c 70.7	× 1.10	=	156
sole plate	2 Pls	900 × 25	c 176.6	× 1.00	=	353
grillage	10 Is	300 × 150	c 65.5	× 1.80	=	1180

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strut 20 L's 150 × 90 × 12 @ 21.5 × 2.65 = 1140

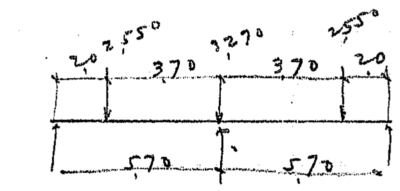
4689
12,947

rivet heads 3½% 450
misc. 203

13,600 kgs.

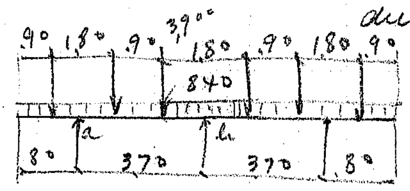
Design of bracket

pavement, slab, stringer + etc 930 × 9.00 = 8,370
2 @ 2,550 = −5100
3,270 kgs



concentration 3,270
$\frac{5100 \times 20}{570}$ = 1,790
5,060 kgs ✓

due to live load



reaction at a = $\frac{3900 \times 6.30}{3.70}$ = 6,640
$\frac{840 \times 4.5^2}{2 \times 3.7}$ = 2,300
8940

reaction at b 3,900 × 6 = 23,400
840 × 9.0 = 7560
30,960
2 @ 8,940 = −17,880
13,080

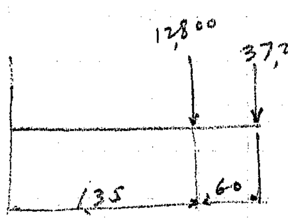
5,060 9,800
19,350 3,000
12,800 12,800 kgs
37,210 kgs

concentration 13,080
$\frac{17,880 \times 20}{570}$ = 6,270
19,350 kgs ✓

concentration due to trunnion concentration
$\frac{43000 \times 13}{57}$ = 9,800 kgs ✓

concentration due to trunnion girder
3,000 kgs ✓

moment



37,210 × 1.95 = 72,500
12,800 × 1.35 = 17,300
89,800
670
90,470 kgm

own weight say 350 kg/m
moment
$\frac{350 \times 1.95^2}{2}$ = 670

summary

for one beam say 45,300 kgm

d = 100 cm web area 100 × 9 = 90 cm² 1/8 web = 11.2 cm²

flange area $\frac{45,300}{.9 \times 1,100}$ = 45.8
11.2
34.6

use 2 L's 150 × 150 × 11 = 64.00 cm²

approximate weight of bracket

8	L's	150 × 150 × 11	@ 25.1	× 3.70	=	743
2	P/s	1,000 × 9	@ 70.7	× 3.70	=	524
24	L's	125 × 75 × 10	@ 14.9	× 1.00	=	358
8	L's	〃	@ 〃	× .85	=	101
8	L's	〃	@ 〃	× .80	=	96
2	P/s	550 × 9	@ 38.9	× 1.00	=	77
1	P/	〃	@ 〃	× .85	=	33
1	P/	〃	@ 〃	× .80	=	31
1	P/	750 × 12	@ 70.7	× .60	=	42

2005

rivet heads 3.5% 72
anchor bolts + misc. 123
2200 kgs

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Grand summary of structural steel

stringers	520 × 19.70	=	10,200
floor beams	600 × 19.70	=	11,800
lateral bracings	215 × 19.70	=	4,230
horizontal girder		=	1,230
main girders		=	57,960
floor break	4 @ 640	=	2,560
Counterweight girder & framing		=	17,800
flooring over machinery room		=	9,800
trunnion girder		=	13,600
brackets		=	2200
			131,380 kg tons
shoes	4 @ 450	=	1,800
			133,180 kg tons
punch scrap			145,200 kg tons

Design of main trunnion shaft

Dead load on shaft (for one bearing) 84,000
impact 30% 25200
109,200 kgs

shaft dia. assumed ~~35~~ 28 cm

$\frac{109200}{140} = 780 < \cancel{35} 28 \times \cancel{52} 40 = \cancel{1820}\ 1,120$

$d = 0.1693 \sqrt[3]{109200 \times \cancel{52}\ 40} = \cancel{30.2}\ 27.7$

4,370,000
1635

Estimate of Operating power

moment due to frictional resistance of journal — load on trunnion shaft
4 @ 84,000 = 336,000 kgs

$M_F = \frac{P f D}{200} = \frac{0.150 \times PD}{200} = 0.00075\, PD$ kgm

assumed the radius of rack circle = 550 cm

Rack force $F_R = \frac{0.00075 PD}{550} = \frac{0.00075 \times 336{,}000 \times 28}{550} = 1,283$ kgs

Rack force due to inertia

time 100 sec.
acc. $\frac{20}{2} = 10$
unif. 60
ret. $\frac{20}{2} = 10$
80

moving leaf $Mr^2 = 110{,}000 \times 8.10^2 \div 9.80 = 736{,}000$
counter weight $= 226000 \times 3.95^2 \div 9.80 = 360{,}000$
1096,000

Equivalent mass $M = \frac{1096000}{5.5^2} = 36{,}250$ kgs

uniform speed at rack circle

$\frac{2\pi \times 5.5 \times 80^\circ}{80 \times 360^\circ} = 0.096$ m/sec

acc $\alpha = \frac{0.096}{20} = 0.0048$ m/sec²

$F_\alpha = M\alpha = 36{,}250 \times 0.0048 = 174$ kgs

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Rack force due to eccentricity

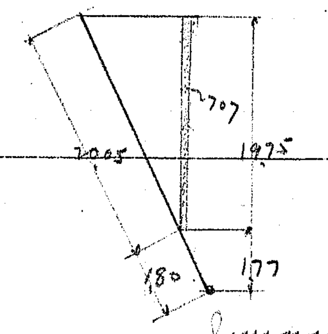
2e/1000 = 2000 kgs

Fe 2,000 × 21.35 ÷ 5.5 = 7,760 kgs

Rack force due to wind pressure 70 × 10.10 = 707 kgs/m

moment 707 × 19.75 × 11.65 = 162,600 kgm

2005 × 9848 = 19.75
180 × " = 1.77



Fw = 162600 ÷ 5.5 = 29,600 kgs

summary of rack force

	during wind blow	no wind
Journal friction	1,283	1,283
Inertia	174	174
Eccentricity	7,760	7,760
wind pressure	29,600	0
	38,817 kgs	9217 kgs

Operating power required

gear efficiency $0.94^6 = 0.69$

$HP = \frac{38817 \times 0.096}{76 \times .69} = 71^{HP}$ $\frac{9217 \times 0.096}{76 \times .69} = 16.9^{HP}$

Gearings

Rack speed $\frac{80°}{360° \times 80} = \frac{1}{360}$ m/sec = 0.1667 m/min.

Total gear ratio $\frac{820}{0.1667} = 4,920$

	1	2	3	4	5	RAP	
	53/15 ×	53/15 ×	53/15 ×	43/15 ×	32/15 ×	276/15	= 4950
	3.53	3.53	3.53	2.87	2.13	18.40	
	1 ✓ ①	2 ✓ ①	3 ✓ ①	4 ②	5 ②	6 ②	
Pitch dia wheel / pinion	636 / 180	742 / 210	1060 / 300	946 / 330	960 / 450	11,000 / 600	
face	90 / 100	110 / 120	130 / 140	150 / 160	210 / 220	240 / 250	
module	12	14	20	22	30	40	
cir. pitch	37.699	43.982	62.832	69.115	94.248	125.664	
			16ϕ		23ϕ	26ϕ	

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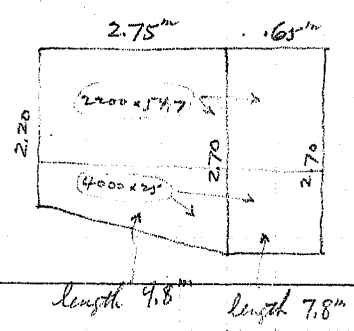
Bascule Bridge for Okinoyama Mining Co.

Concrete.

Total weight required = 220,000 kg about



volume of counterweight

2.45 × 2.75 × 9.80 = 66.00
2.70 × 0.65 × 7.80 = 13.70
79.70 cub m.

average unit weight = 220000 / 79.70 = 2760 kg/m³

25 m³ @ 4000 = 100,000
54.7 " @ 2200 = 120,000
79.70 m³ 220,000

proportion of 4000 kg. scrap concrete.

x = volume of steel scrap in one cub m.
$1-x$ = " " cement mortar " "

$7850x + (1-x)1700 = 4000$
$6150x = 2300$
$x = 0.374$

0.374 @ 7850 = 2935 kg
0.626 @ 1700 = 1065
4000 ✓

Cost.

Concrete 1:2:4		54.70 m³	@15 =	820
Steel scrap	25 @ 2935 =	73.4 ton	@80 =	5870
Cement mortar	25 @ .626 =	15.7 m³	@18 =	280
form	8.3 × 9.8 =	82.0 m²	@2.5 =	205
reinforcements	79.7 m³ @ 25 =	2.00 ton	@130 =	260
				65
				7500円

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CALCULATIONS FOR

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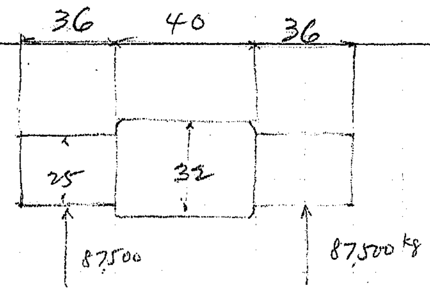
Bascule Bridge for Okinoyama Coal Mining Co.

Design of Main Trunnion Bearing, shaft and boss.

Total load on trunnion.

weight of bascule leaf	27.0 m³ @ 2,150 =	58,000
Counterweight		113,000
Shoes, air buffers, floor breaks &c.	4000÷2 =	2,000
		173,000
Trunnion shaft say		2,000
		175,000 kg for one shaft.



$d = 1.7205 \sqrt[3]{\frac{Pl}{s}} = 0.1693 \sqrt[3]{Pl}$ for $s = 1050$ kg/cm² forged steel

$= 0.1693 \sqrt[3]{87500 \times 40} = 0.1693 \times 151.8 = 25.7$ cm

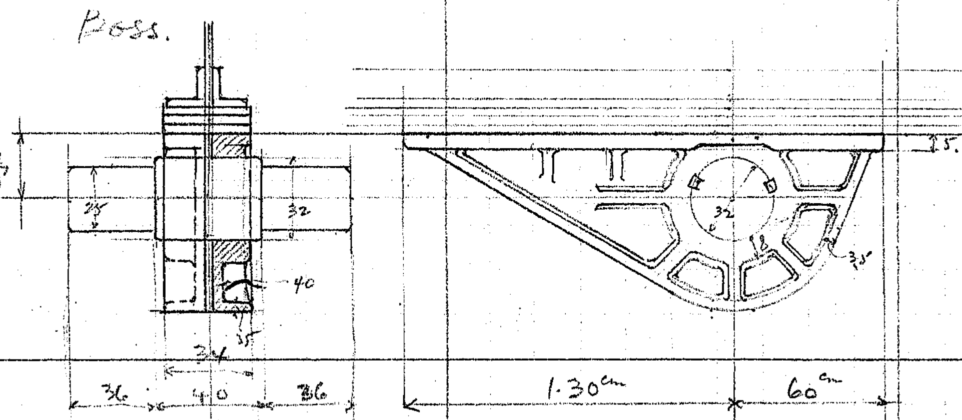
$d = 0.1693 \sqrt[3]{87500 \times 36} = 0.1693 \times 146.7 = 24.8$ cm

use 25 cm φ forged steel shaft.

weight of shaft.

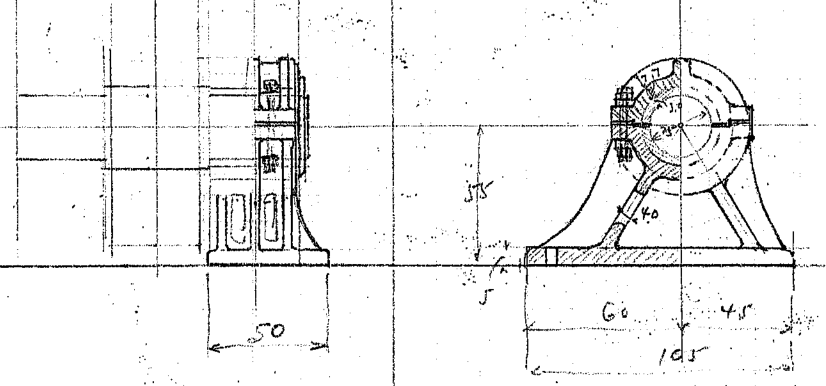
25φ × 72 =	35,350	
32φ × 40 =	32,200	
	67,550 cm³ @ .00785 =	530 kg.

Boss.



34 × 5 × 190 =	32,300 cm³
34 × 3.5 × 235 =	28,000
2 × 40 × 4 × 150 =	48,000
− 2 × 50φ × 4 =	(−) 15,700
(52φ − 32φ) × 32.4 =	37,600
4 × 24 × 120 =	11,500
	141,700

141,700 @ .00785 = 1,112
bolts &c say 88
1,200 kg



(45φ − 31φ) × 36 =	30,600
(60φ − 45φ) × 4 × 3 =	14,700
30 × 80 × 4 × 3 =	28,800
5 × 10 × 36 × 4 =	7,200
30 × 4 × 25 × 2 =	6,000
50 × 5 × 105 =	26,800
	114,100

114,100 @ .00785 = 900 kg
bolts &c say 100
1,000 kg

phosphor bronze

(31φ − 25φ) × 36 =	9,500
(45φ − 25φ) × 2 × 2 =	4,400
	13,900

13,900 @ .00815 = 113 kg

Summary.

	forged steel	cast steel	phosphor bronze	
Shaft	530			
boss		1200		
bearing		2000	115	
	530	3200	230	
for 2 bearings	1060 +	6400 +	460 =	7920 kg

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal Mining Co.

Estimate of cost for Bascule proper.

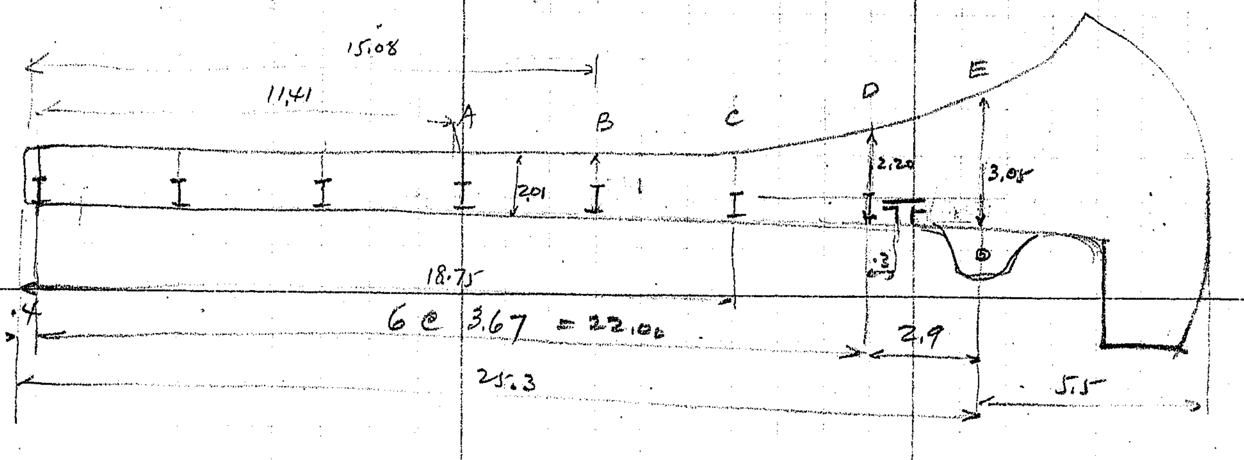
Structural	142.00 tons	@ 320			= 45,400
bascule floor					
10 cm planking	~~188.00~~ 196 m²	@ 6.00	=	~~1130~~ 1170	
nailing pieces + copings etc	~~7.08~~ 7.14 m³	@ 45.00	=	~~320~~ 330	
bolts + nails	0.60 tons	@ 250.00	=	150	
cast iron drains	6	@ 8.50	=	50	1700 ~~1680~~
Counterweight					
1:2:4 concrete	54.70 m³	@ 15.00	=	820	
punch scrap	73.40 tons	@ 80.00	=	5870	
1:2 cement mortar	15.70 m³	@ 18.00	=	280	
forms	82.00 m²	@ 2.50	=	205	
reinforcements	2.00 tons	@ 130.00	=	260	
misc.				65	
					7,500
Operating house 木造塗喰仕上					
建坪 3.20 × 7.20 = 23.00 m²		@ 40.00	=	900	
stairs with handrails say				200	
					1100
					55,700
mechanical equipments					
Forged steel parts	6.92 tons	@ 1800	=	12,500	
cast steel "	17.96 "	@ 1300	=	23,400	
cast iron "	13.00 "	@ 700	=	9100	
rolled steel "	6.16 "	@ 650	=	4000	
phosphor bronze "	1.30 "	@ 3300	=	4300	
	45.34				53,300
front + rear gates 木部青塗	2 sets	@ 300	=	600	
brake rope, sheaves etc say				100	
					700
gasoline engine set 7~10 HP	1 set.				1500
Electrical equipments					
motors with accessories	2 - 40 HP motors @				
	3 - 1 HP " @				
2" centrifugal pump with 1 HP motor say					
electric wiring complete say					
					8,600
					64000
					119,700
					15000
					134,700

Bascule Bridge for Okinoyama Coal Mining Co.

21m Bascule Span.

Design of main girder.

Dead load on one girder assumed as 2150 kg per lin. meter.



Moment on main girder

			moment	imp. coef		moment	approx. eff. depth		net area	16mm web 1/8 web	
A	1/2 × 2150 ×	11.41² =	140,000	× 1.30	=	182,000	÷ 1.92	÷ 1200 =	79.00	− 38.4	= 40.6
B	〃	15.08²	245,000	〃		328,000	1.96		139.50	− 39.2	100.3
C	〃	18.75²	377,000	〃		490,000	2.00		204.00	− 40.0	164.0
D	〃	22.40²	540,000	〃		702,000	2.20		266.00	− 44.0	222.0
E	〃	25.30²	688,000	〃		895,000	3.05		244.50	− 61.0	183.5

27m 橋ト同一ノ section ヲ用ヒ 最大 section ニテ 3.60 + 1.60 (splice ヲ含ム) = 5.20m [illegible]

Approximate weight of main girder.

(weight for 18m span.)

280×2 = 560
330
890 cm²

900 × 1.40 @ .785 × 5.2 = 29,400
5,200
400
35,000 kg for one girder

Counterweight required 688,000 × 2 ÷ 3.9 = 353,000 tons

air buffers, shoes, floor brakes & c. say 3000 × 25.3 ÷ 3.9 = 20,000

373,000

rear arm 1/2 × 3000 × 5.5² ÷ 3.9 = 13,000

360,000 tons

Volume of cwt.

2.50 × 3.10 × 9.80 = 75.9

0.98 × 3.3 × 7.40 = 23.2

99.1 cub. m.

20. m³ @ 2200 = 44.00 plain conc.

79.1 m³ @ 4000 = 316.00 scrap conc.

360.00 tons

Cwt.

concrete 1:2:4		20.0 m³ @ 15.0 =	300	円
steel scrap	79.1 @ 2935 =	233.0 tons @ 80.0 =	18600	
cement mortar 1:2	79.1 @ 626 =	49.5 m³ @ 18 =	900	
form		100 m² @ 2.5 =	250	
reinforcements		2.00 tons @ 130 =	260	
			90	
			20400	円

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3.7 3.0

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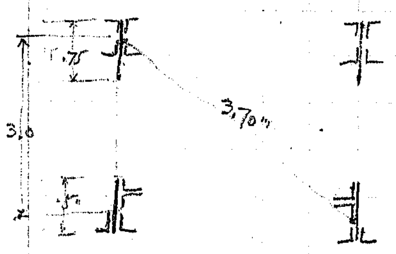
CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal mining Co.

Counterweight girder framing . span length 9.80.



Cwt. : 360 000 ÷ 9.8 = 36800 kg/m

moment 1/8 × 36800 × 9.8² = 441,000 kgm
30% impact = 132,000
573,000

flange stress for bridge closed } = 573,000 / 3.0 = 191,000

Flg. area = 191,000 ÷ 1200 = 159.00 cm² net for 2 flange

flange stress during operation } = 573000 / 3.70 = 155,000

Flange area = 155,000 ÷ 1200 = 129.00 cm² net for one flange.

Use. 2∟ 150 × 150 × 19 = 106.76 − 19 = 87.76
2∟ 125 × 90 × 9 = 37.08 − 9 = 28.08
1 web 500 × 9 = 45.00 − 9 = 36.00
188.84 151.84

Approx. weight of cwt girder .
17.8 + 5.00 + 2.00 = 24.8 ton.
24 800 × 1.25 = 31,000 tons

Fixed floor framing say 10,000 ton

Trunnion girder with brackets 14000 + 3000 = 17,000 ton

Summary of structural steel .

Stringers	22.7m @ 520 kg		=	11,800
floor beams	22.7 @ 600		=	13,600
lateral bracing	22.7 @ 215		=	4,900
main girders	2 @ 35,000		=	70,000
hor. strut	1		=	1,200
floor brackets			=	3,000
cwt girder framings complete			=	31,000
fixed floor framings			=	10,000
trunnion girders with brackets			=	17,000
shoes	4 @ 500		=	2000
				164,500 kg

8.500

Call this 165.000 tons

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal Mining Co.

Estimate of cost for Bascule proper.

Structural steel		165.00 tons @ 320.0		=	52800
bascule floor	9.80 × 22.7 =	223.0 m² @ 8.80		=	2000
Counterweight					
	1:2:4 concrete 20.0 m³	@ 15.00	= 300		
	1:2 cement mortar 49.5 m³	@ 18.00	= 900		
	punch scrap 233.0 tons	@ 80.00	= 18600		
	forms say		300.		
	reinforcements say		400		
					20500
Operating house 木造漆喰 set					1100
					76400
Mechanical equipments say		52.5 tons @ 1200		=	63000
	front + rear gates etc say				700
	gasoline engine set	1			1500
Electrical equipments say		2 – 30 HP motors, 3 – 1 HP motors } with accessories			
	1 – 2"φ Centrifugal pump with 1 HP motor				
	Electric wiring say				9000
					74200
					150600
					15000
					165600

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CALCULATIONS FOR

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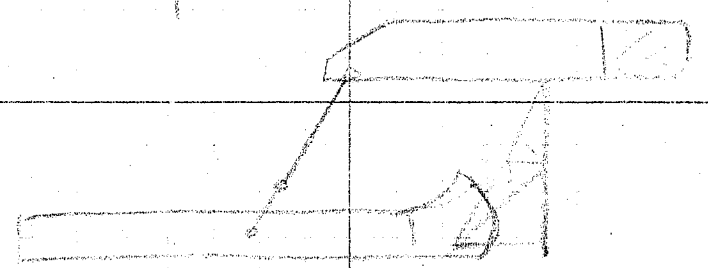
（玉森千代案）

昭和十年三月

山口縣宇部市

沖の山炭鑛株式會社

可動橋概算設計



十八米 鋼重は第十九頁参照 一〇八、三〇〇
廿一米 鋼重は第廿三頁参照 一四五、七〇〇

18 — 47,500
21 — 55,000 7500t3

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CALCULATIONS FOR

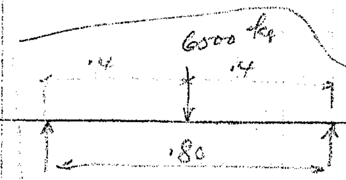
Bascule Bridge for Okinoyama Tanko Kaisha

Designing Data:-
Width of Roadway = 9.00 m clear.
Span length = 18.00 m clear.
Loading - - - - 2nd class loading.

Design of Floor.
Planking span length say 80 cm
Dead Load.
10 cm planking assumed @ 80 kg = 80 kg/m²
Dead Load m = 1/10 × 80 × 0.8² = 5 kgm /m. strip
" " shear = 1/2 × 80 × 0.8 = 32 kg "

Live Load 8 ton motor truck rear wheel = 3000 kg
30% impact = 900
3,900 kg

Effective width say 60 cm
Live load per meter strip = 3900/0.6 = 6500 kg

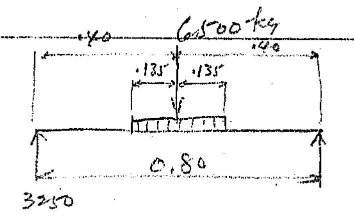


~~moment 3250 × .4 = 1300 × 8/10 = 1,040 kgm/m. strip~~
~~Shear = 6,500 kg~~

~~Summary of moments + shears.~~

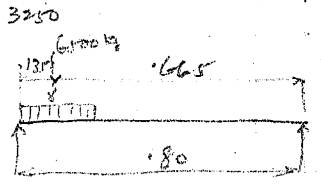
	moment	shear
D L	5	32
L L	1040	6500
	1,045 kgm	6,532 kg

~~Section modulus required = 1045 × 100 / 70 = 1,495 cm³~~
~~Depth of planking required = $\sqrt{\frac{1495 \times 6}{100}}$ = 9.47 cm~~



Live load moment 3250 × 0.4 = 1300
3250 × .135/2 = -220
1080 × 8/10 = 865 kgm /m. strip

Live load shear 6500 × .665/.8 = 5400 kg/ "



Summary of moments + shears.

	moment	shear
D.L.	5	32
L.L.	865	5400
	870 kgm	5432 kg

Section modulus required = 870 × 100 / 70 = 1245 cm³

Depth of planking req'd. = $\sqrt{\frac{1245 \times 6}{100}}$ = 8.64 cm.
for wearing course, add 1.36 cm
use 10,00 cm planking

unit shear = 5432/(10×100) × 3/2 = 8.2 kg/cm² < 25 ✓

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CALCULATIONS FOR

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Bascule Bridge for Okinoyama Tanko Kaisha.

Design of I-beam stringer. Span length 4.0m about, spacing 0.8m a/t.

Dead Load.

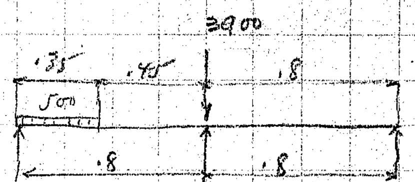
Floor planking	80 kg × 0.8	=	64.0
nailing piece	0.16×0.12 @ 800	=	15.4
Stringer assumed			40.0
bolts, nails &c say			10.6
			130.0 kg/m.

Dead load moment = 1/8 × 130 × 4.0² = 260 kgm

" " shear = 1/2 × 130 × 4.0 = 260 kg

Live load. 8 ton motor truck rear wheel with imp. = 3900 kg

" " front " " = 1300 "

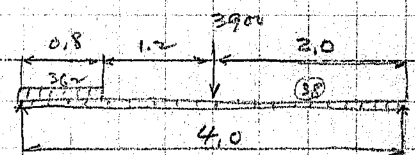


unif. load on stringer

front + rear of truck = 0.8 × 500 = 400 kg/m

side of truck $\frac{500 \times .35 \times .175}{.8}$ = 38

362

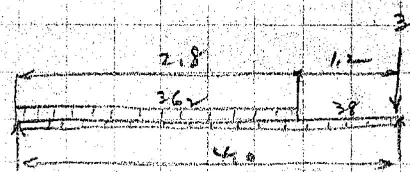


unif. load $\frac{362 \times 1.8 \times 1.4}{4.0}$ = 29.0 (R) × 2.0 = 60

wheel 3900 ÷ 2 = 1950 × 2.0 = 3900

unif. load 1/8 × 38 × 4.0² = 80

Live load moment = 4040 kgm



38 × 2 = 76

$\frac{362 \times 2.8 \times 1.4}{4}$ = 354

3900

Live load shear = 4330 kg

Summary of moment + shear

	moment	shear
D.L.	260	260
L.L.	4040	4330
	4300 kgm	4590 kg

Sm. reqd. = $\frac{4300 \times 100}{1100}$ = 391 cm³

Use I beam 250×125 @ 38.3 kg Sm. = 414.9 cm³

unit fibre stress = $\frac{4300 \times 100}{414.9}$ = 1,036 kg/cm²

shear on web = $\frac{4590}{25 \times .75}$ = 245 kg/cm²

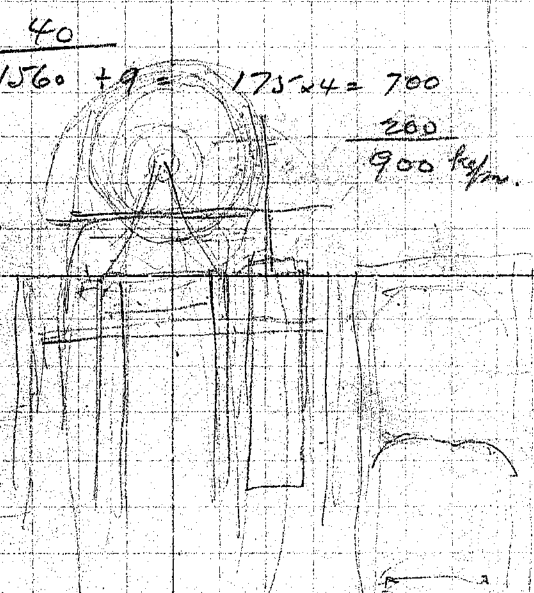
Design of Floor beam. Span length 9.40m spacing 4.0m a/t.

Dead Load.

Floor planking	9.4m @ 80		=	750
nailing pieces	13 @ 15.4		=	200
bolts nails &c say	13 @ 10		=	130
Stringer say	11	@ 40	=	440
coping	2	@ 20	=	40
				1560 ÷ 9 = 173 × 4 = 700
Floor beam assumed				200
				900 kg/m.

D.L. moment = 1/8 × 900 × 9.0² = 9120 kgm

" shear = 1/2 × 900 × 9.0 = 4050 kg



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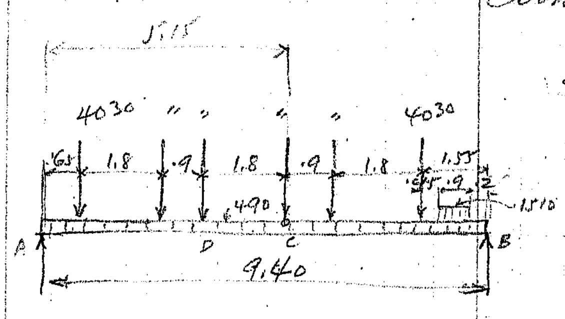
Bascule Bridge for Okinoyama Tanko Kaisha

Live load!

8 ton motor truck rear wheel with imp. = 3900 kg
" " front " = 1300 "
Unif. load on front + rear of truck =
500 × 2.8 × 1.4 ÷ 4 = 490 kg/m.
" " side of truck
500 × 4.0 = 2000 "
1510 "



max. wheel concentration on floor beam.
Front wheel 1300 × 0.4 ÷ 4 = 130
rear " 3900
4030 kg

Reaction R_A.
wheel load.
1.55 × 6 = 9.30
1.8 × 5 = 9.00
0.9 × 4 = 3.60
1.8 × 3 = 5.40
0.9 × 2 = 1.80
1.8 × 1 = 1.80
$\frac{30.90 \times 4030}{9.40}$ = 13300 kg

unif. load
$\frac{1510 \times 0.9 \times .65}{9.4}$ = 100
490 × 4.7 = 2300
2400
R_A = 15700 kg

Live load moment at (C)
15700 × 5.15 = 80900
4030 × 9.0 = − 36300
$\frac{490 \times 5.15^2}{2}$ = − 6500
38100 kgm

moment at (D)
15700 × 3.35 = 52600
4030 × 3.60 = − 14500
$\frac{490 \times 3.35^2}{2}$ = − 2700
35400 kgm

max. L. L. shear = 15700 kg.

Summary of moments + shears

	Moment	shear
D L	9120	4050
L L	38100	15700
	47220 kgm	19750 kg

Web assumed 1Pl. 800 × 9 = 72.0 cm² 1/8 web area = 9.00 cm²
eff. depth assumed 81.0 − 2 × 2.09 = 76.82 cm
flange stress = $\frac{47220 \times 100}{76.82}$ = 61500 kg
bott. flg. area reqd. = $\frac{61500}{1200}$ = 51.20
1/8 web area = − 9.00
42.20 cm² net

Use 2Ls 150 × 90 × 12 = 54.72 − 12 = 42.72 net

Approx. weight of floor beam.

Flange Ls	4Ls 150 × 90 × 12	@ 21.50	× 9.40	=	807
web	1Pl. 800 × 9	@ 56.50	× 9.40	=	531
Stiff Ls	22Ls 90 × 75 × 9	@ 11.00	× 0.72	=	174
"	4Ls 130 × 100 × 12	@ 22.40	× 0.70	=	63
fills	22Pls 75 × 12	@ 7.65	× 0.54	=	90
"	4Pls 220 × 12	@ 22.40	× 0.53	=	44
web spl.					80
					1789
	rivet heads say 3½%			=	61
					1850 kg

$\frac{1850}{9.4}$ = 197 kg/m.

Bascule Bridge for Okinoyama Tanko Kaisha.

Design of Main girders for bascule leaf.

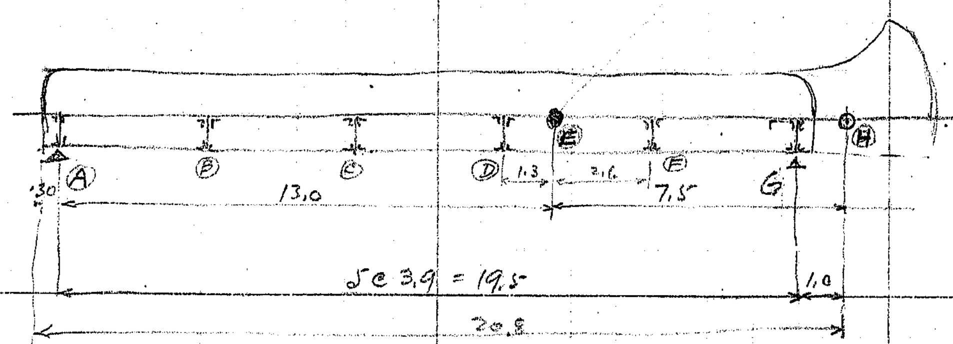
Dead load of moving leaf.

Floor planking	9.40 @ 80 =	752	
Nailing pieces 13 @ .12 x .16 =	.125 @ 800 =	200	
bolts nails drains etc say	=	58	
Stringers	11. @ 40 =	440	
floor beams	1850 ÷ 4 =	463	
Copings	2 @ 20 =	40	
			1950
lateral bracings assumed		200	
main girders assumed.	2 @ 550	1100	
			1300
			50
			3300 kg/m of bridge
			1650 kg/m for one girder.

$\frac{1}{2} \times 33 \times 12.5^2 = 3000$ … / 2 = 150,000 kgm

$\frac{150000}{1.9} = 79000$

$\frac{79000}{1200} = 65.8 \times 1.3 = 85.6$; − 22.5; 63.1



Vertical reaction at (E)
$\frac{1}{2} \times 1650 \times 20.8^2 \div 7.5 = 47600$ kg × 1.30 imp

cup lift at (A)
$1650 \times 20.8 \times 2.9 \div 7.5 = -13300$ kg × 1.30

			30 % imp	
Dead load moment at (E)	$= \frac{1}{2} \times 1650 \times 13.3^2 =$	−146,000 kgm.	−43,800 kgm	−189,800 kgm
(B)	$= \frac{1}{2} \times 1650 \times 4.2^2 =$	−14,500	−4,400	−18,900
(C)	$= \frac{1}{2} \times 1650 \times 8.1^2 =$	−54,000	−16,200	−70,200
(D)	$= \frac{1}{2} \times 1650 \times 12.0^2 =$	−119,000	−35,700	−154,700
(F)	$= \frac{1}{2} \times 1650 \times 15.9^2 =$	−208,500		
	$47600 \times 2.60 =$	+124,000		
		−84,500	−25,400	−109,900

Live load — Unif. load = 500 kg/m²
500 × 4.5 = 2250 kg/m for one girder
Rear wheel with imp. = 3900 kg
front " " " = 1300 "
max. wheel conc. on main girder
13300 } see page 4
1170 }

2250 × 4 = 9000
13300
4300 extra single concentration.

		$\frac{wx(l-x)}{2}$	$\frac{Px(l-x)}{l}$	Total.
Live load moment at (E) =	2250 × 13. × 6.5 × ½ =	95000		
	4300 × 13 × 6.5 ÷ 19.5 =		18600	113,600 kgm.
(B) =	2250 × 3.9 × 15.6 ÷ 2 =	68,500		
	4300 × 3.9 × 15.6 ÷ 19.5 =		13400	81,900
(C) =	2250 × 7.8 × 11.6 ÷ 2 =	102,000		
	4300 × 11.6 × 7.8 ÷ 19.5 =		20000	122,000
(D) = (C)				122,000
(F) = (B)				81,900

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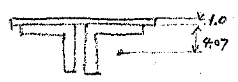
CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha

Summary of moments and shears

Moments

	B	C	D	E	F
Dead Load	-14,500	-54,000	-119,000	-146,000	-84,500
" 30% impact	-4400	-16200	-35700	-43,800	-25,400
Total D.L.m.	-18,900	-70,200	-154,700	-189,800	-109,900
Live Load	81,900	122,000	122,000	113,600	81,900
	67400	68,000	3,000	-32,400	-2,600



32.00 × 1.0 = 32.00
64.00 × 5.07 = 325.00
96.00 3.72 357.00

Try web 2000 × 9 = 180 cm² 1/8 web area = 22.5 cm²
Eff. depth say 201 - 2@3.72 = 193.56 cm
flange stress = $\frac{189800 \times 100}{193.56}$ = 98100 kg
flange area req'd. = $\frac{98100}{1200}$ = 81.8 + 10.2 = 92.0 (shoe, buffer, lock, floor break etc)
1/8 web area
-32.50
69.50 cm² net

Use 2Ls 150×150×11 = 64.00 - 11 = 53.00
1 cov pl. 320 × 9 = 28.80 - 4.5 = 24.30
92.80 77.30 cm² net

Approx. weight of main girder.

Flange	2Ls	150 × 150 × 11	@ 25.10	× 24.0	= 1205
"	2Ls	"	@ "	× 20.1	= 1010
"	2 cov pls	320 × 9	@ 22.61	× 9.0	= 407
web	1 pl.	2000 × 9	@ 141.30	× 20.1	= 2840
					5,462
Stiffeners	44Ls	125 × 75 × 9	@ 13.5	× 2.00	= 1188
"	8Ls	125 × 90 × 13	@ 20.6	× 1.99	= 328
fills panel pt	4 pls	75 × 11	@ 6.48	× 1.70	= 44
" end	4 "	250 × 11	@ 21.59	× 1.70	= 147
" like cont.	2 pls	1,700 × 9	@ 120.11	× 4.05	= 973
Splice					300
sole pl.		2 @ 30			= 60
Shelf L for planking	2Ls	155 × 75 × 9	@ 13.5	× 20.0	= 54
	Rivet heads etc say 5%				= 430
					3524
					8,986 kg call this 9,000 kgs

5462
3094
8556

$\frac{9,000}{20.1}$ = 448 kg/m

92.8
92.8
180
365.6 × .785 × 20.1 = 5770 $\frac{9000}{5770}$ = 1.56

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CALCULATIONS FOR

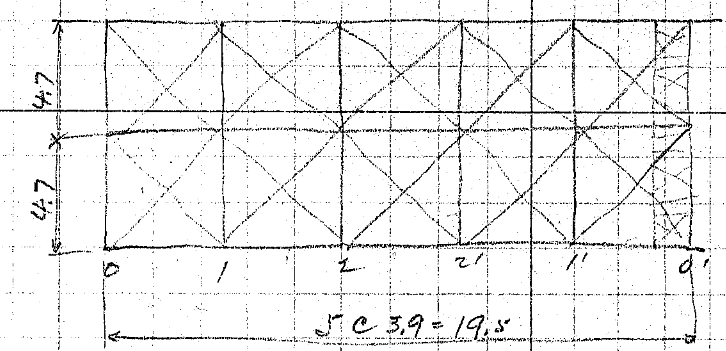
Bascule Bridge for Okinoyama Tanko Kaisha.

Outside main girder (for Operating)

Flange		2 Ls	150 × 150 × 11	@ 25.1	× 10.2	=	512		
〃		2 Ls	〃	@ 〃	× 11.0		552		
〃	rack circle	2 Ls	200 × 200 × 20	@ 59.7	× 4.0		477		
〃		2 cov. pls	320 × 9	@ 22.61	× 4.0		181	3667	
〃	rack circle	1 cov. pl.	410 × 14	@ 45.06	× 4.0		180		
web		1 pl.	2000 × 9	@ 141.3	× 8.0		1130		
〃		1 pl.	3000 × 9	@ 211.95	× 3.0		635		
	side pls.	2 pls	7740 × 11	@ 146.80	× 4.0		1170		1170
	side pls	2 pls	2600 × 11	@ 224.51	× 2.8		1258		
	stiff. pls	2 pls	1200 × 12	@ 113.04	× 2.0		452		
stiff Ls		26 Ls	125 × 75 × 9	@ 13.5	× 2.0		702		
	fills	8 pls	150 × 11	@ 12.95	× 1.7		176		
	〃	6 pls	75 × 11	@ 6.48	× 1.7		66	5077	
	断面変部=〃	1 L	125 × 75 × 9	@ 13.5	× 20.0		270		
Diaphragms			3	@ 120		=	360		
Tie pls.		6 pls	800 × 12	@ 43.96	× 0.9	=	238		
	stiff. pls.	2 pls	1200 × 12	@ 113.04	× 1.7	=	385		
								8744	
			rivet heads etc say	5 %				454	
								9,200 kg	11.2

Design of Lateral Bracing.

wind load 600 kg/m of bridge, Bridge as a simple span of 19.5 m



Diagonal length = $\sqrt{4.7^2+3.9^2} = \sqrt{22.1+15.2} = \sqrt{38.3} = 6.19^{m}$

coef. = $\frac{6.19}{4.7} = \underline{\underline{1.32}}$

wind panel load = 600 × 3.9 = 2,340 kg

11.2
2.8
14.0

panel	Shear.	for one diag.	coef	Stress	net area req'd.
0 – 1	4680	2340	× 1.32	= 3090 T ÷ 1500	= 2.06 cm²
1 – 2	2340 × 6/5 = 2810	1410	× 〃	= 1866	= 1.24

Use 2Ls 125 × 75 × 9 = 34.38 − 4.5 = 29.88 cm² net. — use 6-19φ rivets for each connection.

least radius of gyration = 3.96 cm

$l/r = \frac{619}{3.96} = 157.$

Approx. weight of lateral bracings.

Diagonal	40 Ls	125 × 75 × 9	@ 13.50 × 5.8	=	3130	
gusset pls. (girder)	12	conn. (600 × 9 × 7)	@ 30.	=	360	
〃 (center str.)	6	〃 (700 × 9 × 8)	@ 40	=	240	
〃	10	〃 (400 × 9 × 6)	@ 20	=	200	
		rivet heads 3.5 %		=	140	
						4070

Strut.	1 L	150 × 100 × 12	@ 22.4 × 9.4	=	211		
tie pls 上下	1 pl.	1000 × 9	@ 70.65 × 5.0	=	353		
lacing	12 pls	75 × 12	@ 7.07 × 1.2	=	101		
end conn.	2 Ls	125 × 75 × 9	@ 13.5 × 1.0	=	27		
		rivet heads 3.5 %			23	715	
						4785	call this 4,800 tons

4,800 / 20 = 240 kg/m

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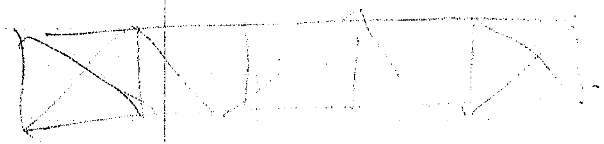
CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha.

Summary of Structural steel for Bascule leaf.

Stringers	10 @	40^{lb} × 20.0$''$	=	8,000		
〃	1 @	80 × 19.5	=	1560		
			=		9,560	
floor beams	6 @	1850			11,100	
lateral bracings			=	4,100		
〃 strut framing			=	700		
					4,800	(61,860)
Main girders (inside)	2 @	9,000	=	18,000		
(outside)	2 @	9,200	=	18400		
					36,400	
Shoes	4 @	500	=		2,000	
floor breaks	2 @	1500	=		3000	
					140	
					67,000 tons.	



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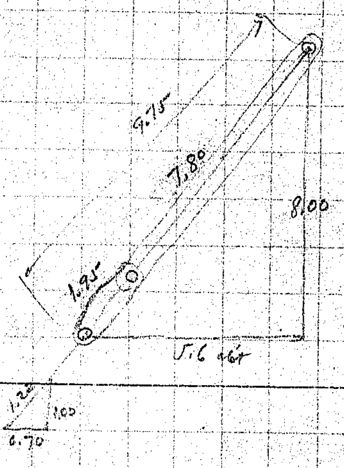
CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha.

Design of Balancing Link



vertical component of link pull = 47600 see page 5

Link pull = 47600 × 1.22 = 58000 kg T for one link

30% impact for D.L. = 17400

75400 kg T

net section required = 75400 / 1200 = 62.9 cm² net

Use 2[s 380×100×13 @ 67.30 kg = 171.42 − {20.00 / 26.00} = 125.00 net

l/r = 780 / 14.32 = 55.

approx. weight of one link

2[s 380×100 @ 67.3 kg × 10.3 = 1,385

details including casting say 65% = 900

2285 call this 2,300 kg one link

Counterweight required.

½×3300 × 20.8² = 714,000 kgm

Counterweight required = 714000 / 5.50 = 130 000 kg (全体 = ?)

for link wt. 4600 × 7.5 / 5.5 = 6300

136,300 kg

Concrete required = 136300 / 2400 = 57.0 cubm

Cross section of cwt. = 57.0 / 9.0 = 6.3 sq.m 2.0 × 3.15

20.0
33
66.00
14.00
80.00 leaf
136.00 cwt

Design of Balance Beam.

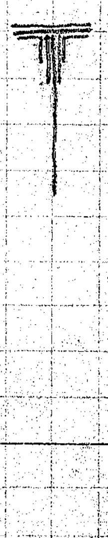
moment on balance beam 714,000 ÷ 2 = −357,000

" due to own wt of " ½×1300 × 7.7² = −38500

" " link wt. with allowance for 2300 × 7.5 = −17,300 imp exf.

−412800 × 1.30 = −537,000 kgm one girder

flange stress say = 537000 / 1.95 = 275000 kg



flange area reqd. = 275600 ÷ 1200 = 229.60

⅛ web area = 200×12 ÷ 8 = 30.00

199.00 cm² net

use 2Ls 150×150×19 = 106.76 − 19.00 = 87.76

2Pls 230 × 12 = 55.20 − 12.0 = 43.20

2 cov pls 320 × 12 = 76.80 − 12.0 = 64.80

238.76 195.76

approx. weight of balance beam

main section 2 flanges @ 238.76 = 477.52

1 web 200×12 = 240.00

717.52 × 0.785 = 563

details say 60% = 337

900. kg/m × 14.8 = 13300 kg

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CALCULATIONS FOR

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Bascule Bridge for Okinoyama Tanko Kaisha.

Approx. weight of lateral bracing for balance beam.

Diagonals	96 Ls	125×90×9	@ 146 × 3.50 =	4900		上下 = 323
gusset pls.	20 pls	600 × 9	@ 42.4 × 0.80 =	679		
"	28 "	800 × 9	@ 56.5 × 0.80 =	1265		
		rivet heads		256		
					7,100	
Cross struts	4		@ 1200 =	4800		
"	(front end) 1		=	1400		
Counterweight girder	2		@ 3300 =	6600		
	下久 横 - Ls			2000		
longitudinal strut.				2500		
					17,300	

Summary of steel for Balance Girder complete.

Balancing beams	2 @	13,300 =	26600
lateral bracing			7100
struts			17300
			51,000 kg
		revised to	46,300 kg

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal mining Co.
Revised

Approx. weight of Balance Beam.

Flange	4Ls	150×150×19	@ 41.9	× 15.0	=	2500
pls.	4pls	230 × 12	@ 21.7	× 14.1	=	1225
cov.	2pls	320 × 12	@ 30.1	× 5.7	=	343
〃	2pls	〃	@ 〃	× 12.2	=	734
web	1Pl.	2000 × 12	@ 188.4	× 13.3	=	2505
〃	1Pl.	1300 × 12	@ 122.5	× 1.50	=	184
						9
						7500 kg

7500 ÷ 15 = 500 kg/m

field splice		1	@ 600		=	600
shop web spl.		1	@ 200		=	200
Side pls. trunnion	2pls	1400 × 12	@ 131.9	× 1.54	=	406
〃	2pls	1400 × 19	@ 197.8	× 1.70	=	673
front end	2pls	800 × 12	@ 75.4	× 0.90	=	136
〃	2 〃	600 × 12	@ 56.5	× 0.80	=	91
〃	2 〃	800 × 19	@ 119.3	× 1.20	=	287
〃	2 〃	1000 × 12	@ 94.2	× 1.00	=	188
						19
						2600

Stiffeners	20Ls	125 × 90 × 9	@ 14.6	× 2.00	=	584
	4Ls	130 × 130 × 12	@ 23.4	× 2.00	=	187
	4Ls	〃	@ 〃	× 1.00	=	94
	4Ls	125 × 90 × 9	@ 14.6	× 1.20	=	70
fills (crimp 19mm 一腹 12)	8pls	250 × 12	@ 23.55	× 1.04	=	290
						25
						1250
		rivet heads say 4%				450

$\frac{11800}{15} = 787$ kg/m

weight of one girder complete = 11800 kg

Approx. weight of lateral bracings for balance beam.

Diagonals	64Ls	90 × 75 × 9	@ 11.00	× 3.40	=	2390
	8Ls	〃	@ 〃	× 2.50	=	220
	64Ls	75 × 75 × 9	@ 9.96	× 1.50	=	956
						34
						3600

gusset pls.					
	600 × 9	@ 42.4	× 18.00	=	763
	700 × 9	@ 49.5	× 19.20	=	950
					37
					1750

600×9 − 4.5×4 = 18.1
700×9 − 5.1×2 = 10.2
〃 − 4.5×2 = 9.0

lateral bracing top + bottom. = 5350 + 150 (rivet heads) = 5500

Struts. cross strut.	4Ls	135 × 75 × 9	@ 13.5	× 10.4	=	562
diag.	7Ls	90 × 75 × 9	@ 11.0	× 1.7	=	131
vert.	16Ls	〃	@ 11.0	× 1.6	=	282
gus. pl.		400 × 9	@ 28.3	× 5.6	=	159
〃	2pls	500 × 9	@ 35.3	× 2.0	=	141
conn.	2Ls	135 × 90 × 9	@ 14.6	× 2.0	=	58
						17
						1350 + 50 = 1400

1400 ÷ 10.6 = 132 kg/m

longitudinal strut say 15m @ 133 = 2000

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal Mining Co.

Summary of steel for Balance beam complete.

Balancing beams	2 @	11800	=	23,600
lateral bracings complete (top + bottom)			=	5500
Cross struts	4 @	1400	=	5600
〃 front end	1 @	1600	=	1,600
Cnt. girders	2 @	3000	=	6000
Longitudinal strut	1 @	2000	=	2000
Cnt. girder [illegible]				2000
				46,300 kg.

Bascule Bridge for Okinoyama Tanko Kaisha.

Design of Counterweight tower

Load on tower

vertical loads.

trunk pull		47600
balance beam	51000 ÷ 2 =	25500
counterweight	136300 ÷ 2 =	68200
link		2300
		143,600 × 1.30 (impact) = 187000 kg on one column

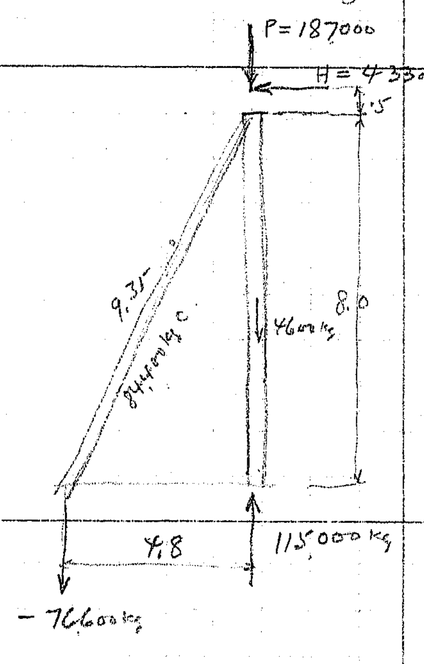
horizontal load 47600 × 0.70/1.00 = 33,300 × 1.30 = 43300 " "

load on stay = 43300 × 9.35 ÷ 4.8 = 84400 kg c

Reaction due to moment = 43300 × 8.5 / 4.8 = ± 76600 kg

max. load on one column

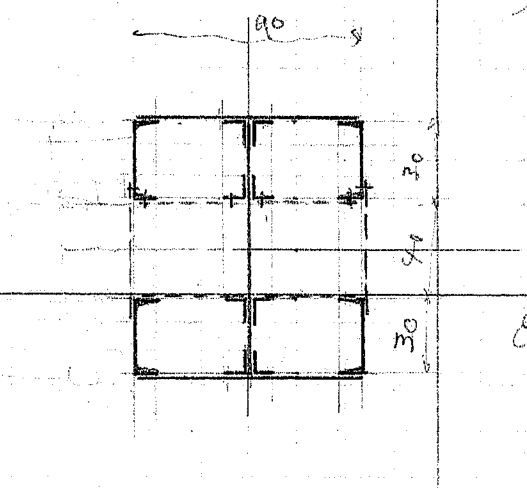
	187,000
	− 76,600
wt of col. say	+ 4600
	115,000 c



Cross section of column.

4[s 300 × 90 × 9 @ 48.57	=	194.28
8Ls 90 × 90 × 10	=	136.00
1 pl. 1000 × 9	=	90.00
2 pls 900 × 9	=	162.00
		582.28 cm²

(90 × 75 × 9)

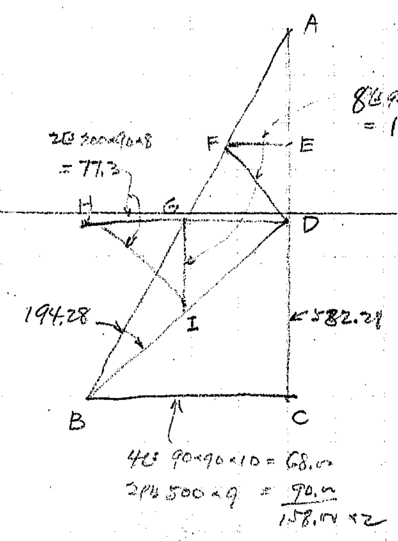


Cross section of stay.

4[s 300 × 90 × 9 = 194.28 cm²

Approximate weight of Tower.

Column	AC	1 @ 582.28	× 9.00	=	5250
Stay	AB	1 @ 194.28	× 8.50	=	1650
Strut	BC	2 @ 158.00	× 4.30	=	1360
	BD	1 @ 194.28	× 5.50	=	1070
	HD	1 @ 77.3	× 4.30	=	330
	HI	1 @ "	× 2.80	=	220
	EF	1 @ 136.00	× 1.00	=	140
	FD	1 @ "	× 1.50	=	205
	GI	1 @ "	× 1.50	=	205
					10430
details say 50%					5215
					15645 @ .785 = 12270



	12270
portal bracing	2000
anchor bolts etc say	1460
	28000 kg

Revised to 23000 kg

206

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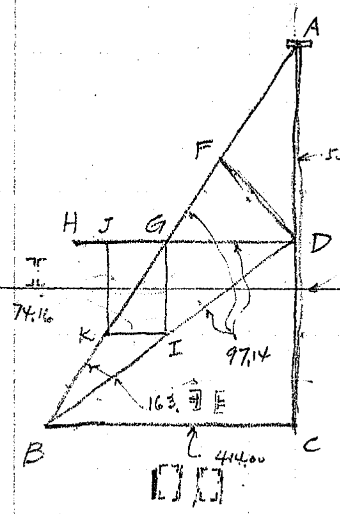
CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal Mining Co.

~~Revised~~

Approximate weight of Counterweight Tower.



Column	AC	1 @	558.60 cm²	×	8.60	=	4800
Stay	AK	1 @	97.14	×	6.00	=	583
〃	DI	1 @	〃	×	2.50	=	243
〃	KB	1 @	163.00	×	2.00	=	326
〃	IB	1 @	〃	×	2.50	=	408
Strut.	HD	1 @	97.14	×	3.50	=	340
braces	FD	1 @	74.16	×	1.50	=	111
〃	GI + JK	2 @	〃	×	1.50	=	222
〃	KI	1 @	〃	×	.80	=	59
Strut	BC	1 @	280.0	×	4.50	=	1260
							8352

8352 @ .785 = 6550 kg

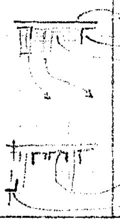
Column 4[s 300×90×9 @ 48.57 = 194.28 cm²
8Ls 90×75×9 @ 14.04 = 112.32
1Pl. 1000×9 = 90.00
2Pls 900×9 = 162.00
558.6 cm²

Stay 2[s 300×90×9 @ 48.57 = 97.14

braces 4Ls 125×90×9 = 74.16

Strut 4Ls 90×90×10 = 68.00
1Pl. 800×9 = 72.00
140.0 ×2 = 280

Cap.



2Pls	500×19	@ 74.6	×	1.25	=	187
図図 1L	150×150×15	@ 33.6	×	4.00	=	135
〃 Stiff 〃 1L	125×90×10	@ 16.1	×	6.60	=	98
top L's 〃 1L	90×90×10	@ 13.3	×	4.80	=	64
shelfies and fillers &c						66

550

Base.

1 base Pl.	1250×16	@ 157.0	×	1.40	=	220
1 〃 L 〃	150×150×15	@ 33.6	×	6.00	=	202
1 tie Pl	〃 1200×9	@ 84.8	×	4.00	=	339
1 Stiff L	〃 125×90×10	@ 16.1	×	6.60	=	106
1 Shelf L	〃 〃	@ 16.1	×	4.00	=	64
fills &c say						35
Anchor bolts	12 @ 7				=	84

1050

Gusset pls.

2 Pls	1000×9	@ 70.7	×	1.40	=	198
2 〃	900×9	@ 63.6	×	1.00	=	127
2 〃	600×9	@ 42.4	×	0.65	=	55
2 〃	1000×9	@ 70.7	×	1.20	=	170
2 〃	500×9	@ 35.3	×	0.60	=	42
2 〃	700×9	@ 49.5	×	0.90	=	89
2 〃	600×9	@ 42.4	×	0.80	=	68
2 〃	1000×9	@ 70.7	×	1.50	=	212
						39

1000

Tie pls. + lacing

1Pl 〃	1000×9	@ 70.7	×	3.00	=	212
1Pl 〃	400×9	@ 28.3	×	10.0	=	283
lacing 32 Pls	70×9	@ 4.9	×	1.10	=	173
〃 180 〃	65×8	@ 4.1	×	0.65	=	480
						52

1200

10350 kg × 2 = 20700 kg

Sway 1500

22200

rivet heads say 3.5% 800

weight of Counterweight Tower complete = 23000 kg

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha.

Summary of Structural steel (revised)

Bascule leaf complete		67,000		page 8
Balance Girder "		51,000	46,300	" 10
Links	2 @ 2300 =	4600		" 9
Counterweight tower complete		28,000	23,000	" 11
grillage under trunnion say	2 @ 1500 =	3,000		
floor beams in fixed floor	2 @ 1700 =	1400		
		155,000	148,000 kg	

Estimate of Operating power.

moment due to frictional resistance of Journals

$M_F = \frac{Pfr}{100} = \frac{PfD}{200}$

Journals	D	load P.	f				M_F
link pins	18 cm ×	75400 ×	0.15	÷200	× 4	=	4060
trunnion shaft	18	35900	"	"	× 2	=	970
cwt trunnion shaft.	25	147,000	"	"	× 2	=	5510
							10,540 kgm

Rack force $F_F = \frac{10540}{2.20} = 4,800$ kg

moment due to eccentricity

End reaction say 2 @ 500 kg = 1,000 kg

moment 1,000 × 20.5 = 20500 kgm

Rack force $F_e = \frac{20500}{2.2} = 9320$ kg

wind moment 70 kg wind assumed during operation.

moment 10.0 × 20.0 × 70 × 11.0 = 154,000 kgm

Rack force $F_w = \frac{154,000}{2.2} = 70,000$ kg

Summary of Rack forces.

Journal friction	4800
eccentricity	9320
inertia say	580
wind pressure	70000
	84700 kg (186,500 #)

Time of operation assumed

20 ÷ 2 = 10
60 = 60
20 ÷ 10 = 10
100 sec 80 sec.

Unif. speed at rack circle $= \frac{2\pi \times 2.20}{4 \times 80^{sec}} = 0.0432$ m/sec. (0.142 '/sec) (48.1 HP)

Theor. HP required $= \frac{84700 \times 0.0432}{76} = 48.1$

gear efficiency = ~~(0.94)^6~~ $(0.94)^7$ = ~~0.69~~ 0.648

Actual HP req'd. $= \frac{48.1}{~~0.69~~ \; 0.648}$ = ~~69.8 HP~~ 74.2 HP

Use ~~2 - 35 HP~~ crane motors.
2 - 40 HP

131 × 10/23 (57) 78.5 (70)

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha.

Hand operation.

Rack force due to.

Journal friction	4800
eccentricity	9320
inertia say	580
wind pressure 10 kg/cm	10000
	24,700 kg

Work done for one operation $= \frac{24700 \times 2\pi \times 2.2}{4} = 85,200$ kgm

Force developed by one man assumed 20 kg (by capstans)

velocity " 0.6 m/sec.

Energy developed by one man = 20×0.6 = 12 kgm/sec.

efficiency assumed 0.69×.7 = 0.48

net energy = 12×0.48 = 5.8 kgm/sec.

Time required for hand operation = 85200 ÷ 5.8 = 14450 sec

by 4 man 14450 ÷ 4 = 3600 sec or 60 min.

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha.

Gearings.

Motor set 2-40HP crane motors, Synchronous speed 865 rev. per min assumed.
Speed at full load assumed as 95% of 865 = 820 rev/min.

Rack speed $= \frac{90^\circ}{360^\circ \times 80} = \frac{1}{320}$ rev/sec $= 0.1875$ rev/min.

Total gear ratio $= \frac{820}{0.1875} = 4350$

Gear ratio

Spur gears 1st	2nd	3rd	4th	5th	6th	rack and Pinion	
$\frac{53}{15}$ ×	$\frac{53}{15}$ ×	$\frac{53}{15}$ ×	$\frac{41}{15}$ ×	$\frac{38}{15}$ ×	$\frac{29}{15}$ ×	$\frac{110}{15}$	= 4340
3.53	3.53	3.53	2.53	2.74	1.94	7.33	

Pinion forged steel $S_0 = 1550$
wheel cast steel $S_0 = 1400$

Diameter, power transmitted, speed and accumulated efficiency of gears.

Gearings	wheels	no. of rev/min n	Efficiency η	HP transmitted HP.η	pitch dia D_p	Speed at pitch circle $v = \pi n D_p$	Allowable Stress $S = S_0 \frac{183}{183+v}$
1st Gear	pinion	820	1.000	80.00	180	464 m/min	438
	wheel $820 \times \frac{15}{53} =$	232	0.940	75.20	636	〃	396
2nd 〃	Pinion	232	0.940	75.2	210	153	844
	wheel $232 \times \frac{15}{53} =$	65.7	0.884	70.7	742	〃	762
3rd 〃	Pinion	65.7	0.884	70.7	300	62.0	1157
	wheel $65.7 \times \frac{15}{53} =$	18.6	0.831	66.5	1060	〃	1045
4th 〃	pinion	18.6	0.831	2@ 33.25 = 66.5	330	19.3	1402
	wheel $18.6 \times \frac{15}{41} =$	6.80	0.781	2@ 31.25 62.5	902	〃	1267
5th 〃	pinion	6.80	0.781	2@ 31.25 62.5	450	9.61	1472
	wheel $6.80 \times \frac{15}{38} =$	2.68	0.734	2@ 29.35 58.7	1140	〃	1330
6th 〃	pinion	2.68	0.734	2@ 29.35 58.7	600	5.06	1510
	wheel $2.68 \times \frac{15}{29} =$	1.39	0.690	2@ 27.60 55.2	1160	〃	1360
main pinion		1.39	0.690	2@ 27.60 55.2	600	2.62	1530
rack	$1.39 \times \frac{15}{110} =$	0.189	0.649	2@ 25.95 51.9	4400	〃	1400

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CALCULATIONS FOR.

Bascule Bridge for Okinoyama Tanko Kaisha.

Dimensions of gears. materials. forged steel pinions
Cast steel spur wheel and rack.

15° involute cut teeth

20° involute stub cut teeth

Gearings	module $M_c = \frac{D_p}{N}$	no. of teeth N	Pitch dia $D_p = NM_c$	Cir. pitch P	face f	load on tooth $w = \frac{4560\ H.P.}{v}$	Strength of tooth $SPfy$		v	S	y
1st Gear											
pinion	12	15	180	37,699	100	786	1288	1.64	464	438	0.078
wheel	〃	53	636	〃	90	739	1490		〃	396	0.111
2nd gear											
pinion	14	15	210	43,982	120	2240	3470	1.55	153	844	0.078
wheel	〃	53	742	〃	110	2110	4090		〃	762	0.111
3rd gear											
pinion	20	15	300	62,832	140	5200	7930	1.52	62.0	1157	0.078
wheel	〃	53	1060	〃	130	4890	9470		〃	1045	0.111
4th gear											
pinion	22	15	330	69,115	160	7850	12100	1.54	19.3	1402	0.078
wheel	22	41	902	〃	150	7390	14,050		〃	1267	0.107
5th gear											
pinion	30	15	450	94,248	220	14830	23,750	1.60		1472	0.078
wheel	〃	38	1140	〃	210	13930	27900			1330	0.106
6th gear											
pinion	40	15	600	125,664	270	26450	40000	1.51		1510	0.078
wheel	〃	29	1.160	〃	260	24900	44800			1360	0.101
main pinion	40	15	600	125,664	340	48100	72,200	1.50		1550	0.109
rack.	〃	110	4400	〃	330	45200	98,000			1400	0.169

Shafts.

3rd shaft.

Torsional moment $M_T = 4890 \times 53 = 260000 \times 1.50 = 390,000$ kg cm

Bending 〃 $M_B = 4890 \times 45^{cm} 34 = 55000 \times 1.50 = 83000$
17000
100000

Equiv. torsional moment $T_E = \sqrt{(1.5 \times 100000)^2 + (1.0 \times 390000)^2}$

$= 418000$ kg cm

$d = \sqrt[3]{\frac{16 T_E}{S_s \pi}} = 0.2087 \sqrt[3]{T_E} = 0.2087 \sqrt[3]{418000} = 0.2087 \times 74.8 = 15.6$ cm φ

use 16 cm φ shaft.

5th shaft.

$M_T = 13930 \times 57 = 795000 \times 1.5 = 1190000$

$M_B = 13930 \times 60 = 84000 \times 1.5 = 126000$
24000
150000

Equiv. Tors. m. T_E = say $1190000 + 20000 = 1210000$ kg cm

$d = 0.2087 \sqrt[3]{1210000} = 0.2087 \times 106.5 = 22.2$

use 23 cm φ shaft.

main pinion shaft.

$M_T = 48100 \times 30 = 1444000 \times 1.2 = 1720000$ kg cm.

$d = 0.2087 \sqrt[3]{1800000} = 0.2087 \times 122 = 25.4$ cm

use 26 cm φ shaft.

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Tanko Kaisha (不用)

Dimensions of Gears. materials: forged steel pinion; Cast steel spur wheel and rack.

Gearings	Pitch dia Dp mm	module $Mc = \frac{Dp}{N}$	face f mm	Cir. pitch P mm	addendum $h_1 = Mc$	no. of teeth N	Load on tooth $w = \frac{4560 \cdot HP}{v}$	Strength of tooth Spfy		s	y
1st Gear											
pinion	180	12	100	37,699		15	688 kg	1287	1.87	[illegible]	.078
wheel	636	"	90	"		53	642	1492	2.32	396	0.111
2nd gear											
pinion	210	14	120	43,982		15	1962	3470	1.77	846	.078
wheel	742	"	110	"		53	1845	4090		762	.111
3rd gear											
pinion	210	14	120	43,982		15	2@ 2850	5170	1.81	1256	.078
wheel	742	"	110	"		53	2@ 2680	6080		1132	.111
4th gear											
pinion	320	20	170	62,832		16	2@ 7100	12170	1.71	1405	.081
wheel	1180	"	160	"		59	2@ 6670	14430		1270	.113
5th gear											
pinion	480	30	240	94,248		16	2@ 15410	27300	1.77	1488	.081
wheel	1770	"	250	"		59	2@ 14500	35800		1204	.113
main pinion	600	40	340	125,664		15	2@ 45200	71300	1.58	1530	.109
rack	4400	"	330	"		110	2@ 42,400	96,800		1380	.169

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CALCULATIONS FOR

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Bascule Bridge for Okinoyama Tanko Kaisha

（不用）

Gearing.

Motor set. 2 − 35 HP. crane motor. Synchronous speed 865 rev/min. assumed.
Speed at full load assumed as 95% of 865 = 820

Rack speed $\frac{90°}{360° \times 80} = \frac{1}{320}$ rev/sec $= \frac{60}{320} = 0.1875$ rev/min

Total gear ratio $= \frac{820}{0.1875} = 4350$

Rack radius

Rack and main pinion.

max. rack force 84700 kg for 2 racks or 42400 kg for one rack.
module Mc assumed as 40 Circular pitch $p = \pi M_c = 3.1416 \times 40 = 125.664$ mm
no. of teeth for pinion 15.
Pitch dia of pinion $= N M_c = 15 \times 40 = 600$ mm
face = 300 mm
Safe load on tooth $= S p f y = 1400 \times 12.57 \times 30. \times 1.09 = 57600$ kg 1.36.
ratio between rack + pinion $= \frac{4400 \text{mm}}{600}$ or $\frac{110 \text{ teeth}}{15} = 7.33$

半硬鋼
20° involute short teeth

rack 〃 鋳鋼

gear ratio

$4350 = 7.33 \times \left(\frac{59}{16}\right)^2 \times \left(\frac{53}{15}\right)^3$ (= 4410) [3.69, 3.54]

Diam., power transmitted, speed and accumulated efficiencies of gears.

Gearing wheels		no. of rev./m. n	pitch dia D_p mm	(Mc)	efficiency η	HP transmitted	HP × η	Speed at pitch line $\pi D_p n$	S $S_0 \frac{183}{V+183}$
1st gear	pinion	820	180	12	1.00		70.00	387 464 m/min	438 1383
	wheel	$820 \times \frac{15}{53} =$ 232	636	〃	0.940		65.80	〃	396
2nd 〃	pinion	232	210	14	0.940		65.80	153	844
	wheel	$232 \times \frac{15}{53} =$ 65.7	742	〃	0.884		61.90	〃	762
3rd 〃	pinion	65.7	210	14	0.884	2 × 30.95	61.90	43.4	1256
	wheel	$65.7 \times \frac{15}{53} =$ 18.6	742	〃	0.831	2 × 29.10	58.20	〃	1132
4th 〃	pinion	18.6	320	20	0.831	2 × 29.10	58.20	18.70	1405
	wheel	$18.6 \times \frac{16}{59} =$ 5.04	1180	〃	0.781	2 × 27.35	54.70	〃	1270
5th 〃	pinion	5.04	480	30	0.781	2 × 27.35	54.70	7.60	1488
	wheel	$5.04 \times \frac{16}{59} =$ 1.366	1770	〃	0.734	2 × 25.70	51.40	〃	1344
main pinion		1.366	600	40	0.734	2 × 25.70	51.40	2.59	1530
Rack		$1.366 \times \frac{15}{110} =$ 0.1865	4400	〃	0.690	2 × 24.15	48.30	2.59	1380

Bascule Bridge for Okinoyama Coal Mining Co.

Approximate weight of Mechanical parts.

Balancing links.
- 2nd links with bearing castings 2 @ 640 = 1280 cast steel
- link boss (6 ton) 2 @ 1000 = 2000 "
- Pins 6 @ 33 = 200 forged steel
- bushings 6 @ 50 = 300 Phos. bronze.

Balance beam trunnions.
- Shaft. 2-26ϕ shaft @ 417 × 1.0 = 834 F.S.
- Bearings 4 @ 700 = 2800 C.S.
- Boss. 2 @ 1000 = 2000 "
- bushing 2 @ 120 = 240 P.B.

Main trunnion
- Shaft. 2-20ϕ @ 247 × 0.9 = 450 F.S.
- Bearing 2 @ 450 = 900 C.S.
- boss 2 @ 340 = 680 "
- bushing 2 @ 25 = 50 P.B

Main pinion
- Pinion 60ϕ × 34 = 96200
- shaft 26ϕ × 60 = 31800
- 128000 @ .00785 = 1000 × 2 = 2000 F.S.
- Bearings 4 @ 500 = = 2000 C.I.
- bushing 2 @ 120 = 240 P.B.

Rack.
- 40 × 4 = 160
- 24 × 5 = 120
- 380 @ .785 = 300 × 4.0 = 1200 × 2 = 2400 C.S.
- ulbs etc 100
- 2500

Spur gear. approx. weight $W = P.F.D.C$

			P	F	D	C	W kg		forged steel	cast steel
1st gear	Pinion	15	3.77	10	18	.039	27	× 1	30	
	wheel	53	"	9	63.6	.044	95	× 1		95
2nd "	P	15	4.40	12	21	.039	43	× 1	45	
	W	53	"	11	74.2	.042	151	× 1		150
3rd "	P	15	6.28	14	30	.039	103	× 1	105	
	W	53	"	13	106.	.043	372	× 1		375
4th "	P	15	6.91	16	33	.039	143	× 2	290	
	W	41	"	15	90.2	.041	384	× 2		770
5th "	P	15	9.42	22	45	.039	364	× 2	730	
	W	38	"	21	114	.041	925	× 2		1850
6th "	P	15	12.57	27	60	.039	794	× 2	1590	
	W	29	"	26	116.	.038	1450	× 2		2900
									130	240
									2920	6380

gasoline gears say

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CALCULATIONS FOR

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Bascule Bridge for Okinoyama Coal mining Co.

Approx. weight of
Spur gear bearings

				Cast iron		Phos. bronze
1st gear bearings	9	1	}	300		30
2nd " "	12	1				
3rd " "	(15φ)	1		330		30
4th " "	18	2	650 + 2@550 =	1750	30 + 2@50 =	130
5th " "	(22φ)	2	2@1200 =	2400	2@100 =	200
gasoline engine gear bearing				500		50
				5280		440

Gear shafts.

1st shaft	1 - 10φ	@ 62kg	× 0.75	=	47
2nd "	1 - 12.5φ	" 96	0.80		77
3rd "	1 - 16φ	" 158	7.70		1215
4th "	2 - 18φ	" 200	1.00		400
5th "	2 - 22φ	" 298	1.20		715
					106
					2560 structural steel

flange coupling 300 c. i

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CALCULATIONS FOR

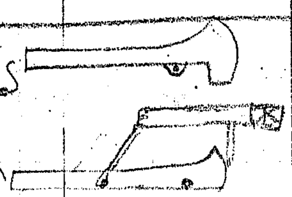
Bascule Bridge for Okinoyama Coal Mining Co.

Summary of weight for mechanical parts

		半硬鋼	鋳鋼	鋳鉄	軟鋼	燐青鋼	
1	Balancing links, pins + bosses bearing blocks etc	200kg	3280 200			300kg	
2	Balance beam trunnion shaft, bearing, brass etc	835	4800			240	
3	Main trunnion shaft, bearing + brass	450 1060	1580 6400			50 460	
~~4~~	~~main pinion, shaft bearing~~	~~2000~~		~~2000~~		~~240~~	
5	Racks.		2500 5000				
6	1st to 6th Spur gears with gears for gasoline engine	2920	6380				
7	" " Bearings			5300		440	
8	1st to 5th shafts			300	2560 (1000)		
~~9~~	~~clutch + motor shaft bearings~~	~~306~~		~~400~~			
10	front + rear air buffers bearing blocks etc	60		1000		50	
11	hand brake	30		300	100	10	
12	indicator mechanism	50	30	100			
13	front end locking	300	100	600	1000 (300)	50	
~~14~~	~~base frames of bearings~~				~~2000~~ (300)		
15	front + rear gates.	200	50	300	500 (300)	50	
		7345	18920	13,000	6160	1430	46855 kg
	単價	(1800円/t)	(1300)	(700)	(650)	(3300)	平均 (1190)
	金額	13200円	24600	9100	4000	4700	計 55600円
		6920	17960	13000	6160	1300	[illegible]
		12500	23400	9100	4000	4300	[illegible]円

14.0

赤字ハ Single trunnion type
黒字ハ balancing link type



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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal Mining Co.

Materials for Bascule floor.

10 cm planking	9.4 × 20 =		18.8 sq. m.	用栂材 防腐剤ニ[illegible]
12cm × 16cm nailing pieces	13 @ .12 × .16 × 20 =	5.000		
15 × 20 copings	2 @ .15 × .2 × 20 =	1.200		
22 × 20 floor beaks	2 @ .22 × .2 × 9.4 =	0.88		
			7.08 cub. m.	

Estimate of Cost for Bascule proper.

Structural steel	145.000 tons	@ 300 =		43500 円	
bascule floor.					
10cm planking	188.0 m²	@ 6.00 =	1130		
nailing pieces + coping etc.	7.08 m³	@ 45.00 =	320		
bolts & nails	0.60 ton	@ 250 =	150		
Cast iron drains	6	@ 8.5 =	50		
				1650	
Counterweight concrete (136 ton) 1:2:4	57.0 m³	@ 15.00 =	850		
forms 7.0 × 9.4 =	66.0 m²	@ 2.50 =	165		
reinforcement 57m³ @ 25 kg =	1.5 tons	@ 130.00 =	195		
			40		
				1250	
Operating house 木造塗喰仕					
建坪 3.20 × 7.20 = 23.0 m²		@ 40 =	900		
stairs with handrails say			200	1100	
					47500 円
Mechanical equipments.					
Forged steel parts	7.35 tons	@ 1800 =	13200		
cast steel "	18.92 "	@ 1300 =	24600		
cast iron "	13.00 "	@ 700 =	9100		
rolled steel "	6.16 "	@ 650 =	4000		
phosphor bronze "	1.43 "	@ 3300 =	4700		
	46.86 tons			55600	
front & rear gates 木製骨地	2 sets	@ 300 =	600		
brake rope, sheaves etc. say			100		
				700	
gasoline engine set. 7~10 HP.	1 set	—		1500	
Electrical equipments					
Motors with accessories	2 - 40 HP motors	@ 2100 =	4200		
	3 - 1 HP "	@ 370 =	1100		
wiring complete say			2700		
				8000	
				65800	
				113300	
				15000	
				128300	

上部1ニツキ 475円/m² or 1590円/坪.

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Bascule Bridge for Okinoyama Coal Mining Co.

21 m clear span.

Main girder.

Dead load. 1650 kg/m. for one girder.

Dead Load moment = 1/2×1650×15.3² = 193,000 kgm
30% impact = 58,000
251,000 kgm

Try web 1900×9 = 171.0 cm²   1/8 web area = 21.4

flange stress = 251000 / 1.84 = 136500

flange area = 136500 / 1200 = 113.80
21.40
92.40 cm² net

Use 2L 150×150×12 = 69.10 − 12 = 57.10
1 cov pl. 320 × 14 = 44.80 − 7 = 37.80
113.90   94.90 cm² net.

approximate weight of main girder
448 + 15 = 463 kg/m

Inside girder 23.1 m @ 463 = 10,700 kg
Outside girder 9200 + 500 + 300 = 10,000 "

Counter weight required.
1/2 × 3300 × 23.8² = 935,000 kgm
Counterweight required = 935000 / 5.60 = 167000 kg
volume 2.30 × 3.20 × 9.40 = 69.2 cub m

Unit weight of c'wt. = 167000 / 69.2 = 2420 kg/m³

7850 x + 2200 (1−x) = 2420
5650 x = 220
x = 220 / 5650 = 0.039

.039 @ 7850 = 306
.961 @ 2200 = 2114
1.000   2420

Concrete req'd. = 69.2 × .961 = 66.5 cub. m.
Scrap " = 69.2 × 306 = 21.2 tons.

Balance girders
moment on beam. 935000 ÷ 2 = 467500
" due to own wt. 1/2 × 1500 × 8.7² = 56,500
" link wt. 2500 × 8.5 = 21,000
545,000 kgm. × 1.30 = 710,000 kgm one girder

flange stress say = 710000 / 1.95 = 364,000 kg

flange area req'd = 364000 ÷ 1200 = 303.0
1/8 web area less 200×1.2 ÷ 8 = − 30.0
273.00 cm² net

Use 2L 150×150×19 = 106.76 − 19.00 = 87.76
2 Pls 250 × 19 = 95.00 − 19.00 = 76.00
2 cov pls 320 × 19 = 121.74 − 19.0 = 102.74
323.50   266.50 net

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Bascule bridge for Okinoyama Coal mine

Main section	4Ls 150×150×19 =	213.52		
	4Pls 250×19 =	190.00		
	4cov.pls 320×19 =	243.48		
	1web 2000×12 =	240.00		
		887.00		
		717.5		
		169.5 cm² @ .785 =	133 kg	
			787	
			920 kg/m	
Balance beam	920×16 m =	14,700 kg		

Summary of structural steel.

Bascule leaf

Stringers	10 @ 40 kg × 23.00 =	9200		
〃	1 @ 80 × 22.50 =	1800		
			11,000	
~~Floor beams~~	7 @ 1850 =		12,950	
lateral bracings		4700		
〃 strut framing		700		
			5400	
main girders, inside	2 @ 10,700 =	21400		
outside	2 @ 10,000 =	20000		
			41,400	
Shoes	4 @ 500 =		2,000	
floor breaks	2 @ 1500 =		3,000	
			250	
				76000 kg

Balancing girders

balancing beams	2 @ 14700 =	29400		
lateral bracing top + bott.	=	5900		
Cross struts	4 @ 1400 =	5600		
〃 front end	1 @ 1600 =	1600		
counterweight girders	2 @ 3500 =	7,000		
longitudinal strut	1 @ 2200 =	2200		
Cwt. girder 桁受座面ノ乙		2 000		
		300		
				54,000 kg

Counterweight tower framing.

towers	2 @ 10350 =	20700		
Sway bracing	1 @ 1500 =	1500		
	rivets heads	800		
				23,000 kg
Balancing links	2 @ 2500 =			5,000
Grillarge under trunnion bearings	2 @ 1500 =			3,000
Floor beams in fixed floor	2 @ 700 =			1,400
				600
				163,000 kg

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CALCULATIONS FOR

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Bascule Bridge for Okinoyama Coal Mining Co.

Estimate of Operating Power.

Link pull. $\frac{1}{2} \times 1650 \times 23.8^2 = 467000 \div 8.5 = 55000$ kg vert comp.

$55000 \times 1.22 = 67000$ kg for one link

Load on main trunnion

$1650 \times 23.8 \times 4.4 \div 8.5 = 20{,}300$ kg for one girder uplift

Load on counterweight trunnion

vert. comp. of link pull	55000
Counter weight	83500
balance beams	27000
	165500 kg one girder

Rack forces (for 2 racks)

Frictional resistances

	D	load P	f			M_F
Journals.						
Link pins	18 cm	67000	× 0.15	÷ 200 × 4	=	3610
trunnion shaft	18	20300	"	" × 2	=	550
cwt. trunnion shaft	25	165500	"	" × 2	=	6200
						10360
		30% imp say				3110
						13470 kgm

Rack force $F_F = \frac{13470}{2.50} = 5390$ kg

Eccentricity

2nd reaction say $20500 = 1000$ kg

$1000 \times 23.5 = 23500$

Rack force $F_e = \frac{23500}{2.50} = 9400$ kg

Wind pressure 70 kg/m²

$10.0 \times 23.0 \times 70 \times 12.5 = 201{,}000$

Rack force $F_w = \frac{201000}{2.5} = 80{,}500$ kg

Summary of Rack forces.

Journal friction	5390
eccentricity	9400
inertia say	650
wind pressure	80500
	95940 kg

Time of operation assumed $\frac{20}{2} + 60 + \frac{20}{2} = 80$ sec.

Unif. speed at rack circle $= \frac{2\pi \times 2.50}{4 \times 80} = 0.0491$ m/sec

Theoretical HP reqd. $= \frac{95940 \times 0.0491}{76} = 61.9$

Gear efficiency $= (.94)^7 = 0.648$

Actual HP required $= \frac{61.9}{0.648} = $ **95.5 HP.**

Use 2 - 50 HP Crane motors.

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Broad Gage Double track Bascule bridge

Clear span 30 meters

Steel

leaf. 30×10 = 300 m² @ 0.6 = 180.0

Balancing girder, Tower, sway etc say 180.0

360 ton

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CALCULATIONS FOR

Bascule Bridge for Okinoyama Coal mining Co.

Estimate of cost for Bascule proper.

Structural steel		163.000 tons	@ 300 =	48900 円	
bascule floor	9.4 × 23 =	216.0 m²	@ 8.80 =	1900	
Counterweight					
1:2:4 concrete		66.5 m³	@ 15.0 =	1000	
steel scrap (forms + reinforcements say)		21.2 tons	@ 80.0 =	1700 / 400	3100
Operating house				900	
stairs with handrails				200	
					1,100
					55,000 円
Mechanical equipment		46,860 × 1.15 = 54.0 tons	@ 1200 =	65,000	
front & rear gates 木部其他				600	
brake ropes sheaves etc				100	700
gasoline engine set					1500
Electrical equipments		2 – 50 HP motors @			
		3 – 1 HP 〃 @			
					8500
					75,700
					130,700
					15,000
					145,700

	[illegible]橋	沖ノ山橋	[illegible]鉄道橋
Clear span	18.00 m	21.00 m	30.00 m
clear width	18.00	9.00	9.00
area	324 m²	189 m²	270. m²
Cost of superstructure 当時	200,000 × 1.3	145,000 × 1.1	
戦前	260,000	160,000	
平米当工費 戦前	800 円/m²	800 円/m²	(Steel 330 円/ton [illegible] 1300 [illegible])

800 × 270 = 216000

鉄道橋ならば此3割増 65000

上部工事費 —— 281,000 円 [illegible]

下部 〃 —— 120,000

400,000 円

総工費 約 600,000 円 Steel 500 円/ton [illegible] 2000 円/ton [illegible]

[illegible]氏へ問合

Double truck railway bascule bridge 1,200,000 円 [illegible]

Single 〃 〃 〃 〃 800,000 〃

逓信省電気局[illegible]

13-10-10