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

CALCULATIONS FOR

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愛媛縣長濱大橋材料調書

昭和八年四月

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 Nagahama-Ō-hashi for Ehime-ken

		Top Chord	$U_1 - U_3$		4-Required				
Main Section	1	Cov. Pl.	540	× 10	@ 42390 kgs	× 7560	= 320.5		
〃 〃	2	L	300	× 90	@ 43800	× 7555	= 661.8		
Splice at U_1	2	L	100×100	× 10	@ 14.9	× .610		= 18.2	
〃 〃	1	Pl	450	× 10	@ 35325	× .540		= 19.1	
〃 〃	2	Pls	85	× 13	@ 8.674	× .300		= 5.2	
Splice at U_3	1	Pl	540	× 10	@ 42390	× .850		= 360	
〃 〃	2	Pls	85	× 13	@ 8.674	× .850		= 14.7	
〃 〃	2	〃	230	× 10	@ 18.055	× .560		= 20.2	
gusset at U_3	2	〃	680	× 10	@ 53.380	× 1.145		= 122.7	
Tie plate	2	〃	510	× 9	@ 36.032	× .670		= 48.3	
〃 〃	2	〃	370	× 9	@ 26.141	× .510		= 26.7	
Lacing bar	16	bars	60	× 9	@ 4.239	× .710		= 48.2	
washer	4		70ϕ		@ 30.200	× .009		= 1.1	
							982.3 + 3599 =	1,342.2	
								4	
								5,368.8	

			$U_3 - U_5$		4-Required				
Main Section	1	Cov. Pl.	540	× 10	@ 42.390	× 7.510	= 318.3		
〃 〃	2	L	300	× 90	@ 43.8	× 7.510	= 657.9		
Tie plate	2	Pls	510	× 9	@ 36.032	× .520		= 37.5	
〃 〃	2	〃	295	× 9	@ 20.842	× .510		= 21.3	
Lacing bar	20	bars	60	× 9	@ 4.239	× .685		= 58.1	
washer	4		70ϕ		@ 30.2	× .009		= 1.1	
							976.2 + 118.0 =	1,094.2	
								4	
								4,376.8	

			Splice at U_5		2-Required				
gusset	2	Pls	660	× 10	@ 51.810	× 1.150		= 119.2	
Splice	2	〃	230	× 10	@ 18.055	× .560		= 20.2	
〃	1	Pl	540	× 10	@ 42.390	× .850		= 36.0	
〃	2	Pls	85	× 13	@ 8.674	× .850		= 14.7	
								190.1	
								2	
								380.2	

Summary of Top chords 10,125.8 kgs

		Bottom chord	$L_0 - L_2$		4-Required				
Main Section	2	Pls	300	× 13	@ 30.615	× 6.120	= 374.7		
〃 〃	2	L	100×100	× 10	@ 14.9	× 6.450	= 192.2		
Gusset at L_0	2	Pls	935	× 10	@ 73.398	× .960		= 140.9	
〃 〃	2	〃	615	× 13	@ 62.761	× .755		= 94.8	
Pin plate	2	〃	320	× 10	@ 25.120	× .360		= 18.1	
Filler at L_0	2	Fills	100	× 13	@ 10.205	× .190		= 3.9	
〃 〃	1	Fill	270	× 10	@ 21.195	× .410		= 8.7	
Lug angle	2	L	90×90	× 10	@ 13.3	× .325		= 8.6	
gusset at L_1	1	Pl	340	× 10	@ 26.690	× .560		= 14.9	
〃 〃	1	〃	340	× 10	@ 〃	× .650		= 17.3	
Splice	2	Pls	300	× 13	@ 30.615	× .625		= 38.3	

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Materials of Nagahama-Ō-bashi for Ehime-ken

Splice	2	Pls	80 × 10	@	6280	× .625	=	7.9	
Fillers for diaph.	6	Fills.	190 × 10	@	14.915	× .200	=	17.9	
Tie plate	1	Pl	285 × 9	@	20,135	× .330	=	6.6	
" "	4	Pls	200 × 9	@	14,130	× .285	=	16.1	
" "	1	Pl	285 × 10	@	22373	× .665	=	14.9	
Gusset for lateral	1	"	360 × 10	@	28260	× .760	=	21.5	
Connection	1	L	90×90×10	@	133	× .445	=	5.9	
Gusset for lateral	1	Pl	390 × 10	@	30,615	× .590	=	18.1	
Spacer	4	Pls	75 × 9	@	5,299	× .294	=	6.2	
								5669 + 460.6 = 10275	
								4	
								41100	

L2 - L4 4-Required

Main Section	2	Pls	300 × 13	@	30,615	× 7.565 = 4637			
" "	2	L	100×100×10	@	14.9	× 7.565 = 225.4			
" "	2	Pls	200 × 10	@	15,700	× 6.950 = 218.2			
Gusset at L2	2	"	695 × 10	@	54,558	× 1.220	=	133.1	
" " L3	1	Pl	340 × 10	@	26,690	× .560	=	14.9	
" " "	1	"	340 × 10	@	"	× .650	=	17.3	
Splice	2	Pls	300 × 13	@	30,615	× .625	=	38.3	
"	2	"	285 × 10	@	22,373	× .625	=	28.0	
Tie plate	4	"	200 × 9	@	14,130	× .285	=	16.1	
" "	1	Pl	285 × 10	@	22,373	× .665	=	14.9	
Gusset for lateral	1	"	590 × 10	@	46,315	× 1.030	=	47.7	
" " "	1	"	390 × 10	@	30,615	× .590	=	18.1	
Spacer	4	Pls	75 × 9	@	5,299	× .274	=	5.8	
								9068 + 334.2 = 12410	
								4	
								49640	

L4 - L4' 2-Required

Main Section	2	Pls	300 × 13	@	30,615	× 9.210 = 5639			
" "	2	"	200 × 10	@	15,700	× 9.210 = 289.2			
" "	2	"	280 × 10	@	21,980	× 8.120 = 357.0			
" "	2	Ls	100×100×10	@	14.9	× 9.210 = 274.5			
Gusset at L4	4	Pls	650 × 10	@	51,025	× 1.080	=	220.4	
" " L5	1	Pl	340 × 10	@	26,690	× .560	=	14.9	
" " "	1	"	340 × 10	@	"	× .650	=	17.3	
Tie plate	4	Pls	200 × 9	@	14,130	× .285	=	16.1	
Gusset for lateral	2	"	590 × 10	@	46,315	× 1.030	=	95.4	
" "	1	Pl	390 × 10	@	30,615	× .590	=	18.1	
Spacers	4	Pls	75 × 9	@	5,299	× .254	=	5.4	
								14846 + 387.6 = 18722	
								2	
								37444	

Diaphragm DM1 4-Required

	4	Ls	90×75×12	@	14.4	× .645	=	37.2	
	1	Pl	285 × 10	@	22373	× .645	=	14.4	
	1	L	90×75×9	@	11.0	× .270	=	3.0	
Washer	1		70ϕ	@	30.2	× .012	=	0.4	

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Materials of Nagahama-Ō-hashi for Ehime-ken

							55.0	55.0
							4	
								220.0
	Diaphragm DM2				12 - Required			
2	L	90×75×9	@	11.0	× .295	=	6.5	
1	Pl	265 × 9	@	18.722	× .295	=	5.5	
							12.0	
							12	
								144.0
	Diaphragm DM3				12 - Required			
2	L	90×90×10	@	13.3	× .295	=	7.8	
1	Pl	265 × 9	@	18.722	× .295	=	5.5	
2	L	100×100×10	@	14.9	× .254	=	7.6	
2	Fills	85 × 10	@	6.673	× .095	=	1.3	
1	Fill	85 × 10	@	"	× .225	=	1.5	
							23.7	
							12	
								284.4
	Diaphragm DM4				6 - Required			
2	L	90×90×10	@	13.3	× .295	=	7.8	
1	Pl	245 × 9	@	17.309	× .295	=	5.1	
2	L	100×100×10	@	14.9	× .234	=	7.0	
2	Fills	65 × 10	@	5.103	× .095	=	1.0	
1	Fill	85 × 10	@	6.673	× .225	=	1.5	
							22.4	
							6	
								134.4

Summary of Bottom chords 13,601.2 kgs

	End Post			Lo - U1	4 - Required			
main section	1	cov Pl	540 × 10	@	42.390	× 5.130	= 217.5	
" "	2	L	300 × 90	@	43.8	× 5.320	= 466.0	
Gusset at U1	2	Pls	750 × 10	@	58.875	× 1.150	=	135.4
Splice at U1	2	"	360 × 10	@	28.260	× .660	=	37.3
" "	2	L	100×100×10	@	14.9	× .610	=	18.2
Connection at Lo	1	Pl	540 × 10	@	42.390	× .585	=	24.8
" "	1	L	90×75×9	@	11.0	× .365	=	4.0
" "	2	L	150×100×12	@	22.4	× .685	=	30.7
" "	2	Fills	145 × 10	@	11.383	× .430	=	9.8
Tie plate	1	Pl	510 × 9	@	36.032	× .670	=	24.1
" "	1	"	510 × 9	@	"	× .595	=	21.4
Lacing bar	12	bars	60 × 9	@	4.239	× .710	=	36.1
washer	2		70ϕ	@	30.2	× .009	=	0.5
							683.5 + 342.3 =	1,025.8
								4
								4,103.2

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Materials of Nagahama-Ō-hashi for Ehime-ken

		Diagonals U1-L2 & L2-U3				8-Required		
main section	4	L	125×90×10	@	16.1	× 4.960	= 3194	
Tie plate	2	P/s	305 × 9	@	21.548	× .370	= 159	
Lacing bars	19	bars	60 × 9	@	4.239	× .315	= 254	
							3194 + 413 =	3607
								8
								28856
		U3-L4 & L4-U5				8-Required		
main section	4	L	100×75×10	@	13.0	× 4.825	= 2509	
Tie plate	2	P/s	305 × 9	@	21.548	× .370	= 159	
Lacing bars	18	bars	60 × 9	@	4.239	× .345	= 263	
							2509 + 422 =	2931
								8
								23448
		Summary of End post and Diagonals						9,333.6 kgs
		Vertical L1-U1				4-Required		
main section	4	L	90×75×9	@	11.0	× 3.415	= 1503	
" "	1	P/	307 × 9	@	21.690	× 3.415	= 741	
CV1	2	P/s	290 × 10	@	22.765	× .300	= 137	
"	2	Fills	160 × 9	@	11.304	× .300	= 68	
							2244 + 205 =	2449
								4
								9796
		L2-U2 & L4-U4				8-Required		
main section	4	L	90×75×9	@	11.0	× 3.890	= 1712	
" "	1	P/	307 × 9	@	21.690	× 3.890	= 844	
gusset	2	P/s	190 × 10	@	14.915	× .350	= 104	
CV1 or CV2	2	"	290 × 10	@	22.765	× .300	= 137	
" "	2	Fills	160 × 9	@	11.304	× .300	= 68	
							2556 + 309 =	2865
								8
								22920
		L3-U3 & L5-U5				6-Required		
main section	4	L	90×75×9	@	11.0	× 3.890	= 1712	
" "	1	P/	307 × 9	@	21.690	× 3.890	= 844	
CV1 or CV2	2	P/s	290 × 10	@	22.765	× .300	= 137	
" "	2	Fills	160 × 9	@	11.304	× .300	= 68	
							2556 + 205 =	2761
								6
								16566
		Summary of Verticals						49282 kgs

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CALCULATIONS FOR

Materials of Nagahama-ō-hashi for Ehime-ken

		End Floor Beam	FB1		2-Required				
main section	4	Flg. L³	125×75×10	@	14.9	× 6.240 = 371.9			
" "	1	Web Pl.	650 × 10	@	51.025	× 6.240 = 318.4			
End connection	4	L³	150×90×12	@	21.5	× .568	=	49.0	
" "	4	Fills	145 × 10	@	11.383	× .434	=	19.8	
Stiffener	4	L³	90×90×10	@	13.3	× .595	=	31.7	
"	4	Fills	90 × 10	@	7.065	× .460	=	13.0	
"	4	L³	75×75× 9	@	9.96	× .641	=	25.5	
"	4	"	90×90×10	@	13.3	× .635	=	33.8	
"	4	Fills	90 × 10	@	7.065	× .500	=	14.1	
"	2	L³	75×75× 9	@	9.96	× .660	=	13.1	
Stringer conn.	8	Fills	90 × 10	@	7.065	× .195	=	11.0	
							6903 + 2108 =	901.1	
								2	
								1,802.2	

		Intermediate Floor Beam	FB2 & FB3		9-Required				
Main section	4	Flg. L³	125×75×10	@	14.9	× 6.260 = 373.1			
" "	1	Web Pl.	650 × 10	@	51.025	× 6.250 = 318.9			
End connection	4	L³	150×90×12	@	21.5	× .568	=	48.8	
" "	4	Fills.	145 × 10	@	11.383	× .434	=	19.8	
Stiffener	4	L³	90×90×10	@	13.3	× .595	=	31.7	
"	4	Fills	90 × 10	@	7.065	× .460	=	13.0	
"	4	L³	75×75× 9	@	9.96	× .641	=	25.5	
"	4	"	90×90×10	@	13.3	× .635	=	33.8	
"	4	Fills	90 × 10	@	7.065	× .500	=	14.1	
"	2	L³	75×75× 9	@	9.96	× .660	=	13.1	
Stringer connect.	8	Fills.	90 × 10	@	7.065	× .195	=	11.0	
Bracket	2	P³	160 × 10	@	12.560	× .170	=	4.3	
							6920 + 215.1 =	907.1	
								9	
								8,163.9	

		Bracket	B1			18-Required			
2	L³	90×90×10	@	13.3	× .980		=	26.1	
1	P³	85 × 10	@	6.673	× .460		=	3.1	
1	"	85 × 10	@	6.673	× .230		=	1.5	
								30.7	
								18	
								552.6	

Summary of Floor beams and brackets 10,518.7 kgs

		Stringer	ST1$^{R}_{L}$ & ST2			40-Required			
1	I	250 × 125	@	55.5	× 37.10 =	2059.			
2	L³	90×90×10	@	13.3	× .174		=	4.6	
						2059 +	4.6 =	210.5	
								40	
								8,420.0	

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Materials of Nagahama-Ō-hashi for Ehime-ken

Bracket of stringer BR^R_L 8-Required

1	I	250 × 125	@	555	× .340	= 189	
1	L	90×90×10	@	133	× .174	= 23	
1	Pl	× 125 × 10	@	9.813	× .540	= 53	
						189 + 76 = 265	
						8	
						2120	

Summary of stringers and brackets 8,632.0 kgs

Bottom Lateral Bracings 1-Required

Bracing	4	L's	125×75×10	@ 14.9	× 4.280	= 255.1
〃	4	〃	125×75×10	@ 〃	× 4.400	= 262.7
〃	16	〃	125×75×10	@ 〃	× 4.425	= 1,054.9
〃	16	〃	125×75×10	@ 〃	× 4.545	= 1,083.5
Lateral plate	5	Pl's	810 × 10	@ 63.585	× .820	= 260.7
						2,655.7 + 260.7 = 2,916.4 kgs

Roller shoe RS1 & etc. 2-Required

Cast steel shoe	RS1	1	@	140	= 140.0
〃 〃 〃	Bed plate BP1	1	@	170	= 170.0
〃 〃 〃	dust guard DG1	2	@	16	= 32.0
〃 〃 〃	〃 DG2	2	@	6	= 12.0
Tapped bolts	9φ × 30	2	@	0.17	= 0.3
〃 〃	6φ × 25	10	@	0.07	= 0.7
〃 〃	22φ × 40	4	@	1.19	= 4.8
Roller	100φ×550	4	@	34	= 136.0
Side plate	70×14×400	2	@	3.08	= 6.2
Pin	22φ × 50	4	@	0.15	= 0.6
〃	〃 —	4	@	0.16	= 0.6
Anchor bolts	30φ × 700	4	@	4.68	= 18.7
Pin and nuts	100φ × 514	1	@	36	= 36.0
					557.9
					2
					1,115.8

Fixed Shoe FS1 2-Required

Cast steel shoe	FS1	1	@	240	= 240.0
anchor bolts	30φ × 700	4	@	4.68	= 18.7
Pin and nuts	100φ × 514	1	@	36	= 36.0
					294.7
					2
					589.4

Summary of shoe 1,705.2 kgs

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CALCULATIONS FOR

Material of Nagakawa-o-bashi for Ehime-Ken

Sumary of truss span (span no 1, 2 & 7)
Structural steel

Top chords	10,125.8	
Bottom chords	13,601.2	37,988.8
End post + diagonals	9,333.6	
Verticals	4,928.2	
Floor Beams	10,518.7	
Stringers	8,632.0	
Bottom laterals	2,916.4	
	60,055.9	
Rivet heads	2,070.0	
	62,125.9	
cast steel shoe	1,705.2	63,831 Kgs

Bottom lateral bracings (span no. 3 & 6)

weight for ordinal span = 2,916.4

less	2	L	125×75×10	@	14.9 × 4,280	= −	127.5
〃	2	〃	〃	@	〃 × 4,400	= −	131.1
〃	1	Pl	810 × 10	@	63.585 × 820	= −	52.1
LB1A	2	L	125×75×10	@	14.9 × 1,875	=	55.9
LB1B	1	L	〃	@	〃 × 2,165	=	32.3
〃	1	〃	〃	@	〃 × 2,285	=	34.0
LB1C	2	L	〃	@	〃 × 4,300	=	128.1
Lateral plate	1	Pl	360 × 10	@	28.260 × 975	=	27.6
〃	1	〃	840 × 10	@	65.940 × 930	=	61.3

2,944.9 Kgs

Summary of truss span (span no. 3 & 6)
Structural steel

Truss	37,988.8	
Floor Beams	10,518.7	
stringers	8,632.0	
Bottom laterals	2,944.9	
	60,084.4	
Rivet heads	2,070.0	
	62,154.4	
Cast steel shoe and accessories	1,705.2	63,859.6

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CALCULATIONS FOR

Materials of Nagahama-Ō-bashi for Ehime-Ken

		moving	span	main	girders	$MG1^R_L$, $MG2^R_L$	2-Req'd
main section	1	web Pl.	1300 ×	10 c	102.050 ×	9.020 =	920.49
〃 〃	1	〃 〃	870 ×	10 c	68.295 ×	2.500 =	170.74
〃 〃	1	〃 〃	1300 ×	10 c	102.050 ×	9.705 =	990.40
〃 〃	2	Flg. L	150 × 150 ·	15 c	33.60 ×	5.150 =	346.08
〃 〃	2	〃 〃	〃	c	〃 ×	4.300 =	288.96
〃 〃	2	〃 〃	〃	c	〃 ×	10.050 =	675.36
〃 〃	2	〃 〃	〃	c	〃 ×	10.930 =	734.50
〃 〃	2	〃 〃	〃	c	〃 ×	9.710 =	652.51
〃 〃	1	Cov. Pl.	320 ×	17 c	30.144 ×	5.670 =	170.92
〃 〃	1	〃 〃	〃	c	〃 ×	6.000 =	180.86
〃 〃	1	〃 〃	〃	c	〃 ×	5.660 =	170.62
side plate	2	Pls	910 ×	15 c	107.153 ×	2.100 =	450.04
〃 〃	2	〃	730 ×	12 c	68.766 ×	.875 =	120.34
〃 〃	2	〃	880 ×	15 c	103.620 ×	1.000 =	207.24
〃 〃	2	〃	780 ×	12 c	73.476 ×	1.200 =	176.34
〃 〃	2	〃	960 ×	15 c	113.040 ×	1.000 =	226.08
〃 〃	2	〃	700 ×	12 c	65.940 ×	.807 =	106.43
Splice	2	L	150 · 150 ·	15 c	33.60 ×	1.000 =	67.20
〃	1	Pl	320 ×	12 c	30.144 ×	1.000 =	30.14
〃	4	L	150 · 150 ·	19 c	41.90 ×	1.030 =	172.63
〃	4	Pls	220 ×	15 c	25.905 ×	.740 =	76.68
〃	2	〃	320 ×	15 c	37.680 ×	.550 =	41.45
Stiffener	2	L	125 · 90 ·	9 c	14.60 ×	1.680 =	49.06
〃	2	〃	125 · 90 ·	10 c	16.10 ×	.430 =	13.85
〃	2	〃	〃	c	〃 ×	.720 =	23.18
〃	2	〃	125 · 90 ·	9 c	14.60 ×	2.010 =	58.69
〃	2	Fills	90 ×	15 c	10.598 ×	.990 =	20.98
〃	2	L	125 · 90 ·	9 c	14.60 ×	1.920 =	56.06
〃	2	Fills	90 ×	15 c	10.598 ×	.990 =	20.98
〃	2	L	125 · 90 ·	10 c	16.10 ×	.440 =	14.17
〃	2	〃	〃	c	〃 ×	.730 =	23.51
〃	2	〃	〃	c	〃 ×	.210 =	6.76
〃	19	〃	125 · 90 ·	9 c	14.60 ×	1.310 =	363.39
〃	7	〃	〃	c	〃 ×	1.280 =	130.82
〃	5	Fills	200 ×	15 c	23.550 ×	.505 =	59.46
〃	5	〃	90 ×	15 c	10.598 ×	.495 =	26.23
〃	2	L	130 · 130 ·	9 c	17.70 ×	.700 =	24.78
〃	4	〃	〃	c	〃 ×	1.280 =	90.62
Bracket	1	Pl	320 ×	12 c	30.144 ×	1.470 =	44.31
〃	2	L	150 · 150 ·	15 c	33.60 ×	1.220 =	81.98
〃	2	〃	〃	c	〃 ×	.655 =	44.02
〃	1	Pl	655 ×	10 c	51.418 ×	.970 =	49.88
〃	2	Pls	505 ×	15 c	59.464 ×	.820 =	97.52
〃	2	Fills	200 ×	15 c	23.550 ×	.290 =	13.66
〃	2	L	100 · 100 ·	13 c	19.10 ×	.540 =	20.63
〃	2	〃	〃	c	〃 ×	.640 =	24.45
〃	2	〃	150 · 150 ·	15 c	33.60 ×	.980 =	65.86
gusset plate	1	Pl	320 ×	12 c	30.144 ×	.630 =	18.99
〃	1	〃	460 ×	10 c	36.110 ×	.630 =	22.75
〃	1	〃	460 ×	10 c	36.110 ×	.635 =	22.93
〃	1	〃	460 ×	10 c	〃 ×	.635 =	22.93
〃	2	〃	310 ×	12 c	29.202 ×	.555 =	32.41
〃	2	〃	370 ×	10 c	29.045 ×	.555 =	32.24
Stiffener	1	〃	125 · 90 ·	9 c	14.60 ×	.400 =	5.84
Bracket	1	〃	320 ×	12 c	30.144 ×	.655 =	19.74

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CALCULATIONS FOR

Materials of Nagahama-Ō-bashi for Ehime-Ken

gusset plate	1	Pl	340 × 12	c	32028 × 620 =	19.86	
〃 〃	1	〃	560 × 10	c	43906 × 620 =	27.22	
						530144 + 332433 = 862577	
						× 2	
						1725154	
		Lateral Bracings				1- Required	
LB 3	2	L	100×100×10	c	1490 × 1,915 =	5707	
〃	2	〃	〃	c	〃 × 1,985 =	5915	
LB 4	2	〃	〃	c	〃 × 4,210 =	12546	
〃	2	〃	〃	c	〃 × 4,350 =	12963	
LB 5	2	〃	〃	c	〃 × 4,210 =	12546	
〃	2	〃	〃	c	〃 × 4,350 =	12963	
LB 6	6	〃	90×90×10	c	1330 × 4220 =	33676	
〃	6	〃	〃	c	〃 × 4360 =	34793	
	10	〃	〃	c	〃 × 385 =	5121	
	10	〃	〃	c	〃 × 250 =	3325	
	10	〃	〃	c	〃 × 1,405 =	18687	
	10	P/s	150 × 12	c	14130 × 350 =	4946	
	10	〃	150 × 10	c	11775 × 350 =	4121	
	20	〃	250 × 9	c	17663 × 480 =	16956	
	118	Washers	70ϕ	c	3020 × 009 =	3207	
gusset plate	2	P/s	350 × 10	c	27478 × 530 =	2913	
〃 〃	2	〃	490 × 10	c	38465 × 840 =	6462	
〃 〃	3	〃	430 × 10	c	33755 × 730 =	7392	
						131109 + 73130 = 204239	
		Floor Beams		FB5, FB6 & FB7		4- Required	
main section	1	web Pl	700 × 10	c	54950 × 6550 =	35992	
〃 〃	2	L	100×75×10	c	1300 × 6305 =	16393	
〃 〃	1	L	〃	c	〃 × 6565 =	8535	
〃 〃	1	〃	〃	c	〃 × 6580 =	8554	
stiffeners	4	L	75×75×9	c	996 × 670 =	2669	
〃	4	〃	〃	c	〃 × 668 =	2661	
〃	4	Fills	75 × 10	c	5888 × 528 =	1244	
〃	8	L	75×75×9	c	996 × 690 =	5498	
〃	8	Fills	75 × 10	c	5888 × 550 =	2591	
End Connection	2	L	125×90×10	c	1610 × 623 =	2006	
〃 〃	2	Fills	120 × 10	c	9420 × 483 =	910	
	2	P/s	160 × 10	c	12560 × 210 =	528	
	12	Fills	90 × 10	c	7065 × 145 =	1229	
						69474 + 19336 = 88810	
						× 4	
						355240	
adjunction FB7 only	4	P/s	315 × 10	c	24728 × 515 =	5094	
						360334	
		Floor Beams		FB4 A		1- Required	
Main sections	1	web Pl	700 × 10	c	54950 × 6550 =	35992	
〃 〃	2	L	100×75×10	c	1300 × 6305 =	16393	
〃 〃	1	L	〃	c	〃 × 6565 =	8535	
〃 〃	1	〃	〃	c	〃 × 6580 =	8554	

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-Ken

Stiffeners	4	L	75×75×9	c	9.96	× 670 =		2669
〃	4	〃	〃	c	〃	× 668 =		2661
〃	4	Fills	75 × 10	c	5.888	× 528 =		1244
〃	8	L	75×75×9	c	9.96	× 690 =		5498
〃	8	Fills	75 × 10	c	5.888	× 550 =		2591
End connection	2	L	125×90×10	c	16.10	× 623 =		2006
〃 〃	2	Fills	120 × 10	c	9.420	× 483 =		910
shelf angle	2	L	90×75×9	c	11.00	× 255 =		561
〃 〃	2	〃	〃	c	〃	× 745 =		1639
〃 〃	4	〃	〃	c	〃	× 740 =		3256
〃 〃	1	L	〃	c	〃	× 655 =		721
Filler	2	Pls	160 × 10	c	12.560	× 210 =		528
〃	6	〃	85 × 10	c	6.673	× 155 =		621
							6947 + 2490 =	9437

Floor Beams FB4B 1- Required

Same as FB4A								9437
Fillers	6	Pls	85 × 10	c	6.673	× 155 =		621
								9500

Summary of Floor Beams 5,497.13 kgo

Strut SR1 2- Required

1	Pl	500 × 10	c	39.250	× 6.580 =		25827	
1	L	125×90×9	c	14.60	× 6.580 =		9607	
4	Pls	150 × 12	c	14.130	× 400 =		2261	
4	〃	150 × 10	c	11.775	× 400 =		1884	
								39579
								2
								79158

Stringers ST6 to ST17 and inclusive 1-Required

30	Is	200 × 150	c	50.4	× 3,440 =		520128	
60	L	90×75×9	c	11.0	× 150 =		9900	
								530028

Stringers ST3 2- Required

4	L	75×75×9	c	9.96	× 3,669 =		14617	
1	Pl	360 × 9	c	25.434	× 3,669 =		9332	
								23949
								2
								47898

Stringers ST4 6- Required

4	L	75×75×9	c	9.96	× 3,478 =		13856	
1	Pl	360 × 9	c	25.434	× 3,478 =		8846	
2	Pls	140 × 9	c	9.891	× 210 =		415	
								23117
								6
								138702

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CALCULATIONS FOR

Materials of Nagahama-Ō-bashi for Ehime-Ken

Stringers ST5 2-Required

4	L	75×75×9	c	9.96 × 3884 =	154.74	
1	Pl	360 × 9	c	25.434 × 3.884 =	98.79	
2	Pl	140 × 9	c	9.891 × 210 =	4.15	
						257.68
						2
						515.36

Brackets BR2 6-Required

2	L	75×75×9	c	9.96 × 200 =	3.98	
1	Pl	285 × 9	c	20.135 × 495 =	9.97	
1	"	160 × 10	c	12.560 × 555 =	6.97	
						20.92
						6
						125.52

Summary of strut, stringers + bracket 8,598.74 Kgo

Live Load Shoe 2-set required

1	cast steel sole plate	c	43.3	=	43.30
1	" " bed plate	c	63.2	=	63.20
4	wedge 50 × 25 × 220	c	2.0	=	8.00
2	Bolts (guide connection) 19φ × 60	c	0.33	=	0.66
4	Anchor bolts 26φ × 500	c	2.25	=	9.00
					124.16
					2
					248.32

Summary of moving span

Structural steel

Main girders	17,251.54	
Floor beams	5,497.13	
Stringers and struts	8,598.74	
Lateral bracings	2,042.39	
	33,389.80	
Rivet heads	1,170.00	
	34,559.80	
Cast steel shoe + accessories	248.32	34,808.12 Kgo

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CALCULATIONS FOR

Materials of Nagahama-Ō-bashi for Ehime-Ken

		counter weight girders				1- Required		
main section	1	web Pl.	2,095 × 9	℄	148.012 × 6,910 =	1,022.76		
〃 〃	2	L	150×150×12	℄	27.1 × 6,280 =	340.38		
stiffener	6	〃	125×75×9	℄	13.5 × 1,986 =		160.87	
〃	2	〃	150×90×9	℄	16.3 × 1,975 =		64.39	
〃	2	〃	〃 〃 〃	℄	〃 × 2,070 =		67.48	
Fillers	3	Fills	160 × 12	℄	15.072 × 1,700 =		76.87	
main section	1	web Pl.	2,095 × 9	℄	148.012 × 6,540 =	968.00		
〃 〃	2	L	150×150×12	℄	27.1 × 6,280 =	340.38		
stiffener	6	〃	125×75×9	℄	13.5 × 1,986 =		160.87	
〃	2	〃	〃 〃 〃	℄	〃 × 2,070 =		55.89	
〃	2	〃	〃 〃 〃	℄	〃 × 1,975 =		53.33	
Fillers	3	Fills	160 × 12	℄	15.072 × 1,700 =		76.87	
Connection	2	L	130×130×15	℄	28.8 × 3,146		181.21	
main section	1	web Pls	2,000 × 9	℄	141.300 × 3,455 =	976.38		
stiffener	6	L	125×75×9	℄	13.5 × 1,700 =		137.70	
〃	2	〃	150×90×9	℄	16.3 × 1,900 =		61.94	
〃	2	〃	〃	℄	〃 × 1,980 =		64.55	
〃	2	Pls	200 × 9	℄	14.130 × 2,000 =		56.52	
Splice	1	Pl	290 × 9	℄	20.489 × 2,000 =		40.98	
upper frame	4	L	125×75×9	℄	13.5 × 2,020 =		109.08	
〃	4	〃	〃	℄	〃 × 955 =		51.57	
〃	4	〃	〃	℄	〃 × 895 =		48.33	
〃	4	〃	〃	℄	〃 × 2,080 =		112.32	
〃	6	〃	〃	℄	〃 × 1,700 =		137.70	
gussets	3	Pls	410 × 9	℄	28.967 × 680 =		59.09	
〃	2	〃	410 × 9	℄	〃 × 550 =		31.86	
〃	1	Pl	420 × 9	℄	29.673 × 730 =		21.66	
〃	2	Pls	430 × 9	℄	30.380 × 670 =		40.71	
End connection	2	〃	360 × 9	℄	25.434 × 2,000 =		101.74	
〃 〃	2	L	100×100×13	℄	19.1 × 1,991 =		76.06	
Strut connection	2	〃	100×100×10	℄	14.9 × 295 =		8.79	
〃 〃	1	Pl	490 × 9	℄	34.619 × 860 =		29.77	
〃 〃	2	L	130×130×12	℄	23.4 × 485 =		22.70	
〃 〃	1	Pl	320 × 9	℄	22.608 × 890 =		20.12	
Cross frame	6	L	100×100×10	℄	14.9 × 2,334 =		208.66	
gussets	12	Pls	390 × 9	℄	27.554 × 455 =		150.44	
〃	2	〃	370 × 9	℄	26.141 × 370 =		19.34	
〃	1	Pl	〃	℄	〃 × 580 =		15.16	
connection	2	L	125×75×9	℄	13.5 × 718 =		19.39	
lug L	12	〃	150×90×9	℄	16.3 × 100 =		19.56	
Top strut	2	〃	125×75×9	℄	13.5 × 6,270 =	169.29		
gusset	1	Pl	630 × 9	℄	44.510 × 670 =		29.82	
Top frame	6	L	75×75×9	℄	9.96 × 1,260 =		75.30	
〃 〃	2	〃	〃	℄	〃 × 1,180 =		23.51	
gussets	3	Pls	275 × 9	℄	19.429 × 350 =		20.40	
〃	2	〃	345 × 9	℄	24.374 × 350 =		17.06	
〃	2	〃	200 × 9	℄	14.130 × 430 =		12.15	
〃	2	〃	〃	℄	〃 × 420 =		11.87	
Filler	8	Fills	75 × 9	℄	5.299 × 140 =		5.93	
〃	2	〃	125 × 9	℄	8.831 × 745 =		13.16	
notch splice	1	Pl	80 × 9	℄	5.652 × 830 =		4.69	
washers	86	Wash.	70φ	℄	30.2 × 9 =		23.37	
							3,817.19 + 2,800.78 = 6,617.97	

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CALCULATIONS FOR

Materials of Nagahama-Ō-hashi for Ehime Ken

			Balance Beams					2-Required	
main section		1	web Pl	1,150 × 10	c	90.275 ×	2,705 =	244.19	
〃	〃	1	〃	2,000 × 10	c	157.000 ×	4,560 =	715.92	
〃	〃	1	〃	〃		〃 ×	4,320 =	678.24	
〃	〃	1	〃	1,650 × 10	c	129.525 ×	2,630 =	340.65	
〃	〃	1	〃	1,555 × 10	c	122.068 ×	1,965 =	239.86	
〃	〃	2	Flg. L	150×150×19	c	41.9 ×	7,350 =	615.93	
〃	〃	2	〃	〃	c	〃 ×	8,820 =	739.12	
〃	〃	1	〃 L	〃	c	〃 ×	2,555 =	107.05	
〃	〃	1	〃	〃	c	〃 ×	2,410 =	100.98	
〃	〃	2	〃 L	〃	c	〃 ×	8,743 =	732.66	
〃	〃	1	cov. Pl	320 × 16	c	40.192 ×	6,230 =	250.40	
〃	〃	1	〃	〃	c	〃 ×	6,160 =	247.58	
Splice		4	Pls	220 × 9	c	15.543 ×	880 =		54.71
〃		2	〃	320 × 9	c	22.608 ×	1,250 =		56.52
〃		4	L	150×150×19	c	41.9 ×	1,080 =		181.01
〃		2	Pls	220 × 9	c	15.543 ×	740 =		23.00
〃		2	〃	〃	c	〃 ×	820 =		25.49
〃		2	〃	320 × 9	c	22.608 ×	920 =		41.60
〃		2	〃	460 × 9	c	32.499 ×	940 =		61.10
〃		2	〃	310 × 19	c	46.237 ×	1,720 =		159.06
Stiffeners		2	L	130×130×15	c	28.8 ×	1,991 =		114.68
〃		2	Fills.	125 × 19	c	18.644 ×	1,720 =		64.14
〃		1	L	125×90× 9	c	14.6 ×	1,193 =		17.42
〃		2	L	〃	c	〃 ×	1,040 =		30.37
〃		2	〃	150×150×11	c	24.9 ×	1,976 =		98.40
〃		1	L	125×90× 9	c	14.6 ×	2,029 =		29.62
〃		1	〃	〃	c	〃 ×	893 =		13.04
〃		1	〃	〃	c	〃 ×	1,174 =		17.14
〃		2	L	130×130×15	c	28.8 ×	3,146 =		181.21
〃		1	Fill.	270 × 19	c	40.271 ×	1,300 =		52.35
〃		1	〃	270 × 9	c	19.076 ×	1,700 =		32.43
〃		1	〃	125 × 10	c	9.813 ×	1,700 =		16.68
〃		1	〃	270 × 19	c	40.271 ×	3,010 =		121.22
〃		6	L	125×90× 9	c	14.6 ×	2,010 =		176.08
〃		8	〃	130×130×12	c	23.4 ×	1,972 =		369.16
〃		2	Fills.	550 × 19	c	82.033 ×	1,700 =		278.91
〃		4	L	125×90× 9	c	14.6 ×	590 =		34.46
〃		2	〃	〃	c	〃 ×	1,820 =		53.14
〃		2	〃	〃	c	〃 ×	1,670 =		48.76
〃		1	L	〃	c	〃 ×	1,500 =		21.90
〃		1	〃	〃	c	〃 ×	1,470 =		21.46
〃		1	Fill.	85 × 19	c	12.678 ×	1,190 =		15.09
〃		2	L	125×90× 9	c	14.6 ×	1,300 =		37.96
〃		2	〃	〃	c	〃 ×	1,120 =		32.70
〃		2	〃	〃	c	〃 ×	910 =		26.57
Side plate		2	Pls.	815 × 19	c	121.557 ×	1,475 =		358.59
〃		2	〃	625 × 9	c	44.156 ×	815 =		71.97
		1	Pl	320 × 16	c	40.192 ×	1,210 =		48.63
		2	L	100×100×10	c	14.9 ×	605 =		18.03
		1	Pl	320 × 16	c	40.192 ×	1,280 =		51.45
		2	L	150×100×12	c	22.4 ×	530 =		23.74
Stiffeners		1	L	100×100×10	c	14.9 ×	1,976 =		29.44
〃		1	Fill	210 × 19	c	31.322 ×	1,720 =		53.87

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CALCULATIONS FOR

Materials of Nagahama-Ō-bashi for Ehime-ken

Bracket	1	L	100×100×10	c	14.9	× 1,035	=	15.42	
〃	1	〃	〃	c	〃	× 1,940	=	28.91	
〃	1	Pl	150 × 10	c	11.775	× 480	=	5.64	
〃	1	Fill.	95 × 9	c	6.712	× 220	=	1.48	
gusset	1	Pl	575 × 9	c	40.624	× 755	=	30.67	
〃	1	Fill	320 × 16	c	40.192	× 755	=	30.34	
〃	1	Pl	530 × 9	c	37.445	× 1,180	=	44.19	
〃	1	〃	420 × 9	c	29.673	× 500	=	14.84	
〃	1	〃	595 × 9	c	42.037	× 605	=	25.43	
〃	1	Fill	320 × 16	c	40.192	× 460	=	18.49	
〃	1	Pl	435 × 9	c	30.733	× 520	=	15.98	
〃 Connection	1	L	100×100×10	c	14.9	× 295	=	4.40	
〃	1	Pl	415 × 9	c	29.320	× 1,025	=	30.05	
〃	1	〃	415 × 9	c	29.320	× 900	=	26.39	
〃	1	〃	410 × 9	c	28.967	× 660	=	19.12	
〃	1	〃	410 × 9	c	〃	× 1,990	=	57.64	
cover plate	1	〃	320 × 12	c	30.144	× 2,420	=	72.95	
								5,012.58 + 3,605.04 =	8,617.62
									2
									17,235.24 ✓

Transverse strut T.S 1 1-Reqd

main section	6	L	150×90×9	c	16.3	× 6,260	=	612.23	
〃	1	web Pl	817 × 9	c	57.721	× 5,710	=	329.59	
〃	8	L	75×75×9	c	9.96	× 1,130	=	90.04	
stiffener	8	〃	90×75×9	c	11.0	× 827	=		72.78
splice	4	Pls	290 × 9	c	20.489	× 640	=		52.45
End connection	1	L	90×75×9	c	11.0	× 809	=		8.90
〃 〃	1	Fill	160 × 9	c	11.304	× 640	=		7.23
gusset	1	Pl	680 × 9	c	48.042	× 950	=		45.64
〃	2	Pls	200 × 9	c	14.130	× 280	=		7.91
〃	3	〃	280 × 9	c	19.782	× 320	=		18.99
〃	4	〃	260 × 9	c	18.369	× 420	=		30.86
〃	1	Pl	420 × 9	c	29.673	× 590	=		17.51
〃	1	〃	780 × 9	c	55.107	× 970	=		53.45
	2	Pl3	150 × 9	c	10.598	× 190	=		4.03
	8	L	90×75×9	c	11.0	× 420	=		36.96
washer	4	wash.	70ϕ	c	30.2	× 9	=		1.09
								1,031.86 + 357.80 =	1,389.66

Transverse strut TS2 1-Reqd

main section	4	L	125×75×9	c	13.5	× 6,260	=	338.04	
〃 〃	8	〃	75×75×9	c	9.96	× 1,400	=	111.55	
gusset	2	Pl3	720 × 9	c	50.868	× 880	=		89.53
〃	3	〃	285 × 9	c	20.135	× 310	=		18.73
〃	4	〃	300 × 9	c	21.195	× 310	=		26.28
〃	2	〃	410 × 9	c	28.967	× 1,455	=		84.29
〃	2	〃	195 × 9	c	13.777	× 285	=		7.85
washer	7	wash.	70ϕ	c	30.2	× 9	=		1.69
								449.59 + 228.37 =	677.96

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CALCULATIONS FOR

Materials of nagahama-ō-bashi for Ehime-ken

		Transverse strut		TS 3		1-Reqd			
main section	2	L	125×75×9	c	13.5	× 6,552	=	176.90	
〃	2	〃	〃	c	〃	× 6,270	=	169.29	
〃	1	web Pl	880 ×9	c	62.172	× 6,920	=	430.23	
stiffener	2	L	125×90×9	c	14.6	× 888	=		25.93
〃	8	〃	90×75×9	c	11.0	× 888	=		78.14
gusset	1	Pl	370 ×9	c	26.141	× 560	=		14.64
〃	1	〃	570 ×9	c	40.271	× 720	=		29.00
								776.42 + 147.71	= 924.13
		Longitudinal strut		LS 1, 2, 3, 5 & 6		1-Reqd			
LS 1	2	L	125×75×9	c	13.5	× 4,090	=	110.43	
LS 2	2	〃	〃	c	〃	× 3,193	=	86.21	
LS 3	2	〃	〃	c	〃	× 3,218	=	86.89	
LS 5	2	〃	〃	c	〃	× 3,145	=	84.92	
LS 6	2	〃	〃	c	〃	× 3,170	=	85.59	
washer	55	wash.	70ϕ	c	30.2	× 9	=		14.95
								454.04 + 14.95	= 468.99
		Longitudinal strut		LS 4		1-Reqd			
main section	4	L	125×75×9	c	13.5	× 4,226	=	228.20	
〃	1	web Pl.	817 ×9	c	57.722	× 4,360	=	251.67	
stiffener	6	L	90×75×9	c	11.0	× 827	=		54.58
End connection	2	〃	〃	c	〃	× 665	=		14.63
〃	1	L	〃		〃	× 800	=		8.80
								479.87 + 78.01	= 557.88
		Summary of transverse and longitudinal strut					=	4,018.62 kgo	
		Top lateral bracings				1-Reqd			
$LB\,1^R_L$	2	L	130×130×9	c	17.7	× 4,890	=	173.11	
LB 2	2	〃	〃	c	〃	× 2,380	=	84.25	
$LB\,3^R_L$	2	〃	〃	c	〃	× 2,325	=	82.31	
$LB\,4^R_L$	2	〃	〃	c	〃	× 4,110	=	145.49	
$LB\,5^R_L$	2	〃	〃	c	〃	× 4285	=	151.69	
gusset	2	Pls	380 ×9	c	26.847	× 825	=		44.30
								636.85 + 44.30	= 681.15
		Bottom lateral bracings				1-Reqd			
LB 6	2	L	130×130×9	c	17.7	× 4,890	=	173.11	
LB 7	2	〃	〃	c	〃	× 2,380	=	84.25	
$LB\,8^R_L$	2	〃	〃	c	〃	× 2,325	=	82.31	
$LB\,9^R_L$	4	〃	〃	c	〃	× 4,245	=	300.55	
LB 10	2	〃	〃	c	〃	× 2,035	=	72.04	
$LB\,11^R_L$	4	〃	〃	c	〃	× 2,030	=	143.72	
LB 12	2	〃	〃	c	〃	× 2,065	=	73.10	
gusset	2	Pls	380 ×9	c	26.847	× 825	=		44.30
〃	4	〃	400 ×9	c	28.260	× 825	=		93.26
								929.08 + 137.56	= 1,066.64
		Summary of top and bottom lateral bracings					=	1,747.79 kgo	

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CALCULATIONS FOR

Materials of nagahama-o-bashi for Ehime-ken

Summary of counter weight

Structural steel

counterweight girders	6617.97	·
Balance Beams	17,235.24	·
Longitudinal & transverse struts	4018.62	·
Lateral bracings	1,747.79	·
	29,619.62	·
Rivet heads	1,034.00	
	30,653.62	kgo

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-Ken

								Z-Required
		counterweight tower, column						
Column	8	L	90×90×10	c	13.3	× 6,304 =		670.75
〃	1	Web P/	730 × 10	c	57.305	× 6,309 =		361.54
〃	2	P/s	500 × 10	c	39.250	× 5,514 =		432.85
Stay	2	L	380 × 100	c	54.500	× 7,650 =		833.85
〃	2	L	100×100×10	c	14.9	× 3,620 =		107.88
〃	2	〃	〃	c	〃	× 3,420 =		101.92
Strut	4	〃	150×150×11	c	24.9	× 1,745 =		173.80
Diagonals	2	〃	〃	c	〃	× 2,830 =		140.93
〃	2	〃	〃	c	〃	× 2,930 =		145.91
Top construction	2	〃	150×150×15	c	33.6	× 1,090 =		73.25
〃 〃	1	P/	390 × 10	c	30.615	× 1,090 =		33.37
〃 〃	1	〃	90 × 15	c	10.598	× 1,090 =		11.55
〃 〃	1	L	150×100×9	c	17.0	× 1,090 =		18.53
〃 〃	5	L	75×75×9	c	9.96	× 370 =		18.43
〃 〃	1	L	130×130×9	c	17.7	× 370 =		6.55
〃 〃	2	Fill's	90 × 10	c	7.065	× 145 =		2.05
〃 〃	2	L	150×150×15	c	33.6	× 1,090 =		73.25
〃 〃	1	P/	390 × 10	c	30.615	× 1,090 =		33.37
〃 〃	1	〃	90 × 15	c	10.598	× 1,090 =		11.55
〃 〃	1	L	150×100×9	c	17.0	× 1,090 =		18.53
〃 〃	6	L	75×75×9	c	9.96	× 370 =		22.11
〃 〃	2	〃	90×90×10	c	13.3	× 370 =		9.84
〃 〃	2	〃	〃	c	〃	× 550 =		14.63
〃 〃	2	Fill's	90 × 10	c	7.065	× 290 =		4.10
〃 〃	2	L	90×90×10	c	13.3	× 550 =		14.63
〃 〃	2	Fill's	90 × 10	c	7.065	× 290 =		4.10
〃 〃	1	P/	730 × 10	c	57.305	× 1,015 =		58.16
〃 〃	2	L	90×90×10	c	13.3	× 950 =		25.27
〃 〃	1	L	150×150×15	c	33.6	× 550 =		18.48
〃 〃	1	〃	90×90×10	c	13.3	× 550 =		7.32
〃 〃	1	〃	150×150×15	c	33.6	× 740 =		24.86
〃 〃	1	Fill.	90 × 15	c	10.598	× 550 =		5.83
〃 〃	2	L	125×75×9	c	13.5	× 370 =		9.99
〃 〃	1	L	125×90×9	c	14.6	× 370 =		5.40
〃 〃	1	Fill.	90 × 10	c	7.065	× 290 =		2.05
〃 〃	2	L	90×90×10	c	13.3	× 585 =		15.56
〃 〃	1	P/	730 × 10	c	57.305	× 1,015 =		58.16
〃 〃	1	〃	390 × 10	c	30.615	× 730 =		22.35
〃 〃	1	L	150×150×15	c	33.6	× 550 =		18.48
〃 〃	1	〃	90×90×10	c	13.3	× 550 =		7.32
〃 〃	1	〃	150×150×15	c	33.6	× 740 =		24.86
〃 〃	1	Fill	90 × 15	c	10.598	× 550 =		5.83
〃 〃	3	L	125×75×9	c	13.5	× 370 =		14.99
〃 〃	1	Fill	90 × 10	c	7.065	× 210 =		1.48
〃 〃	1	L	90×90×10	c	13.3	× 740 =		9.84
〃 〃	4	L	〃	c	〃	× 391 =		20.80
Column stiffeners	8	〃	75×75×9	c	9.96	× 740 =		58.96
〃 tie plate	2	P/s	495 × 10	c	38.858	× 730 =		56.73
Connections of sway	2	L	100×100×10	c	14.9	× 350 =		10.43
〃 〃	2	〃	125×90×10	c	16.1	× 950 =		30.59
〃 〃	1	Fill	260 × 10	c	20.410	× 350 =		7.14
〃 〃	2	L	125×90×10	c	16.1	× 600 =		19.32
Base	1	P/	1,000 × 19	c	149.150	× 1,070 =		159.59
〃	4	L	90×90×10	c	13.3	× 740 =		39.37

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-ken

Base	2	L3	150×150×15	c	33.60	× 740 =		49.73
〃	2	〃	〃	c	〃	× 1,000 =		67.20
〃	8	〃	75×75× 9	c	9.96	× 225 =		17.93
〃	2	〃	90×90×10	c	13.30	× 470 =		12.50
〃	2	Fills	90 × 15	c	10.598	× 470 =		9.96
Gussets	2	P/s	640 × 10	c	50.240	× 1,230 =		123.59
〃	2	〃	1,015 × 10	c	79.678	× 1,350 =		215.13
〃	2	Fills	240 × 10	c	18.840	× 370 =		13.94
〃	2	P/s	920 × 10	c	72.220	× 1,120 =		161.77
〃	2	〃	630 × 10	c	49.455	× 830 =		82.10
〃	2	Fills	310 × 10	c	24.335	× 320 =		15.57
〃	2	P/s	1,000 × 10	c	78.500	× 1,170 =		183.69
〃	2	Fills	320 × 10	c	25.120	× 515 =		25.87
Tie plate	2	P/s	320 × 9	c	22.608	× 730 =		33.01
〃 〃	2	〃	390 × 9	c	27.554	× 730 =		40.23
〃 〃	1	P/	940 × 9	c	66.411	× 1,540 =		102.27
〃 〃	1	〃	500 × 9	c	35.325	× 940 =		33.21
〃 〃 stiff	10	L3	75×75× 9	c	9.96	× 740 =		73.70
Lacing	16	bars	75 × 12	c	7.065	× 920 =		104.00
〃	4	〃	〃	c	〃	× 890 =		25.15
washers	8	wash.	75φ	c	34.7	× 012 =		3.33
Connection of stay	2	L3	150×150×11	c	24.90	× 520 =		25.90
〃 〃	2	P/s	260 × 10	c	20.410	× 350 =		14.29
〃 〃	2	Fills	140 × 10	c	10.990	× 300 =		6.59
Cap plate	1	P/	1,090 × 19	c	162.574	× 1,340 =		217.85
Tie plate	3	P/s	370 × 9	c	26.141	× 730 =		57.25
							296.943 + 282.476 =	579.419
								2
								1158.838

Sway bracing and strut 1- Required

Strut	4	L3	150×100×9	c	17.0	× 5,470 =	37.196	
〃	4	〃	〃	c	〃	× 5,830 =	39.644	
Bracings	4	〃	75×75×9	c	9.96	× 995 =	39.64	
〃	12	〃	〃	c	〃	× 1,075 =	128.48	
gussets	2	P/s	420 × 10	c	32.970	× 760 =		50.11
〃	2	〃	630 × 10	c	49.455	× 635 =		62.81
〃	2	〃	300 × 10	c	23.550	× 1,400 =		65.94
〃	3	〃	530 × 10	c	41.605	× 630 =		78.63
〃	2	〃	430 × 10	c	33.755	× 550 =		37.13
tie plate	3	〃	190 × 10	c	14.915	× 190 =		8.50
Sway end	4	L3	150×100×12	c	22.40	× 1,920 =		172.03
〃	2	Fills	110 × 10	c	8.635	× 400 =		6.91
〃	2	〃	95 × 10	c	7.458	× 230 =		3.43
	8	Bars	60 × 10	c	4.710	× 340 =		12.81
	8	〃	80 × 10	c	6.280	× 390 =		19.59
	4	〃	100 × 10	c	7.850	× 390 =		12.25
Diaphragm conn.	12	L3	75×75×9	c	9.96	× 382 =		45.66
〃 〃	6	Fills	160 × 10	c	12.560	× 190 =		14.32
End connection	4	P/s	125 × 10	c	9.813	× 330 =		12.95
Lacing	8	bars	75 × 10	c	5.888	× 760 =		35.80
〃	8	〃	〃	c	〃	× 835 =		39.33
washers	8	wash.	70φ	c	30.2	× 010 =		2.42
Strut	2	L3	100×100×10	c	14.9	× 5,470 =	163.01	
Diaphragm conn.	6	〃	75×75×9	c	9.96	× 380 =		22.71

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materials of Nagahama-O-bashi for Ehime-ken

Tie plate	3	P/s	290	× 9	℄	20489 × 350 =		2151
	8	Bars	80	× 9	℄	5652 × 350 =		1583
	4	″	100	× 9	℄	7065 × 350 =		989
	16	″	60	× 9	℄	4239 × 340 =		2306
End connection	2	P/s	310	× 10	℄	24335 × 390 =		1898
″ ″	2	″	170	× 10	℄	13345 × 330 =		881
								10953 + 80141 = 190094

Diaphragm DM1 3- Required

4	L-	75 × 75 × 9	℄	996 × 400 =		1594
1	web P/	390 × 9	℄	27554 × 620 =		1708
4	P/s	150 × 9	℄	10598 × 160 =		678
						3980
						3
						11940

Diaphragm DM2 6- Required

1	P/	240 × 10	℄	18840 × 370 =		697
2	L-	90 × 90 × 10	℄	133 × 380 =		1011
						1708
						6
						10248

Ladder 2- Required

2	Bars	75 × 9	℄	5299 × 7300 =		7737
17	″	19ϕ	℄	223 × 530 =		2009
8	L-	125 × 75 × 9	℄	135 × 170 =		1836
2	P/s	130 × 9	℄	9185 × 270 =		496
						12078
						2
						24156

Anchor bolts 2- Required

4	Turned bolt	30ϕ × 615	℄	390 =		1560
8	washers	90 × 10	℄	7065 × 090 =		509
4	nuts		℄	55 =		220
						2289
						2
						4578

Summary of structural steel of tower

Tower	1158838
sway bracing and strut	190094
Diaphragms, ladders	46344
anchor bolts	4578
	1399854
Rivet heads	49000
	1448854 Kgo

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-ken

Counter weight Span
Main girders $MG3^{R}_{L}$, $MG5^{R}_{L}$, MG4A & B & MG6A & B 1-Req'd

Flange angle	8	L	150×150×15	c	336	×	9,540 =	2,564.35	
〃 〃	8	〃	〃	c	〃	×	7,814 =	2,100.40	
〃 〃	4	〃	〃	c	〃	×	7,400 =	994.56	
〃 〃	4	〃	〃	c	〃	×	7,790 =	1,046.98	
〃 〃	8	〃	〃	c	〃	×	7,596 =	2,041.80	
web plate	4	P/s	1,800 × 10	c	1413.0	×	7,810 =	4,414.21	
〃 〃	4	〃	〃	c	〃	×	7,590 =	4,289.87	
Side plate	8	〃	1,500 × 10	c	1177.50	×	2,190 =	2,062.98	
Stiffeners	28	L	130×130×12	c	23.4	×	1,780 =		1,166.26
〃	8	Fills	270 × 15	c	31.793	×	1,500 =		381.52
〃	40	L	125×90× 9	c	14.6	×	1,810 =		1,057.04
〃	4	〃	125×90×10	c	16.1	×	1,810 =		116.56
〃	38	〃	〃	c	〃	×	1,780 =		1,089.00
〃	10	〃	〃	c	〃	×	1,750 =		281.75
〃	8	Fills	190 × 15	c	22.373	×	1,500 =		268.48
〃	4	〃	90 × 15	c	10.598	×	1,000 =		42.39
〃	4	〃	200 × 15	c	23.550	×	500 =		47.10
〃	4	〃	190 × 15	c	22.373	×	1,500 =		134.24
〃	2	〃	90 × 15	c	10.598	×	1,000 =		21.20
〃	2	〃	200 × 15	c	23.550	×	500 =		23.55
〃	22	L	90×90×10	c	133	×	1,780 =		520.83
〃	2	〃	〃	c	〃	×	1,140 =		30.32
〃	8	Fills	510 × 15	c	60.053	×	1,500 =		720.64
〃	8	L	90×90×10	c	133	×	1,120 =		1197
〃	8	〃	125×90×10	c	16.1	×	880 =		113.34
〃	8	〃	〃	c	〃	×	940 =		121.07
〃	4	〃	90×75× 9	c	11.0	×	1,010 =		44.44
〃	4	〃	130×130×12	c	23.4	×	1,640 =		153.50
〃	4	Fills	270 × 15	c	31.793	×	1,500 =		190.76
〃	4	〃	〃	c	〃	×	1,450 =		184.40
〃	4	L	130×130×15	c	288	×	1,880 =		216.58
〃	4	〃	150×150×15	c	336	×	1,370 =		184.13
〃	3	Fills	275 × 15	c	32381	×	500 =		48.57
〃	3	〃	125 × 15	c	14719	×	720 =		31.79
〃	4	〃	95 × 15	c	11.186	×	340 =		15.21
〃	4	〃	145 × 15	c	17.074	×	1,215 =		82.98
〃	1	Fill	125 × 15	c	14719	×	1,215 =		17.88
〃	3	Fills	130 × 15	c	15308	×	640 =		29.39
〃	2	〃	120 × 15	c	14130	×	640 =		18.09
〃	24	L	90×90×10	c	133	×	640 =		204.29
〃	4	Fills	320 × 15	c	37.680	×	400 =		60.29
〃	4	〃	〃	c	〃	×	380 =		57.27
Splice	16	P/s	220 × 15	c	25905	×	905 =		375.10
〃	8	〃	345 × 15	c	40624	×	1,050 =		341.24
〃	4	〃	945 × 10	c	74.183	×	1,060 =		314.54
〃	4	〃	〃	c	〃	×	1,280 =		379.82
〃	16	L	150×150×15	c	336	×	945 =		508.03
Filler	4	Fills	160 × 15	c	18.840	×	430 =		32.40
〃	6	〃	75 × 15	c	8831	×	430 =		22.78
〃	2	〃	310 × 15	c	36503	×	430 =		31.39
At Base of tower	8	L	90×90×10	c	133	×	230 =		24.47
〃 〃	8	Fills	135 × 10	c	10598	×	230 =		19.50
〃 〃	16	L	75×75× 9	c	996	×	225 =		35.86
〃 〃	8	Fills	60 × 10	c	4710	×	235 =		8.85
									9,888.01

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-ken

at base of gear	4	P/s	310 × 19	@	46237	× 2,070 =		38284
〃 〃	8	L	150×100×12	@	224	× 310 =		5555
〃 〃	16	〃	150×90×12	@	215	× 573 =		1971
〃 〃	8	Fills	310 × 12	@	29202	× 430 =		10045
〃 〃	8	〃	88 × 10	@	6908	× 573 =		3167
hole	6	L	75×75× 9	@	996	× 1755 =		7500
〃	2	P/s	400 × 10	@	31400	× 400 =		2512
Tie plate	2	〃	1,000 × 19	@	149150	× 1,070 =		31918
〃 〃	2	Fills	190 × 15	@	22373	× 430 =		1924
〃 〃	2	P/s	550 × 10	@	43175	× 1060 =		9153
Gussets	2	〃	825 × 12	@	77715	× 1365 =		21216
〃	2	〃	405 × 10	@	31793	× 1280 =		8139
〃	2	〃	910 × 10	@	71435	× 1350 =		19287
〃	2	〃	910 × 12	@	85722	× 1350 =		23145
〃	2	〃	585 × 12	@	55107	× 1280 =		14107
〃	2	〃	880 × 12	@	82896	× 1400 =		23211
	2	〃	310 × 12	@	29202	× 460 =		2687
	4	〃	395 × 16	@	49612	× 640 =		12701
	2	〃	510 × 16	@	64056	× 1050 =		13452
								195515+12565.15
								= 320830
		Diaphragm			1- Required			
DM5	2	P/s	700 × 10	@	54950	× 1770 =		19452
〃	4	L	75×75× 9	@	996	× 710 =		2829
〃	2	〃	150×100× 9	@	170	× 420 =		1428
DM6	4	P/s	700 × 10	@	54950	× 1770 =		38905
〃	12	L	75×75× 9	@	996	× 710 =		8486
DM7	2	P/s	670 × 10	@	52595	× 1740 =		18303
〃	6	L	75×75× 9	@	996	× 680 =		4064
DM8	2	〃	90×90×10	@	133	× 710 =		1889
〃	2	〃	100×75×10	@	130	× 420 =		1092
〃	1	Pl	700 × 10	@	54950	× 1785 =		9809
DM9	8	L	150×90× 9	@	163	× 710 =		9258
〃	2	P/s	460 × 10	@	36110	× 700 =		5055
〃	8	L	100×75×10	@	130	× 450 =		4680
〃	8	Fills	70 × 9	@	4946	× 280 =		1108
DM10	4	L	100×75×10	@	130	× 1620 =		8424
〃	4	〃	〃	@	〃	× 1780 =		9256
〃	2	P/s	700 × 10	@	54950	× 1550 =		17035
〃	4	Fills	290 × 15	@	34148	× 1230 =		16801
DM11	4	L	100×75×10	@	130	× 560 =		2912
〃	4	〃	〃	@	〃	× 620 =		3224
〃	2	P/s	700 × 10	@	54950	× 570 =		6264
DM12	4	L	100×75×10	@	130	× 440 =		2288
〃	4	〃	〃	@	〃	× 520 =		2704
〃	2	P/s	700 × 10	@	54950	× 450 =		4946
DM13	4	L	90×90×10	@	133	× 686 =		3650
〃	2	P/s	695 × 10	@	54558	× 700 =		7638
〃	4	L	150×90× 9	@	163	× 420 =		2738
DM14	2	〃	90×90×10	@	133	× 710 =		1889
〃	4	〃	100×75×10	@	130	× 510 =		2652
〃	2	〃	〃	@	〃	× 420 =		1092
〃	1	Pl	690 × 10	@	54165	× 1120 =		6066

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CALCULATIONS FOR

Materials of Nagahama-o-bashi for Ehime-ken.

DM14	1	Pl	655 × 10	c	51.418	× 690 =		35.48
DM15	4	L	100 × 75 × 10	c	13.0	× 710 =		36.92
〃	4	〃	90 × 90 × 10	c	13.3	× 640 =		34.05
〃	1	Pl	635 × 10	c	49.848	× 690 =		34.40
〃	4	Fills	85 × 10	c	6.673	× 480 =		12.81
	2	〃	125 × 10	c	9.813	× 1,140 =		22.37
	6	〃	〃	c	〃	× 1,780 =		104.80
	1	Fill	85 × 10	c	6.673	× 1,780 =		11.88
	1	〃	〃	c	〃	× 1,140 =		7.61
	2	Fills	〃	c	〃	× 1,124 =		15.00
	4	〃	125 × 10	c	9.813	× 950 =		37.29
DM 14	4	L	90 × 90 × 10	c	133	× 640 =		34.05
								2,646.03

Summary of main girders and diaphragms 34,726.33 Kgo

End Floor Beam FB8 1- Required

Main Section	2	Flg L	100 × 75 × 10	c	13.0	× 5,550 =	144.30	
〃 〃	2	〃 〃	〃	c	〃	× 5,540 =	144.04	
〃 〃	1	Web Pl.	710 × 10	c	55.735	× 5,800 =	323.26	
Stiffeners	2	L	75 × 75 × 9	c	9.96	× 675 =		13.45
〃	2	〃	〃	c	〃	× 698 =		13.90
〃	2	〃	〃	c	〃	× 712 =		14.18
〃	1	L	〃	c	〃	× 716 =		7.13
〃	2	L	90 × 75 × 9	c	11.0	× 675 =		14.85
〃	2	〃	〃	c	〃	× 698 =		15.36
〃	2	〃	〃	c	〃	× 712 =		15.66
〃	1	L	〃	c	〃	× 716 =		7.88
							611.60 +	102.41 = 714.01

Intermediate Floor Beams FB9 & FB10 2- Required

Main Section	1	Flg. L	100 × 75 × 10	c	13.0	× 5,560 =	72.28	
〃 〃	1	〃	〃	c	〃	× 5820 =	75.66	
〃 〃	2	Flg L	〃	c	〃	× 5,530 =	143.78	
〃 〃	1	web Pl.	710 × 10	c	55.735	× 5,800 =	323.26	
End connection	2	L	125 × 90 × 10	c	16.1	× 625 =		20.13
〃 〃	2	Fills	120 × 10	c	9.420	× 555 =		10.46
Stiffeners	4	L	75 × 75 × 9	c	9.96	× 675 =		26.89
〃	4	〃	〃	c	〃	× 698 =		27.81
〃	4	〃	〃	c	〃	× 712 =		28.37
〃	2	〃	〃	c	〃	× 716 =		14.26
							614.98 +	127.92 = 742.90
								2
								1,485.80

Intermediate Floor Beams FB11 1- Required

Main Section	1	Flg L	100 × 75 × 10	c	13.0	× 5,790 =	75.27	
〃 〃	1	〃	〃	c	〃	× 5,520 =	71.76	
〃 〃	2	〃 L	〃	c	〃	× 5520 =	143.52	
〃 〃	1	web pl.	710 × 10	c	55.735	× 5,770 =	321.59	
End connection	2	L	125 × 90 × 10	c	16.1	× 615 =		19.80
〃 〃	2	Fills	120 × 10	c	9.420	× 545 =		10.27

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CALCULATIONS FOR

Materials of nagakama-o-bashi for Ehime-ken

Stiffeners	4	L	75·75·9	c	9.96	×	675 =	26.89	
〃	4	〃	〃	c	〃	×	698 =	27.81	
〃	4	〃	〃	c	〃	×	712 =	28.37	
〃	2	〃	〃	c	〃	×	716 =	14.26	
								612.14 + 127.40 =	739.54

Intermediate Floor Beam FB12 1-Required

Main Section	2	Flg L	100·75·10	c	130	×	5,820 =	151.32	
〃 〃	2	〃 〃	〃	c	〃	×	4,930 =	128.18	
〃 〃	1	web pl.	1,150 · 10	c	90.275	×	5,800 =	523.60	
〃 〃	2	Flg L	100·75·10	c	130	×	2,510 =	65.26	
〃 〃	2	〃	〃	c	〃	×	3,740 =	97.24	
〃 〃	1	web pl.	1,090 × 10	c	85.565	×	2,505 =	214.34	
End Connection	6	L	125·90·10	c	16.1	×	625 =		60.38
〃 〃	6	Fills	120 · 10	c	9.420	×	555 =		31.37
Stiffeners	4	L	75·75·9	c	9.96	×	1,130 =		45.02
〃	4	〃	〃	c	〃	×	1,150 =		45.87
〃	2	〃	〃	c	〃	×	1,158 =		23.07
〃	1	L	90·90·10	c	13.3	×	1,097 =		14.59
〃	4	L	75·75·9	c	9.96	×	1,097 =		43.70
	2	〃	100·75·10	c	13.0	×	1,680 =		43.68
	2	〃	〃	c	〃	×	1,365 =		35.49
	2	〃	〃	c	〃	×	2,060 =		53.56
	1	web pl	420 · 10	c	32.970	×	1,365 =		45.00
	1	〃	〃	c	〃	×	1,370 =		45.17
	4	L	100·75·10	c	13.0	×	625 =		32.50
Splice	6	Pls	270 · 9	c	19.076	×	270 =		30.90
〃	4	〃	65 · 10	c	5.103	×	630 =		12.86
〃	2	〃	210 · 10	c	16.485	×	630 =		20.77
	4	Fills	95 · 12	c	8.949	×	315 =		11.28
	1	Fill	210 × 10	c	16.485	×	940 =		15.50
Tension plate	1	Pl	210 · 16	c	26.376	×	1,560 =		41.15
Gusset	1	〃	410 · 10	c	32.185	×	410 =		13.20
								1,179.94 + 665.01 =	1,844.95

Intermediate Floor Beam FB13 1-Required

main section	2	Flg L	100·75·10	c	13.0	×	5,820 =	151.32	
〃 〃	2	〃	〃	c	〃	×	5,090 =	132.34	
〃 〃	2	〃	〃	c	〃	×	2,740 =	71.24	
〃 〃	2	〃	〃	c	〃	×	2,350 =	61.10	
〃 〃	2	〃	〃	c	〃	×	3,930 =	102.18	
〃 〃	2	〃	〃	c	〃	×	3,855 =	100.23	
〃 〃	1	web pl	1,150 · 10	c	90.275	×	5,800 =	523.60	
〃 〃	1	〃	420 · 10	c	32.970	×	2,345 =	77.31	
〃 〃	1	〃	〃	c	〃	×	3,535 =	116.55	
End Connection	4	L	125·90·10	c	16.1	×	625 =		40.25
〃 〃	4	Fills	120 · 10	c	9.421	×	555 =		20.91
Stiffeners	2	L	90·75·9	c	11.0	×	230 =		5.06
washers	2	wash.	70ϕ	c	30.2	×	010 =		0.60

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-Ken

Stiffener	4	L	75×75×9	c	9.96	× 1,130 =		45.02
〃	4	〃	〃	c	〃	× 1,150 =		45.82
〃	2	〃	〃	c	〃	× 716 =		14.26
〃	2	〃	〃	c	〃	× 430 =		8.57
Splice.	4	〃	100×75×10	c	13.0	× 545 =		28.34
〃	4	Pl	270 × 9	c	19.076	× 270 =		20.60
〃	4	〃	65 × 10	c	5.103	× 630 =		12.86
〃	2	〃	210 × 10	c	16.485	× 630 =		20.77
〃	4	Fills	95 × 12	c	8.949	× 315 =		11.28
	2	L	150×90×9	c	16.3	× 230 =		7.50
	2	Fills	90 × 10	c	7.065	× 145 =		2.05
Lateral connection	2	L	90×75×9	c	11.0	× 1,120 =		24.64
〃 〃	2	〃	〃	c	〃	× 910 =		20.02
Gusset	1	Pl	370 × 12	c	34.854	× 1,120 =		39.04
〃	1	〃	350 × 12	c	32.970	× 910 =		30.00
〃	1	〃	340 × 10	c	26.690	× 610 =		16.28
	2	Pl	60 × 10	c	4.710	× 210 =		1.98
							133.87+ 41.85 =	175.72

Intermediate Floor Beams FB14 1- Required

main section	2	L	100×75×10	c	13.0	× 5,790 =	150.54	
〃 〃	2	〃	〃	c	〃	× 4,840 =	125.84	
〃 〃	2	〃	〃	c	〃	× 2,865 =	74.49	
〃 〃	2	〃	〃	c	〃	× 2,475 =	64.35	
〃 〃	2	〃	〃	c	〃	× 2,105 =	54.73	
〃 〃	2	〃	〃	c	〃	× 2,495 =	64.87	
〃 〃	2	〃	〃	c	〃	× 3,785 =	98.41	
〃 〃	1	web pl	1,150 × 10	c	90.275	× 5,770 =	520.89	
〃 〃	1	〃	420 × 10	c	32.970	× 2,470 =	81.44	
〃 〃	1	〃	〃	c	〃	× 1,415 =	46.65	
	2	L	90×75×9	c	11.0	× 230 =		5.06
	2	wash	70#	c	30.2	× 010 =		0.60
Stiffener	4	L	75×75×9	c	9.96	× 1,130 =		45.02
〃	4	〃	〃	c	〃	× 1,150 =		45.82
〃	2	〃	〃	c	〃	× 1,158 =		23.07
〃	4	〃	〃	c	〃	× 1,097 =		43.70
〃	1	L	90×90×10	c	13.3	× 1,097 =		14.59
main section	1	web pl	1,090 × 10	c	85.565	× 2,490 =		213.06
End connection	6	L	125×90×10	c	16.1	× 625 =		60.38
〃 〃	6	Fills	120 × 10	c	9.420	× 555 =		31.37
Splice	4	L	100×75×10	c	13.0	× 655 =		34.06
〃	6	Pl	270 × 9	c	19.076	× 270 =		30.90
〃	4	〃	65 × 10	c	5.103	× 630 =		12.86
〃	2	〃	210 × 10	c	16.485	× 630 =		20.77
〃	4	Fills	95 × 12	c	8.949	× 315 =		11.28
	1	L	75×75×12	c	13.0	× 2,140 =		27.82
	1	Pl	750 × 9	c	52.988	× 750 =		39.74
	4	L	90×75×9	c	11.0	× 130 =		5.72
	1	Fill	210 × 10	c	16.485	× 940 =		15.50
Gusset	1	Pl	410 × 10	c	32.185	× 410 =		13.20
	2	Pl	60 × 10	c	4.710	× 210 =		1.98
Tension plate	1	Pl	210 × 16	c	26.376	× 1,590 =		41.94

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CALCULATIONS FOR

Materials of Nagakama-O-bashi for Ehime-Ken

Bed plate	1	Pl	230 × 19	c	34305 × 230 =		7.89
Anchor bolts	2	Bolts	22φ × 500	c	1.50 =		300
							12822 + 74933 = 203.54
		End Floor Beam FB15			1-Required		
Beam	1	[	250 × 90	c	34.6 × 5530 =	19134	
post	10	L	100×75×10	c	130 × 1,109 =		14417
	5	"	75×75× 9	c	996 × 595 =		2963
	5	Pl	130 × 9	c	9,185 × 145 =		666
	5	"	"	c	" × 215 =		987
	10	L	150×150×11	c	249 × 220 =		5478
	5	Pl	220 × 16	c	27632 × 300 =		4145
	20	wash	70φ	c	302 × 009 =		544
	20	bolts	16φ × 370	c	0.67 =		1340
						19134 + 30540 =	49674
		Bracket BR3			7-Required		
	2	L	75×75× 9	c	996 × 250 =		498
	1	Pl	330 × 9	c	23315 × 350 =		816
							1314
							7
							9198
		Summary of Floor beams and Brackets					9,15628 kgo
		Longitudinal girder LG1			1-Required		
Flange	4	L	100×75×10	c	130 × 4,915 =	25558	
web	1	Pl	1,090 × 10	c	85565 × 4,905 =	41970	
End connection	4	L	125×90×10	c	161 × 1,070 =		6891
" "	4	Fills.	120 × 10	c	9420 × 940 =		3542
Stiffeners	8	L	75×75× 9	c	996 × 1,097 =		8741
"	1	L	90×90×10	c	133 × 1,097 =		1459
	1	Fills	170 × 10	c	13345 × 210 =		280
						67528 + 20913 =	88441
		Strut SR2			1-Required		
	1	L	75×75× 9	c	996 × 2,250 =		2241
	1	"	100×75×10	c	130 × 2,250 =		2925
	1	Pl	240 × 10	c	18,840 × 2,683 =		5055
							10221
		Strut $SR3^{R}_{L}$			2-Required		
	1	[	180×90	c	271 × 2,680 =		7263
	1	Bar	60×20	c	9420 × 1,580 =		1488
							8751
							2
							17502

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CALCULATIONS FOR

Materials of nagahama-o-bashi for Ehime-ken

Strut SR4 2-Required

1	L	180 × 90	c	27.1 × 440 =		11.92
2	L	90 × 90 × 10	c	13.3 × 130 =		3.46
1	Bar	60 × 20	c	9.420 × 510 =		4.80
						20.18
						2
						40.36

Summary of longitudinal girder + struts 1,202.00 Kgo

Lateral Bracing 1-Required

LB 6	10	L	125 × 75 × 10	c	14.9 × 3,290 =	490.21
〃	10	〃	〃	c	〃 × 3,410 =	508.09
LB 7 R	2	〃	100 × 100 × 10	c	14.9 × 3,230 =	96.25
〃	2	〃	〃	c	〃 × 3,290 =	98.04
LB 8	2	〃	100 × 75 × 10	c	13.0 × 3,030 =	78.78
gussets	2	P/s	720 × 10	c	56.520 × 900 =	101.74

1,271.37 + 101.74 = 1,373.11 Kgo

Roller shoe cast steel 4-sets required

Top casting		1	c	71.00	= 71.00
Bolts	22ϕ × 85	8	c	0.52	= 4.16
Pin & tapped bolts		1	c	6.90	= 6.90
Collars		2	c	5.40	= 10.80
Bottom casting		1	c	68.00	= 68.00
Rollers		3	c	18.87	= 56.61
Base plate		1	c	88.50	= 88.50
Dust guards		2	c	16.00	= 32.00
Side plate	130 × 10 × 350	2	c	3.57	= 7.14
Tapped bolts	6ϕ × 25	8	c	0.07	= 0.56
〃	22ϕ × 40	4	c	1.19	= 4.76
pins	22ϕ × 50	2	c	0.15	= 0.30
〃	〃	4	c	0.16	= 0.64
Anchor bolts	25ϕ × 650	4	c	2.56	= 10.24
					361.61
					4
					1,446.44

Fixed Shoe cast steel 4-sets required

Top casting		1	c	71.00	= 71.00
Bolts	22ϕ × 85	8	c	0.52	= 4.16
Pin with tapped bolts		1	c	6.90	= 6.90
Collars		2	c	5.40	= 10.80
Base casting		1	c	168.00	= 168.00
Anchor bolts	25ϕ × 650	4	c	2.56	= 10.24
					271.10
					4
					1,084.40

Summary of Shoes + accessories 2,530.84 Kgo

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CALCULATIONS FOR

Materials of Nagahama-O-bashi for Ehime-Ken

Summary of counterweight span
Structural steel

main girders	34,726.33
Floor beams	9,156.28
Longitudinal girder & struts	1,202.00
Bracings	1,373.11
	46,457.72
Rivet heads	1,640.00
	48,097.72
Cast steel shoes & accessories	2,530.84
	50,628.56 kgo

Expansion Joints EJ 1 2-Required sheet no. 7

1	L	100×75×10	c	13.0 × 6,410 =		83.33
1	Bar	30 ×10	c	2.355 × 6,410 =		15.10
1	Pl	230 × 9	c	16.250 × 5,500 =		89.38
2	Pls	300 × 9	c	21.195 × 325 =		13.78
5	⌊	65×65×10	c	9.42 × 210 =		9.89
5	Is	150×125	c	36.2 × 250 =		45.25
5	bolts	12ϕ × 400		c 0.42 =		2.10
5	wash.	70 × 9	c	4.946 × .070 =		1.73
5	"	65 × 9	c	4.592 × 140 =		3.21
10	bolts	12ϕ × 60		c 0.13 =		1.30
					265.07	
					2	
						530.14

Expansion Joints EJ2 5-Required sheet no. 7

1	L	65×65×10	c	9.42 × 6,410 =		60.38
1	Pl	225 × 9	c	15.896 × 5,500 =		87.43
2	Pls	300 × 9	c	21.195 × 320 =		13.56
1	chek. Pl	230 × 9	c	16.250 × 6,410 =		104.16
4	⌊	65×65×10	c	9.42 × 210 =		7.91
5	bolts	12ϕ ×300		c 0.36 =		1.80
8	"	12ϕ × 60		c 0.13 =		1.04
					276.28	
					5	
						1,381.40

Expansion Joints EJ3 4-Required sheet no. 7

1	L	100×75×10	c	13.0 × 6,410 =		83.33
1	Bar	30 ×10	c	2.355 × 6,410 =		15.10
1	Pl	225 × 9	c	15.896 × 5,500 =		87.43
2	Pls	300 × 9	c	21.195 × 320 =		13.56
4	⌊	65×65×10	c	9.42 × 210 =		7.91
5	bolts	12ϕ ×300		c 0.36 =		1.80
8	"	12ϕ × 60		c 0.13 =		1.04
					210.17	
					4	
						840.68

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CALCULATIONS FOR

Materials of Nagahama-o-bashi for Ehime-Ken

Expansion Joint EJ4 1-Required Sheet no. 18

1	L	65×65×10	℄	9.42	× 6.100 =	57.46
1	Pl	230 × 9	℄	16.250	× 6.110 =	99.29
1	'	255 × 9	℄	18.016	× 5.500 =	99.09
2	Pls	150 × 9	℄	10.598	× 345 =	7.31
7	L	65×65×10	℄	9.42	× 210 =	13.85
14	bolts	12ϕ × 50		℄ 0.11	=	1.54
7	'	12ϕ × 300		℄ 0.36	=	2.52
						281.06

Floor Break FL1 1-Required sheet no. 18

1	L	75×75×9	℄	9.96	× 5.530 =	55.08
1	Pl	265 × 9	℄	18.722	× 5.530 =	103.53
6	L	75×75×9	℄	9.96	× 190 =	1.135
5	bolts	12ϕ × 300		℄ 0.36	=	1.80
12	'	12ϕ × 50		℄ 0.11	=	1.32
						173.08

Floor Break FL2 1-Required sheet no. 8

1	L	75×75×9	℄	9.96	× 5.760 =	57.37
1	'	'	℄	9.96	× 5.600 =	55.78
1	Pl	275 × 10	℄	21.588	× 5.760 =	124.35
2	L	150×90×9	℄	16.3	× 080 =	2.61
12	bolts	12ϕ × 50		℄ 0.11	=	1.32
						241.43

Floor Break FL3 1-Required sheet no. 8

1	L	75×75×9	℄	9.96	× 5.760 =	57.37
1	'	'	℄	'	× 5.600 =	55.78
1	Pl	240 × 10	℄	18.840	× 5.760 =	108.52
2	L	150×90×9	℄	16.3	× 080 =	2.61
2	Pl	100 × 10	℄	7.850	× 2.880 =	45.22
40	bolts	12ϕ × 30		℄ 0.10	=	4.00
12	'	12ϕ × 60		℄ 0.13	=	1.56
						275.06

Floor Break FL4 1-Required sheet no. 3

1	L	75×50×9	℄	8.20	× 0.400 =	52.48
1	Pl	240 × 9	℄	16.956	× 5.500 =	93.26
2	Pls	300 × 9	℄	21.195	× 335 =	14.20
4	L	65×65×10	℄	9.42	× 210 =	7.91
8	bolts	12ϕ × 60		℄ 0.13	=	1.04
5	'	12ϕ × 300		℄ 0.36	=	1.80
						170.69

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CALCULATIONS FOR

Materials of nagahama-o-bashi for Ehime-ken

Summary for Expansion joints + floor breaks

EJ 1, 2, 3 & EL 4
Rivet heads 2,922.91
-60.00
2,982.91

FL 1, 2, 3 & EJ 4 970.63
120.00
990.63

grand summary
Structural steel
For Truss span
For span no. 1, 2 & 7 3 c 62,1259 = 186377.70
For span no. 3 & 6 2 c 62,1544 = 124308.80
Expansion joints & Floor break 2,982.91
313,669.41
Cast steel shoes & accessories 5 c 1,7052 = 8,526.00
322,195.41 kgo

Structural steel
For moving; counterweight span, tower & counterweight
moving span = 34559.80
counter weight = 30,653.62
Tower = 14488.54
Counter weight span = 48,097.72
Expansion joint & floor break = 990.63
128,790.31
Cast steel shoes & accessories
moving span = 248.32
counter weight span = 2530.84
2779.16
131,569.47 kgo

453,764.88 kgo

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CALCULATIONS FOR

Materials of Nagahama-O-Hashi for Ehime Ken.

Floor of Bascule span.

Wood-block pavement. cwood-block 5寸×3寸×2寸 Creosote 3才/立方尺

width of pavement	5.50 meter		
length " "	17.81 "		
paved area	= 17.81 × 5.50 =	(Drain holes neglected)	97.96 sq. meters
		with 12000 - 4" nails	= 115 kg.

Planking 休地產赤松厚 7.5 糎.

width of planking	5.76 meter		
length of "	17.62 "		
Area of planking	= 17.62 × 5.76 =		101.49 sq. meters.

Curb timber

End panels	2 - 14.0 cm × 21.5 cm × 3.580 m,	=	0.216
"	2 - " × " × 3.100	=	0.187
"	2 - " × " × 0.680	=	0.041
"	2 - " × " × 0.480	=	0.029
Int. panels	6 - " × " × 3.580	=	0.647
			1.120 Cub. meter

Nailing pieces

nailing pieces	8 - 10.0 × 15.0 × 3.470	=	0.416
"	2 - " × " × 3.690	=	0.111
"	8 - 9.5 × 15.0 × 3.470	=	0.396
"	2 - " × " × 3.690	=	0.105
"	8 - 10.5 × 15.0 × 3.470	=	0.437
"	2 - " × " × 3.690	=	0.116
"	8 - 7.0 × 10.0 × 3.470	=	0.194
"	2 - " × " × 3.690	=	0.052
			1.827
End beams	2 - 10.5 × 18.0 × 2.880	=	0.109
"	1 - 8.5 × 18.0 × 3.290	=	0.050
"	1 - " × " × 2.470	=	0.038
			0.197
			2.024 Cub. meter

Bolts, nails and stop angles.

Bolts. Curbs	74 - 16 mmφ × 160 mm @ 0.41	=	30.34 kg	with one washer
" nailing pieces	122 - 16 × 90 @ 0.37	=	45.14	" one washer and one bevel washer
" "	224 - 16 × 130 @ 0.44	=	98.56	" " "
" "	112 - 16 × 140 @ 0.45	=	50.40	" "
" End Beams.	14 - 16 × 140 @ 0.38	=	5.32	" one washer
" "	14 - 16 × 145 @ 0.39	=	5.46	" "
			235.22	
Nails planking	3300 - 5" nails	=	50.00	
Stop angles.	3L 40 mm × 40 × 3 × 5.400 m @ 9.88	=	29.64	
	69 - 9φ Lug screws	=	1.00	
			30.64	
			315.86 Call this 315 kg	

Cast iron drains 6 drains with lug screws

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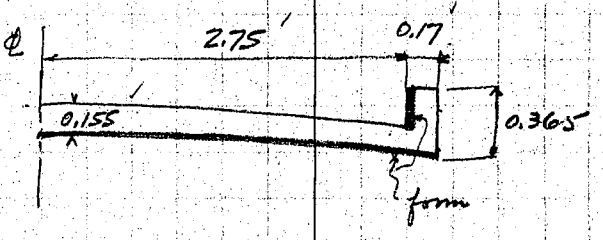
CALCULATIONS FOR

Materials of Nagahama-O-Hashi for Ehime Ken.

Floor of Counterweight span.

Roadway floor:-

Concrete 1:2:4 mixture



Cross section of slab.

Slab 5.50 × 0.155 = 0.853 ✓
Copings 2 × 0.17 × 0.365 = 0.124 ✓
0.977 ✓ sq. meters

Total length of slab 15.983 ✓ meters

Volume of slab concrete = 0.977 × 15.983 = 15.62 − 1.40 × 0.45 × 0.155 = 15.52 ✓ cub meters
(10 man hole.)
(Drain holes neglected).

Reinforcements Plain bars. (see drawing no 17) 1.557 ✓ kg tons.

Forms. 3 cm thick.

Total width of form

Bottom of slab 5.50 + 2@0.17 = 5.84 ✓
Curb lines 2 @ 0.21 = 0.42 ✓
6.26 meters ✓.

Total length of form. 15.993 − 7×0.21 − 2×0.08 = 14.363 ✓ meters.

Total area of form = 6.26 × 14.363 = 89.91 ✓ sq. meters.

Asphalt-block pavement asphalt-block 240 mm × 120 × 38 — 34 ✓ blocks per sq meter.

width of pavement = 5.500 meters ✓
length " = 15.993 − 2×0.07 = 15.853 ✓ meters
Total area of pavement = 5.50 × 15.853 = 87.19 ✓ sq. meters
man hole, less 1.40 × 0.45 = − 0.63 ✓
86.56 ✓ sq. meters.

Cast iron man hole cover. 2 covers required. ✓

Weight of one cover.

72.85 × 50.7 × 2 = 7,387 ✓
2.5 × 3 × 44.7 × 3 = 1006 ✓
1.5 × 3 × 44.7 = 201 ✓
2.5 × 3 × 60.85 = 456 ✓
1.5 × 3 × 60.85 × 2 = 548 ✓
9598 cm³ @ 0.00725 = 69.586 ✓ kg

Artificial granite finish.

0.35 × 2 × 15.983 ✓ = 11.19 ✓ sq. meters.

Cast iron drain 4 cast iron drains with 3 mm galvanized iron troughs 82 cm long. ✓

Intermediate Lamp. 2 Lamps with cast iron brackets, (on cwt. tower) ✓

Construction joint 1 joint − 1.0 cm elastite filling. ✓

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CALCULATIONS FOR

Materials of nagahama – O – Hashi

Machinery room floor.

Concrete 1:2:4 mixture

Floor	2.463 × 14.18 × 0.10	=	3.49	✓
"	2 × 2.463 × 2.60 × 0.05	=	0.64	✓
"	2.463 × 0.80 × 0.14	=	0.28	✓
"	2.463 × 0.60 × 0.05	=	0.07	✓
fillet bott.	0.09 × 0.15 × 11.0 × 2	=	0.30	✓
" "	0.09 × 0.15 × 3.18 × 2	=	0.09	✓
" "	0.09 × 0.15 × 2.463 × 3	=	0.10	✓
" top	0.12 × 0.30 × 2.463 × 4	=	0.35	✓
" "	0.19 × 0.30 × 2.463 × 2	=	0.28	✓
man hole less.	0.60 × 1.00 × 0.100	= –	0.06	✓
			5.54	✓
machinery bases.	1.70 × 1.33 × 0.20	=	0.45	✓
"	0.875 × 1.29 × 0.20	=	0.23	✓
motor	0.30 × 0.23 × 0.90	=	0.06	✓
"	0.30 × 0.20 × 1.818	=	0.11	✓
worm gear less	0.18 × 0.20 × 0.80	= –	0.03	✓
	0.40 × 0.90 × 0.20	=	0.07	✓
2nd gear base	1.38 × 0.90 × 0.20	=	0.25	✓
3rd " "	0.80 × 0.60 × 0.20	=	0.10	✓
			1.24	✓
			6.78 cub meter	✓

Reinforcing bars, plain bars (see drawing no.17) 0.5753 kg tons.

Forms 3 cm thick.

floor slab	2.463 × 14.18	=	34.93	✓
top fillets say	0.40 × 2.463 × 6	=	5.91	✓
machinery base	0.20 × 5.45	=	1.09	✓
2nd gear base	0.20 × 3.66	=	0.73	✓
3rd " "	0.20 × 2.00	=	0.40	✓
			43.06 sq. meters.	✓

Man hole cover cast iron. 1 required.

105.7 × 65.7 × 1.2 = 8333 ✓
60.0 × 3.0 × 3.0 × 4 = 2160 ✓
10493 @0.00725 = 76.074 kg ✓ ✓

Man hole frame structural steel 1 required ✓
1L 100×100×10 @14.9 × 3.20m = ✓ 47.68 kg

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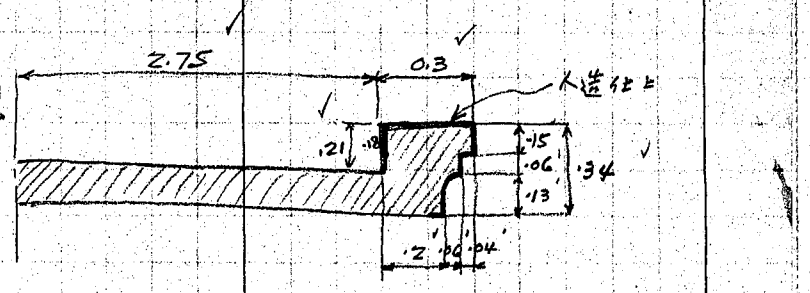
CALCULATIONS FOR

Materials of Nagahama — O-Hashi for Ebine Kaw.

Floor of Fixed spans.

Concrete 1:2:4 mixture.

Cross section of slab.



Slab	5.50 × 0.14	=	0.770
Copings	2 @ 0.30 × 0.15	=	0.090
"	2 @ 0.26 × 0.06	=	0.031
"	2 @ 0.20 × 0.13	=	0.052
			0.943 sq. meter

Total length of slab.

20 FSI @ 7.49	=	149.80
5 FS2 @ 8.22	=	41.10
		190.90 meters

Total volume of concrete = 0.943 × 190.90 = 180.02 cub meters (Drain holes neglected)

Reinforcements. plain bars. (see drawing no. 3) = 17.8912 kg tons.

Forms. 3 cm thick

Total width of form.

Slab, bottom = 5.50

Coping, sides 0.21
" 0.34
" 0.30
0.85 × 2 = 1.70
7.20 meters

Total area of form

	7.20 × 190.90	=	1374.48
Top of floor beams	55 @ 0.20 × 5.90	=	64.90
Top of Stringers	4 @ 0.125 × 190.90	=	95.45
			1214.13 sq. meters

Asphalt-block pavement asphalt-block 240 mm × 120 × 38 — 34 blocks per sq meter.

Total width of pavement = 5.50 meters

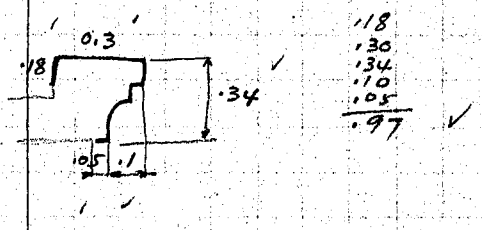
Total length " "

5 spans	@ 37.50	=	187.50
Overhangs 5	@ 0.55	=	2.75
			190.25 meters

Total area of pavement = 5.50 × 190.25 = 1,046.38 sq. meters
(Drain area neglected)

Cast iron drain 50 drains required.

Artificial granite finish



Total width of finishing = 2 @ .97 = 1.94 meters
Total length " " 190.90 "
Total area of finishing
1.94 × 190.90 = 370.35
Handrail post areas, less 310 posts @ .19 × .10 = - 5.89
364.46 sq. meters

Intermediate Lamps. 10 lamps with cast iron brackets.

Construction joints. 20 joints - 1.0 cm Elastite filling

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CALCULATIONS FOR

Materials of Nagabama-O-Hashi for Ekimae Ken.

Handrails.

Cast iron Grate.

HG1, HG2, HG3 & HG4.

Total area	(A) 79.0 × 118.0	=	9322
Hollow area less	(A_h) 70.0 × 101.8	=	− 7126
			2196 × 2.5 = 5490
Ornament add	(A_o) 70.0 × 1.7	=	119
" "	" 7.0 × 1.7 × 6	=	71
" "	" 1.5 × 1.5 × 12	=	27
			217 × 2.0 = 434
			5924 @ 0.00725 = 42.95 kg

HG5.

Total area	(A) 79.0 × 79.5	=	6281
Hollow area	less (A_h) 70.0 × 66.7	=	− 4669
			1612 × 2.5 = 4030
Ornament	add (A_o) 70.0 × 1.7	=	119
"	" 7.0 × 1.7 × 2	=	24
"	" 1.5 × 1.5 × 8	=	18
			161 × 2.0 = 322
			4352 @ 0.00725 = 31.55 kg.

HG6

	(A) 79.0 × 41.1	=	3247
less	(A_h) 70.0 × 33.4	=	− 2338
less	16.5 × 1.0	=	− 17
			892 × 2.5 = 2230 @ 0.00725 = 16.17 kg.

HG7

	(A) 79.0 × 36.5	=	2884
less	(A_h) 70.0 × 28.8	=	− 2016
"	5.0 × 1.0	=	− 5
			863 × 2.5 = 2158 @ 0.00725 = 15.65 kg

HG8.

	(A) 79.0 × 38.0	=	3002
less	(A_h) 70.0 × 30.3	=	− 2121
			881 × 2.5 = 2203 @ 0.00725 = 15.97 kg.

HG9.

	(A) 76.0 × 109.0	=	8284
less	(A_h) 67.5 × 92.8	=	− 6264
			2020 × 2.5 = 5050
add	(A_o)		426
			5476 @ 0.00725 = 39.70 kg.

HG10

	(A) 76.0 × 36.5	=	2774
less	(A_h) 67.5 × 28.8	=	− 1944
			830 × 2.5 = 2075 @ 0.00725 = 15.04 kg

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CALCULATIONS FOR

Materials of Nagahama-O-Hashi for Ehime Ken.

Cast iron post.

HP1.

post.		10.0 × 9.0	= 90.	
hollow	less	7.2 × 3.2	= −23	
depressions	"	2.9 × 5.0	= −15	
"	"	0.6 × 0.6 × 4	= −11	
			51 × 7.5 =	3825
base		10.0 × 19.0	= 190	
hollow	less	7.2 × 3.2	= −23	
			167 × 2 =	334
			4159 @ 0.00725 =	30.15 kg

HP3

post		6.0 × 9.0	= 54	
	less	2.9 × 2.5	= −7	
	"	0.6 × 0.6 × 4	= −1	
			46 × 7.5 =	3450
base		6.0 × 19.0	= 114	
		2.9 × 2.5	= −7	
			107 × 2 =	214
			3664 @ 0.00725 =	26.56 kg.

HP2.

Post.		10.0 × 9.0	= 90	
	less.	2.9 × 7.5	= −22	
	"	0.6 × 0.6 × 4	= −1	
			67 × 7.5 =	5025
base		10.0 × 19.0 × 2	=	380
			5405 @ 0.00725 =	39.19 kg

HP4.

Post.		Same as for HP1.		3825
base		14.0 × 20.0	= 280	
	less	7.2 × 3.2	= −23	
			267 × 2 =	534
			4359 @ 0.00725 =	31.60 kg.

HP5

post.		10.0 × 9.0	= 90	
	less	7.2 × 5.7	= −41	
	"	2.9 × 2.5	= −7	
	"	0.6 × 0.6 × 4	= −1	
			41 × 7.5 =	3075
base		14.0 × 20.0	= 280	
	less	7.2 × 5.7	−41	
			239 × 2 =	478
			3553 @ 0.00725 =	25.76 kg.

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CALCULATIONS FOR

Materials of Nagabama-O-Hashi for Ehime Ken.

Cast iron top rails.

Cross section. 7.0 × 2 × 0.9 = 12.6 ✓
9.5 × 0.9 = 8.6 ✓
6.7 × 0.9 = 6.0 ✓
27.2 @ 0.00735 = 0.1972 kg/lin cm. ✓

Top rails	Length		wt/cm		weight		ties		Total weight of top rail
TR1	124	cm @	0.1972	kg =	24.45	+	0.18	=	24.63 kg.
TR2	207.5	@	"	=	40.92	+	0.36	=	41.28
TR3	171	@	"	=	33.72	+	"	=	34.08
TR4	164.5	@	"	=	32.44	+	"	=	32.80
TR5	166.	@	"	=	32.74	+	"	=	33.10
TR6	115	@	"	=	22.68	+	0.18	=	22.86
TR7	155.5	@	"	=	30.66	+	0.36	=	31.02
TR8	120.5	@	"	=	23.76	+	0.18	=	23.94

Structural steel accessories.
Posts HP1 and HP2

Cap.	1Pl. 100 × 10 × 0.370 m	@	7.85	= 2.90 kg
Anchor bolts	2 − 16φ × 0.280	@	0.56	= 1.12
washer	1 Pl. 50 × 9 × 0.200	@	3.53	= 0.71
				4.73 kg for 1 Post.

Posts HP4 & HP5

Cap.	Same as for HP1.			= 2.90 kg
Anchor bolts	4 − 16φ × 0.060 m	@	0.22	= 0.88
				3.78 kg for 1 Post.

Screws and plugs as noted on drawing.

Summary for weight of Handrails.
Fixed span.

		Required no.		Casting		Steel accessories	Summary
Grate	HG1	30	@	42.95 kg	= 1288.50	—	
	HG2	78	@	"	= 3350.10	—	
	HG3	108	@	"	= 4638.60	—	
	HG4	84	@	"	= 3607.80	—	
	HG5	6	@	31.55	= 189.30	—	
	HG6	4	@	16.17	= 64.68	—	
	HG7	2	@	15.65	= 31.30	—	
	HG8	2	@	15.97	= 31.94	—	
					13202.22 kg	—	
				or	13.2022 kg tons	—	13.2022 kg tons
Post	HP1	304	@	30.15	= 9165.60	304 @ 4.73 = 1437.92	
	HP2	6	@	39.19	= 235.14	6 @ 4.73 = 28.38	
	HP3	4	@	26.56	= 106.24	—	
					9506.98 kg	1466.30 kg	
				or	9.5070 kg tons. +	1.4663 kg tons =	10.9733 kg tons

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CALCULATIONS FOR

Materials of Nagabama – O – Hashi for Shime ken.

Top rails.	Required no.				Castin	Steel accessories	Summary
TR1	286	@	24.63 kg	=	7044.18	—	
TR2	6	@	41.28	=	247.68	—	
TR3	4	@	34.08	=	136.32	— ✓	
TR4,	2	@	32.80	=	65.60	—	
TR5	2	@	33.10	=	66.20	—	
					7559.98 kg	—	
				or	7.5600 kg tons.	—	7.5600 kg tons.

Summary for fixed span.

Cast iron grates	13.2022
" " posts	9.5070
" " top rails	7.5600
	30.2692
Structural steel caps, bolts, washers etc	1.4663
	31.7355 kg tons.

Handrail for Bascule span.

Grates	Required no.				Castin	Steel accessories	Summary
HG9	28	@	39.70 kg	=	1111.60	—	
HG10	2	@	15.04	=	30.08	— ✓	
					1141.68 kg	—	
				or	1.1417 kg tons	—	1.1417 kg tons
Posts							
PH4	28	@	31.60		884.80	28 @ 3.78 kg = 105.84	
PH5	2	@	25.76		51.52	2 @ " = 7.56	
					936.32 kg	113.40 kg	
				or	0.9363 kg tons	+ 0.1134 kg tons =	1.0497 kg tons
Top rails							
TR6	24	@	22.86		548.64	—	
TR7	2	@	31.02		62.04	—	
TR8	2	@	23.94		47.88	— ✓	
					658.56 kg	—	
				or	0.6586 kg tons	—	0.6586 kg tons

Summary for Bascule span.

Cast iron grates	1.1417
" " posts	0.9363
" " top rails	0.6586
	2.7366
Structural steel caps, bolts, washers etc	0.1134
	2.8500 kg tons.

Total weight of handrails for the entire bridge

Fixed span	31.7355 kg tons
Bascule span	2.8500
	34.5855 kg tons

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CALCULATIONS FOR

Materials of Nagahama-O-Hashi for Ehime ken.

Light Pedestal. Stone facing. 土木産花崗石				
Base layer.	5 —	35 cm × 35 cm × 20 cm	=	0.123 cub.m.
	4 —	40 × 20 × 15	=	0.048
	1 —	35 × 30 × 20	=	0.021
1st, 2nd & 3rd layers	12 —	50 × 30 × 33	=	0.594
	6 —	40 × 33 × 12	=	0.095
4th layer	4 —	43.5 × 40 × 26	=	0.181
	2 —	40 × 35 × 12	=	0.034
5th, 6th, 7th & 8th layers	16 —	37.5 × 33.5 × 21	=	0.422
(5th & 7th)	4 —	33.5 × 33 × 12	=	0.053
(6th & 8th)	4 —	33.5 × 33 × 25	=	0.111
9th layer	1 —	50 × 50 × 23.5	=	0.059
10th & 11th layers	2 —	44 × 44 × 23.5	=	0.091
Top layer	1 —	44 × 44 23.5	=	0.045
				1.877 cub. meters
Concrete filling	1:2:4 mixture			
Total volume of light pedestal.				
Base layer.	1.10 m × 1.10 m × 0.20 m		=	0.242
	0.35 × 0.65 × 0.20		=	0.046
1st, 2nd & 3rd layers	1.00 × 1.00 × 1.00		=	1.000
4th layer	0.87 × 0.87 × 0.40		=	0.303
5th, 6th, 7th & 8th layers	0.75 × 0.75 × 1.35		=	0.759
9th layer	0.50 × 0.50 × 0.235		=	0.059
10th, 11th & top layers	0.44 × 0.44 × 0.715		=	0.138
				2.547 cubm
Volume of concrete filling		2.547 − 1.877	=	0.67
add hole in 9th layer		0.25φ × 0.235	=	0.01
				0.68 cub meter
4 Bronze lamps				
1 — 2"φ gas pipe with 4 — 1"φ branches.				
1 — 17 cm × 67.5 cm Bronze name plate				
4 — 11 × 11 Bronze ornaments				

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CALCULATIONS FOR

Materials of Nagahama-O-Hashi for Ehime Ken.

Counterweight. 82.500 kg tons required.

Total volume of counterweight
2.028 × 2.075 × 6.591 = 27.736 ✓

Structural steel $\frac{6.28 \text{ tons}}{7.850} = 0.800$ ✓

Reinforcements $\frac{1.7872}{7.850} = 0.228$ ✓

-1.028 ✓

26.708 ✓ cub meters

Total weight of cw't concrete required
82.500 kgs ✓

Steel 6.280
reinforcements 1.787
-8.067 ✓
74.433 ✓ kg

Unit weight of cw't. concrete $= \frac{74433}{26.708} = 2790$ ✓ kg/m^3

$7850x + 1700(1-x) = 2790$
$6150x = 1090$ ✓
$x = \frac{1090}{6150} = 0.177$ ✓ cub m @ 7,850 = 1,390 kg tons/m^3
$1-x = 0.823$ ✓

Counterweight concrete 26.708 cub.m. ✓
1:2 cement mortar 26.708 @ 0.823 = 21.980 cub. meters ✓
Steel punch scrap 26.708 @ 0.177 = 4.727 @ 7,850 = 37.107 kg tons.

Materials of counterweight

Steel scrap concrete 26.708 cub meters.
Reinforcements 1.7872 kg tons.
Cement mortar finish (1:2) 2×6.6 = 13.20 sq. m
Drain pipe 2 - 6.5 cmϕ - 1.10 m.

上記計算中 Cement mortar finish 1.5 cm 厚、モノ重量ハ餘猶トシテ保留ス.

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CALCULATIONS FOR

List of Materials for Nagahama-O-Hashi.

Pier no.1

volume of Concrete.

well. 2 × 6.60 × .40 = 5.280

Ends. 3.30φ 8.553
2.50φ 4.909
3.644

Partition 2 × .40 × 2.5 2.000
fillet. 4 @ .30 × .30 0.360
11.284 sq. meters

Volume 11.284 × 5.85 = 66.01 cubic meters

.75 meter upper section

Sides 2 × 6.60 × .25 = 3.300

Ends 3.30φ 8.553
2.80φ 6.158
2.395
5.695 sq. meters

Volume 5.695 × .75 = 4.27 cubic meters

Conical part of curb shoe.

Volume = $\frac{1}{3}h(B + b + \sqrt{Bb})$.

B = 3.644

b = 3.30φ 8.553
3.03φ 7.211
1.342

Vol = $\frac{.47}{3}(3.644 + 1.342 + \sqrt{3.644 \times 1.342})$ = 1.127

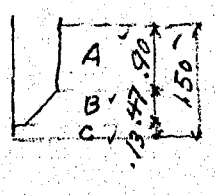
Vol. on sides 2 × .126 × 6.60 = 1.660
2.787

Summary for well shell and partition

.75 meter strip at top	4.27	
intermediate part	66.01	
curb shoe.	2.79	
	73.07	cubic meters.

Bottom filling 1:2:4 Concrete.

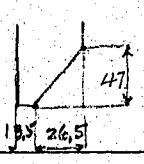
Volume of A:— Area between partition walls. 2.50 × 3.00 = 7.50
less fillets 2 × .3 × .3 = −0.18
7.32 Sq.m



Area both ends. 2@ 1.40 × 2.50 = 7.00
less fillets 2 × .3 × .3 = −0.18
6.820
4.909
11.729
7.320
Total Area = 19.049

Volume of A = 19.049 × .90 = 17.144 cub. m.

Volume of Part B:—
straight portion of sides $\frac{.265 \times .47}{2} \times 2 \times 6.60$ = 0.822
2.50φ × 0.47 × 6.60 = 7.755
8.577 cubic meters



Round ends.

Top Area 2.50φ 4.909 sq.m
Bottom Area 3.03φ 7.211 "

Volume = $\frac{.47}{3} \times (4.909 + 7.211 + \sqrt{4.909 \times 7.211})$ = 2.830 cubic meters

14.257 − 2.787 = 11.470 cubic meters

Summary for Part B on sides 8.577 use this figure
on ends 2.830
11.407 cubic meters

Check Total vol. 30.333 × 0.47 = 14.257 14.257 − 2.787 = 11.470 m³ use this figure

Volume Part C straight portion 3.30 × 6.60 = 21.780
Ends 3.30φ = 8.553
30.333

Volume = 30.333 × .13 = 3.943 cubic meters

Summary for Bottom Filling :—

Part A	17.144
Part B	11.470
Part C	3.943
	32.557 cubic meters

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CALCULATIONS FOR

List of Materials for Nagakawa-O-Hashi.

2

1:4:8 Concrete Fill. at both ends.

Volume = 11.729 × 4.95 = 58.06 cubic meters
中央部打設混凝土 7.32 × .10 = .73 " "
58.79 " "

Sand Fill between partition walls.

Volume = 7.32 × 4.95 = 36.23 cubic meters
less .73
35.50 " "

Concrete in shafts and strut.

Bottom. slab (inside filling) Area 2.8 ϕ 6.158
2.8 × 6.60 = 18.480
24.638

Volume A = 24.638 × .75 = 18.478 cubic meters

Shaft B. coping 2.20 ϕ 3.801
Volume = 2 × 3.801 × .30 = 2.280

Body 2.0 ϕ 3.142
Volume B = 2 × 3.142 × 1.252 = 7.867
10.147 cubic meters

Strut C plan area. 2 × 6.60 = 13.200
less 2.0 ϕ - 3.142
10.058

Average height say .35
Volume C = 10.058 × .35 = 3.520 cubic meters

Summary
A 18.478
B 10.147
C 3.520
32.145 cubic meters.

Summary of concrete in well and shafts
well 73.070
shafts and strut 32.145
105.215

Area of Forms.

Well lower section straight sides 2 × 6.60 + 2 × 4.60 = 22.40
both ends. 3.30 ϕ 10.37
2.50 ϕ = 7.85
Partition 4 × 1.90 = 7.60
fillets 8 × .42 = 3.36
Area 51.58 × 5.85 = 301.74 sq. meters

Well upper section straight sides 4 × 6.60 = 26.40
both ends. 3.30 ϕ = 10.37
2.80 ϕ = 8.80
Area 45.57 × 0.75 = 34.18

Around coping stone .30 high
straight sides 2 × 6.60 = 13.20
both ends - 2.0 ϕ 6.28
Area 19.48 × 0.30 = 5.84
Shafts. 2.0 ϕ Area 2 × 6.28 × .95 = 11.96
Copings 2.2 ϕ 2 × 6.91 × .30 = 4.15
Area under coping 2.2 ϕ - 2.0 ϕ 0.66 × 2 = 1.32
5.47
23.27
359.19 sq. meters

Coping Stone. 16 @ 0.30 × 0.30 × 0.825 = 1.188
8 @ 0.30 × 0.38 × 1.00 = 0.912
2.100 cubic meters.

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CALCULATIONS FOR

List of Materials for Nagahama-O-Hashi.

Reinforcing Bars in pier No 1. - 5.001 ✓ tons.

Structural steel in curb shoe - 2.972 ✓ tons.

Excavation. for well sinking below elevation -1.00 ✓ to -8.00 ✓ = 7.00 ✓ meters.
Total volume 30.33 ✓ × 7.0 ✓ = 212.31 ✓ cubic meters

Rock excavation .20 about.
Total volume 30.33 × 0.2 = 6.06 ✓ " "

Total depth of Sinking 7.20 ✓ meters.

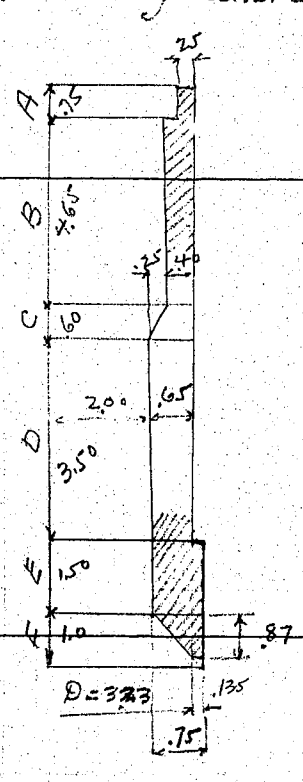
Summary list of Materials Pier No 1

1:2:4 Concrete (Velo.)	105.22 ✓ cubic meters	well and shaft.
1:2:4 Concrete fill.	32.56 ✓ "	Bottom Filling
1:4:8. Concrete fill	58.79 ✓ "	Intermediate Filling
Sand Fill	35.50 ✓ "	" "
Area of Forms	359.19 ✓ Sq meters	
Reinforcing Bars	5.001 ✓ tons	
Structural steel in curb shoe	2.972 ✓ "	
Coping stone on well	2.10 ✓ cubic meters	
Vol. of Excavation Sand	212.31 ✓ " "	
rock	6.06 ✓ " "	
Total depth of Sinking	7.20 ✓ meters.	

Pier No 2.

Volume of Concrete in well.

Volume of Part A ✓ same as pier No 1. 427 ✓ cubic meters. ✓



Volume Part B. 11.284 ✓ × 4.65 ✓ = 52.471 ✓ cubic meters

Volume Part C sides. 2 ✓ × .525 ✓ × .60 ✓ × 6.60 ✓ = 4.158 ✓ cubic meters
Partition 2 ✓ (.40 ✓ × 2.25 ✓ + .18 ✓) × .60 ✓ = 1.296 ✓
Round Ends. Bottom area 3.304 ✓ 8.553 ✓ Top Area 3.6444 ✓
2.00 ✓ 3.141 ✓
5.412 ✓

Vol. of ends. $\frac{.60}{3}$ ✓ (5.412 ✓ + 3.644 ✓ + $\sqrt{5.412 \times 3.644}$ ✓) = 2.698 ✓
Sides 4.158 ✓
partition 1.296 ✓
Part C Total 8.152 ✓ m^3

Volume Part D. sides 2 ✓ × .65 ✓ × 6.60 ✓ = 8.580 ✓ sq. m
round ends 5.412 ✓
Partition 2 × .40 × 2.0 + .36 = 1.960 ✓
15.952 ✓

Volume 15.952 × 3.50 = 55.832 m^3

Volume Part E sides 2 ✓ × .75 ✓ × 6.60 ✓ = 9.900 ✓ m^2
round ends 3.50 ✓ 9.621 ✓
2.00 3.141 ✓
6.480 ✓
6.480 ✓
16.380 ✓ m^2

Volume = 16.380 ✓ × 1.50 ✓ = 24.57 ✓
Volume Partition 2 ✓ × .40 ✓ × .65 ✓ × 2.00 = 1.024 ✓
25.61 ✓ cubic meters.

Volume Part F Straight sides $\frac{.885}{2}$ ✓ × 2 ✓ × 0.87 ✓ × 6.60 ✓ = 5.082 ✓ m^3

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CALCULATIONS FOR

List of Materials for Nagahama-O-Hashi.

4

round ends Bottom Area 3.50φ ✓ — 9.621 ✓ Top Area = 6.480 ✓
3.23φ ✓ — 8.194 ✓
1.427 ✓

Volume round ends = $\frac{.87}{3}$ ✓ (1.427 ✓ + 6.480 ✓ + $\sqrt{1.427 \times 6.480}$ ✓) = 3.172 ✓
straight side. 5.082 ✓
8.254 ✓ m³.

Summary Volume of well.

Part A	4.270 ✓		
B	52.471 ✓		
C	8.152 ✓	116.455 ✓	
D	55.832 ✓		
E	25.610 ✓	33.864 ✓	
F	8.254 ✓		

154.589 ✓ cubic meters.

Bottom Fill. depth. 2.50 meters. ✓

Outside Volume. ends 3.50φ — 9.621 ✓
sides 3.50 × 6.60 = 23.100 ✓
32.721 ✓ × 2.50 ✓ = 81.802 ✓
— (E+F) — 33.864 ✓
47.938 ✓ cubic meters.

Intermediate Concrete filling 1:4:8

Part D. Area straight portion 2 × 1.40 × 2.00 = 5.60 ✓
less fillet — 0.18 ✓
5.420 ✓
Circular ends. 2.00φ 3.141 ✓
8.561 ✓

Volume = 8.561 ✓ × 3.50 ✓ = 29.963 ✓ m³.

Part C straight portion 2 × 1.40 × 2.25 = 6.30 ✓
less fillets — .18 ✓
6.12 ✓ sq. meters

Volume = 6.12 ✓ × .60 ✓ = 3.672 m³

Round Ends.
Vol. 3.3φ 8.553 ✓ × .60 ✓ = 5.132 ✓
less. conical part — 2.698 ✓
2.434 ✓
3.672

Total. volume 6.106 cubic meters

Part B. straight portion 2 ✓ × 1.40 ✓ × 2.50 ✓ = 7.00 ✓
less fillets — .18 ✓
6.820 ✓
Round Ends. 2.50φ 4.909 ✓
11.729 ✓

Volume = 11.729 ✓ × 4.65 ✓ = 54.539 ✓ cubic meters.

Summary for concrete Fill. 1:4:8

Part D	29.963 ✓	
" C	6.106 ✓	
" B	54.539 ✓	
	90.608	cubic meters.
Add 掘削土	.73	
	91.338	" "

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CALCULATIONS FOR

5

List of Materials for Nagahama-Ō-Hashi.

Sand Filling between partition walls.

Part D. 2.0 × 3.0 = 6.00
less fillets −.18
5.83 × 3.50 = 20.405 m³

Part C 2.25 × 3.0 = 6.75
less −.18
6.57 × 0.60 = 3.942

Part B 2.50 × 3.0 = 7.50
less −.18
7.32 × 4.65 = 34038
58.385 cubic meters.
less −.73
57.655
32.145 cubic meters.
1.885
34.030
154.589
34.030
188.619 cubic meters.

Concrete in shaft &c Same as pier No 1.
Add 2 × 3.142 × 6.299 =

Summary for well and shafts. well shaft.

Area of Forms.

well Part D straight sides 2 × 6.60 + 2 × 4.60 = 22.40
both ends 3.30 ϕ 10.37
2.00 ϕ 6.28
Partition 4 × 1.40 5.60
fillets. 8 × 0.42 3.36
48.01 × 3.50 = 168.03

Part B straight sides 2 × 6.60 + 2 × 4.60 = 22.40
(Part C assumed same as B) both ends 3.30 ϕ 10.37
2.50 ϕ 7.85
Partition 4 × 1.90 7.60
Fillets 8 × 0.42 3.36
51.58 × 5.25 = 270.80

Part A
Around coping stone
Shafts 2.0 dia 2 × 6.28 × 1.25
Copings 2.2 dia
45.57 × 0.75 = 34.18
19.48 × 0.30 = 5.84
= 15.71
5.47
500.03 sq. meters

Coping stone same as pier No 1. 7.10 cubic meters.

Reinforcing Bars in Pier No 2 7.968 tons

Structural steel in curb shoe 10.680 tons

Excavation sand and gravel. below elevation −3.00
Base area 3.50 ϕ 9.621
3.50 · 6.60 = 23.100
32.721 × 9.80 = 320.66 cubic meters

Rock Excavation say 32.721 × .20 = 6.54 cubic meters

Total length of sinking say 10.0 meters.

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CALCULATIONS FOR

6

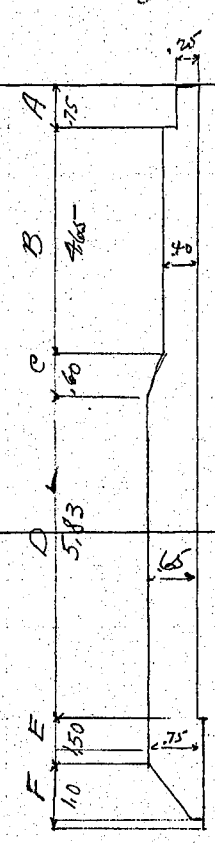
List of Materials for Nagahama-O-Hashi.

Summary List of Materials for Pier No 2.

Concrete Velocement 1:2:4	188.62 ✓ m^3	well and shaft
" Fill 1:2:4	47.94 ✓ m^3	Bottom Filling
" " 1:4:8	91.34 ✓ "	Intermediate Filling
Sand Fill	57.66 ✓ "	" "
Forms	500.03 ✓ m^2	
Rinforcing Bars	7.968 ✓ tons	
Structural steel in curb shoe	10.680 ✓ "	
Coping stone on well.	2.10 ✓ m^3	
Vol. of Excavation Sand	320.66 ✓ "	
" " " Rock	6.54 ✓ "	
Total length of Sinking	10.00 ✓ m	

Pier No 3.

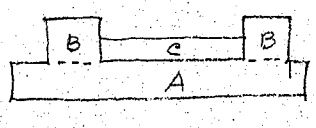
Volume of Concrete in well.



Volume Part A same as Pier No 2	4.270 ✓	cubic meters
Volume Part B same as Pier No 2	52.471 ✓	cubic meters
Volume Part C same as Pier No 2	8.152 ✓	cubic meters
Volume Part D 15.952 ✓ × 5.83 ✓ =	93.000 ✓	cubic meters
Volume Part E same as Pier No 2	25.610 ✓	" "
Volume Part F same as Pier No 2	8.254 ✓	" " } 33.864 ✓
	191.757 ✓	" "
Bottom Fill same as Pier No 2	47.938 ✓	cubic meters

Intermediate Concrete Filling 1:4:8			
Volume Part D	8.561 ✓ × 5.83 ✓	=	49.911 ✓ cubic meters
Volume Part C	same as Pier No 2		6.106 ✓ " "
Volume Part B	" " " "		54.539 ✓ " "
	捨流凝土		110556 ✓ " "
			+ .73 ✓
			111.286 ✓
Intermediate Sand Filling			
Volume Part D	5.83 ✓ × 5.83 ✓	=	33.989 ✓ cubic meters
" " C	Same as Pier No 2		3.942 ✓ " "
" " B	" " " "		34.038 ✓ " "
	捨流凝土		71.969 ✓ " "
			- .73 ✓
			71.239 ✓

Concrete in shafts and strut.



Bottom slab inside filling A	Same as Pier No 1.	=	18.478 ✓ cubic meters.
Shaft B			
Coping 2.7φ Volume =	2 ✓ × 5.726 ✓ × .30 ✓ = 3.436 ✓		
body 2.5φ Volume =	2 ✓ × 4.909 ✓ × 1.65 ✓ = 16.200 ✓		
			19.636 ✓ " "

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CALCULATIONS FOR

7

List of Materials for Nagahama-O-Hashi.

Strut C Plan area 2.50 × 6.60 = 16.500 ✓
less 2.50φ 4909 ✓
11.501 ✓

Volume = 11.501 ✓ × .35 ✓ = 4.025 ✓ cubic meters

Summary

Part A	18.478 ✓	well	191.757
" B	19.636 ✓	shaft	42.139 ✓
" C	4.025 ✓		233.896
	42.139 ✓ cubic meters.		

Area of Forms.

Well
Part D 48.01 ✓ × 5.83 ✓ = 279.90 ✓
Part B and C (C assumed same as B) Same as pier No 2 ✓ = 270.80 ✓ } 584.88
Part A Same as pier No 2 ✓ = 34.18 ✓

Around coping stone .30 high ✓
Straight sides 2 × ✓ 6.60 ✓ = 13.20 ✓
Ends. 2.5φ 7.85 ✓
21.05 ✓ × .30 ✓ = 6.32 ✓

Shafts. 2.5φ ✓ 2 × ✓ 7.85 ✓ × 1.35 ✓ = 21.19 ✓
coping 2.7φ 2 × ✓ 8.48 ✓ × 0.30 ✓ = 5.09 ✓
under coping 2.7φ − 2.5φ 0.82 ✓ × 2 ✓ = 1.64 ✓
6.73 ✓
619.12 ✓ sq. meters.

Coping stone
16 ✓ @ 0.30 ✓ × 0.25 ✓ × 0.825 ✓ = 0.990
12 ✓ @ 0.30 ✓ × 0.30 ✓ × 0.80 ✓ = 0.864
1.854 cubic. meters.

Reinforcing Bars in Pier No 3. 9.569 ✓ tons.

Structural steel in curb shoe 10.680 ✓ tons

Excavation Sand and gravel. below elevation −3.00 Base Area = 32.721 ✓
Volume = 32.721 ✓ × 12.13 ✓ = 396.91 ✓ cubic meters

Rock = 32.721 ✓ × 0.20 ✓ = 6.544 ✓ " "

Total depth of well sinking 15.33 − 3.0 = 12.33 ✓ meters.

Summary List of Materials for Pier No 3.

Concrete 1:2:4 Velo cement.	233.90 ✓	m^3 well and shafts
Concrete 1:2:4 bottom fill.	47.94 ✓	"
Concrete 1:4:8 Interm. fill.	111.29 ✓	"
Sand fill " "	71.24 ✓	"
Forms	619.12 ✓	m^2
Reinforcing Bars	9.569 ✓	tons
structural steel in curb shoe	10.680 ✓	tons
Volume of excavation Sand	396.91 ✓	m^3
" " " rock	6.54 ✓	"
Depth of sinking	12.33 ✓	meters
Coping stone	1.85 ✓	cubic meters

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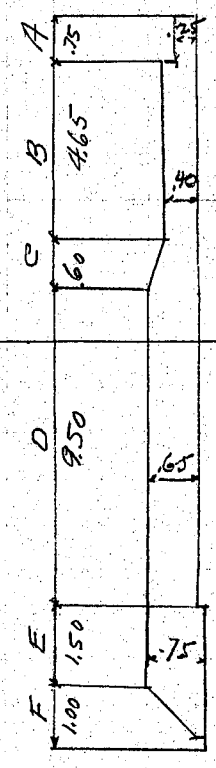
CALCULATIONS FOR

8

List of Materials for Nagahama-O-Hashi.

Pier No 4

Volume of Concrete in well.



Volume Part A same as Pier No2 = 4.270 ✓ cubic meters
Volume Part B " " " " = 52.471 ✓ " "
Volume Part C " " " " = 8.152 ✓ " "
Volume Part D 15.952 × 9.50 = 151.544 ✓ " "
Volume Part E same as Pier No2 = 25.610 ✓ " " } 33.864
Volume Part F " " " " = 8.254 ✓ " "
250.301 ✓ " "

Bottom Fill 1:2:4 concrete same as Pier No2 47.938 ✓ cubic meters.

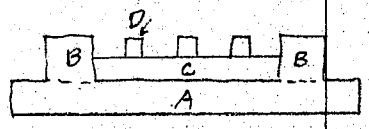
Intermediate Concrete Filling 1:4:8 ✓
Volume Part D 8.561 ✓ × 9.50 ✓ = 81.330 ✓ cubic meters
Volume Part C same as Pier No2 = 6.106 ✓ " "
Volume Part B " " " " = 54.539 ✓ " "
Volume ½ Concrete under slab = 0.730 ✓ " "
142.705 ✓ " "

Intermediate Sand filling

Volume Part D 5.83 ✓ × 9.50 ✓ = 55.385 ✓ cubic meters
" " C same as Pier No2 = 3942 ✓ " "
" " B " " " " = 34.038 ✓ " "
93.365 ✓ " "
less ½ Concrete - 0.730 ✓ " "
92.635 ✓ " "

Concrete in shafts and strut.

Bottom slab filling A same as Pier No1 = 18.478 ✓ cubic meters.



Shafts B
coping 2.7φ V = 2 × 5.726 ✓ × .30 ✓ = 3.436 ✓
body 2.5° V = 2 × 4.909 ✓ × 1.65 ✓ = 16.200 ✓
19.636 ✓ " "

Struts Plan area 2.50 ✓ × 6.60 ✓ = 16.500 ✓
less 2.50φ ✓ - 4.909 ✓
11.501 ✓ sq.m
Volume = 11.501 ✓ × 0.30 ✓ = 3.450 ✓ cubic meters

Intermediate body - Plan area. say 1.90 ✓ × 4.40 ✓ about = 8.36 ✓ sq.m
Volume = 8.36 ✓ × .75 ✓ = 6.270 ✓ cubic meters

Coping proper Plan area say 2.10 ✓ × 4.5 ✓ about = 9.45 ✓ sq.m
Volume = 9.45 ✓ × .35 ✓ = 3.308 ✓ cubic meters.

Summary for struts
Lower strip 3.450 ✓
body 6.270 ✓
coping 3.308 ✓
13.028 ✓ cubic meters.

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CALCULATIONS FOR

9

List of Materials for Nagahama-O-Hashi.

Part D 3 × 0.5 × 0.5 × .60 = 0.450 cubic meters

Summary for shafts and strut.

Part A	18.478	
" B	19.636	
" C	13.028	
" D	0.450	
	51.592	cubic meters.

Summary for well and shaft

well	250.301	
Shafts + c	51.592	
	301.893	cubic meters.

Area of Forms.

Well.

Part D	48.01 × 9.50	=	456.09
Parts B and C	same as pier No 2	=	270.80
Part A	" " "	=	34.18
Around coping stone	same as 1st pier No 2	=	6.32
Shafts and Coping	21.19 + 6.73 = 27.92		
	less strut. say	-	4.40
			23.52
Strut approx.	2 × 1.15 × 4.90	=	11.27
Bearing Blocks	3 × 1.2 m²	=	3.60
			805.78 square meters.

805.78

Coping Stone same as Pier No 3 1.854 cubic meters.

Reinforcing Bars in Pier No 4 14.212 tons

Structural steel in curb shoe 10.680 tons.

Excavation Sand and gravel. below elevation -3.00

Volume = 32.721 × 15.80 = 516.99 cubic meters

Rock .20 about Volume. 6.54 " "

Depth of well sinking 19.00 - 3.00 = 16.0 meters

Summary List of Materials for Pier No 4

Concrete	1:2:4	Velo	301.89 cubic meters well and shafts
Concrete	1:2:4	bottomfill	47.94 " "
Concrete	1:4:8	Interm. fill	142.71 " "
Sand Fill			92.64 " "
Forms			805.78 Sq. meters
Reinforcing Bars			14.212 tons
Structural steel in curb shoe			10.680 tons
Excavation	Sand and gravel		516.99 cubic meters
	rock		6.54 " "
Depth of sinking			16.00 meters
Coping stone			1.85 cubic meters.

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CALCULATIONS FOR

10

List of Materials for Nagahama-O-Hashi.

Pier No 5. details similar to Pier No 3.

Volume of Concrete in well. = 191.757 ✓ cubic meters.

Bottom Fill same as Pier No 3 47.938 ✓ " "

Intermediate Concrete Filling 1:4:8 111.286 ✓ " "

Intermediate Sand Filling 71.239 ✓ " "

Concrete in shafts and strut

same as pier No 3 ✓ 42.139 ✓

Add Bearing block 2×.80×1.30×.285 = .593 ✓

42.732 ✓ " "

Volume of Concrete in well and shafts = 191.757 ✓
42.732 ✓
234.489 ✓

Area of Forms same as pier No 3 619.12 ✓
add 2 @ 1.20 for bearing block 2.40 ✓
621.52 ✓ sq. meters.

Reinforcing Bars. 9.602 ✓ tons

Structural steel in curb shoe 10.680 ✓ tons

Excavation sand and gravel. 396.91 ✓ cubic meters
6.544 " "
403.454 " "

Depth of well sinking 12.33 ✓ meters.

Coping stone 1.854 cubic meters.

Summary List of Materials for Pier No 5

Concrete	1:2:4	Velo	234.49 ✓ m^3 well and shafts
"	"	Neat bottom fill	47.94 ✓ "
"	1:4:8	Interm. fill	111.29 ✓ "
Sand Fill			71.24 ✓ "
Forms			621.52 ✓ m^2
Reinforcing bars			9.602 ✓ tons
Structural steel in curb shoe			10.680 ✓ tons
Excavation sand & gravel			403.45 ✓ m^3
Depth of well sinking			12.33 ✓ meters
Coping stone			1.85 ✓ m^3.

Pier No 6 details same as Pier No 5 except shaft.

Volume of Concrete in well. = 191.757 ✓ cubic meters
Bottom Fill = 47.938 ✓ " "
Intermediate concrete filling = 111.286 ✓ " "
Intermediate sand filling = 71.239 ✓ " "

Concrete in shafts and strut similar to Pier No 1.
shafts and strut pier No 1. 32.145 ✓
add 2 × 3.142 × .173 = 1.085 ✓
33.230 ✓ cubic meters

well. 191.757 ✓
shaft 33.230 ✓
224.987 cubic meters

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CALCULATIONS FOR

List of Materials for Nagahama-O-Hashi.

Pier No 6

Area of Forms. well. same as Pier No 3. ✓ 584.88 ✓ sq. m
Shafts same as Pier No 1 23.27 ✓
add. 2 × 6.28 × 1.73 2.17 ✓
25.44 ✓
610.32 ✓ sq. m.

Reinforcing Bars 9.438 ✓ tons
Structural steel in curb shoe 10.680 ✓ tons

Excavation sand and gravel. 403.454 ✓ cubic meters same as pier No 5

Depth of well sinking 12.33 ✓ meters " " " "

Coping stone same as pier No 1. 2.10 ✓ cubic meters.

Summary List of Materials for Pier No 6

Concrete	1:2:4	velo	224.99 ✓ cubic meters
Concrete	1:2:4	bottom fill	47.94 ✓ " "
Concrete	1:4:8	Intermediate fill	111.29 ✓ " "
Sand Fill.			71.24 ✓ " "
Forms			610.32 ✓ sq. "
Reinforcing Bars			9.438 ✓ tons
Structural steel in curb shoe			10.680 ✓ tons
Excavation sand and gravel			403.45 ✓ cubic meters
Depth of well sinking			12.33 ✓ meters
Coping stone			2.10 ✓ cubic meters

Materials for Pier Fenders

Wooden Piles	5 @ 21φ × 11.0 m				
	2 @ 21φ × 8.5 m				
Wales	9 @ 25 × 10 × 6.5 m	=	9 @ 0.163	=	1.467
"	4 @ 25 × 10 × 5.0 m	=	4 @ 0.125	=	0.500
"	12 @ 25 × 10 × 2.2 m	=	12 @ 0.055	=	0.660
Struts	4 @ 20 × 20 × 3.5 m	=	4 @ 0.140	=	0.560

3.187 cubic meters

Bolts. 22φ mm

65 - 22φ	× 40 cm	@	1.78	=	115.70
10 - 22φ	× 55"	@	2.27	=	22.70
2 - 22φ	× 80"	@	3.00	=	6.00
77					144.40 Kgs.

2 Fenders Required thus.

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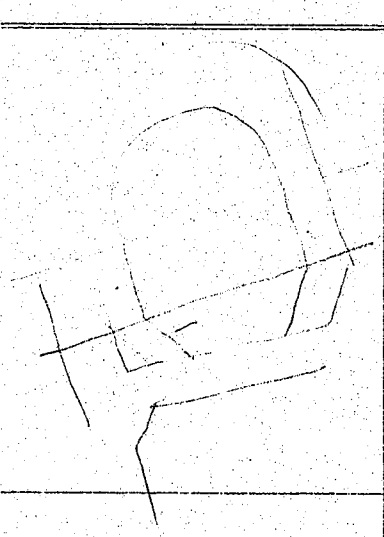

7.20

3.64 x

60

6.60

40
13
27

check 11.284 × .90 = 10.02 ✓
2.787
12.807 ✓
32.557
45.364

32557

3.3 × 6.60 = 21.78

30.333 × 1.5
5166
45.499

11.284

7.32
6.82
4.909
19.049
11.284
30.333

B — 10.770
2.79
13.560

30.333 × .47 = 14.25

8.553 × .47 = 4020

33 × 6.6 × .47 = 10.22

2,193
1 127
3.320

14257
1,127
3.13

2.83
1,127
3.957

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12.31
1.36
13.67

Velo concrete -	well + shaft —	171.00	12.
"	1:2:4 Bottom fill —	48. —	12.31
	148 —	91.	777
	Sand.	60 —	
	form	500	
	Reinf.	7,968	
	Curb shoe	10,680	
	Coping —	2.07	

15.33
3
12.33

11.83
6
5.83

38
.3
11.4

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CALCULATIONS FOR

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愛媛縣 長濱大橋 可動部機械裝置

昭和八年一月

設計々算書

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(1m)

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CALCULATIONS FOR

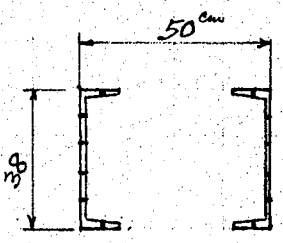
Machinery Design of Nagahama-O-Hashi for Ehime Ken.

Design of link.

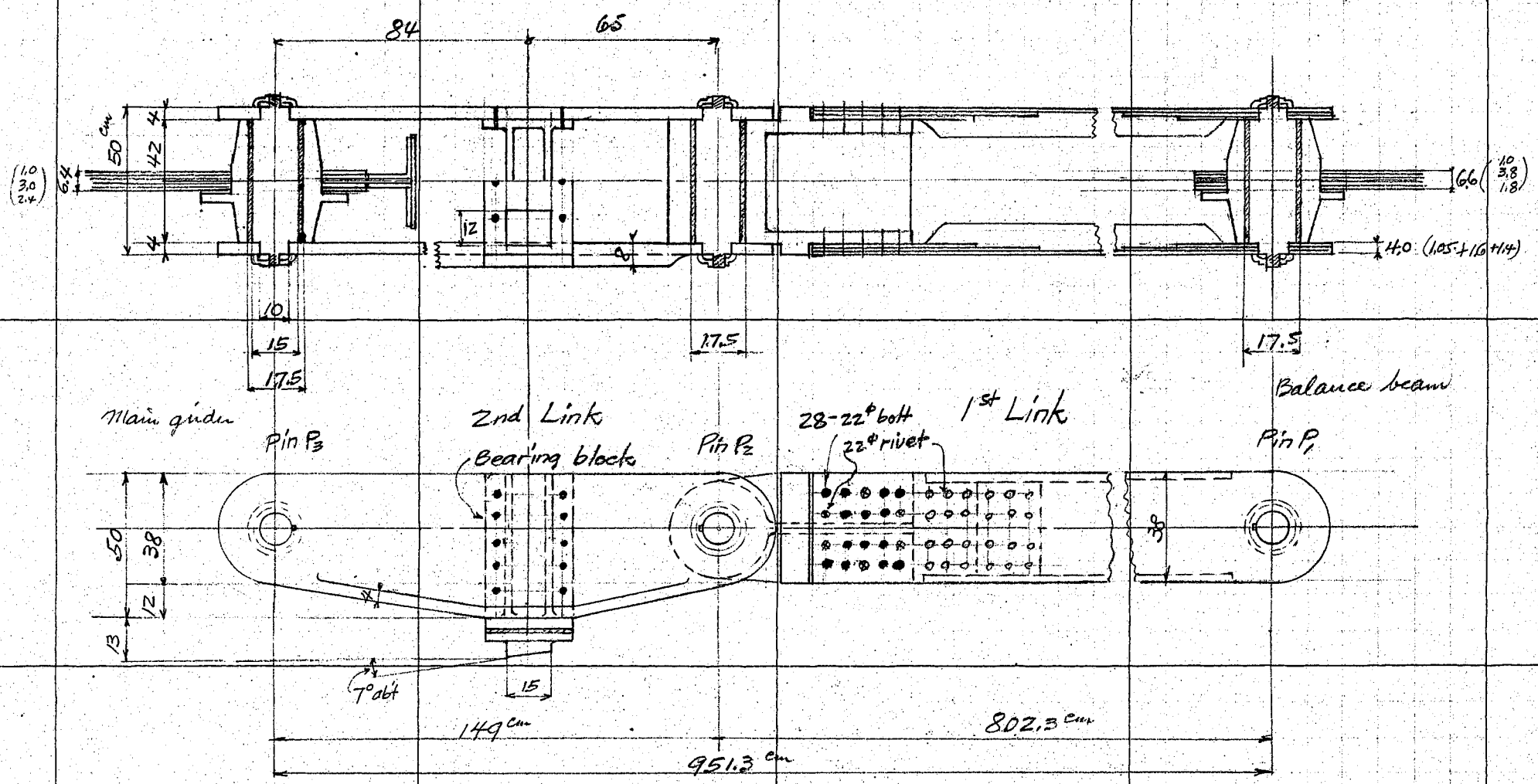
Max. stress of link due to Dead Load = 79900 See on page 66B
30% impact = 24000
103900 kg for 2 links

Stress on one link = 103900 ÷ 2 = 52000 kg in round number.

Sectional area required = $\frac{52000}{1200}$ = 43.4 cm² net



Use 2 [S 380 × 100 × 10.5 @ 54.5 kg = 138.78 − 31.7 = 107.08 cm² net.

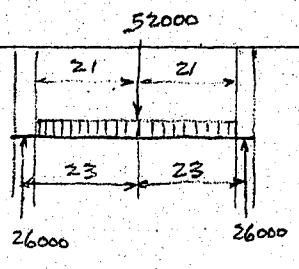


Sketch of link scale 1:20

Design of Pins P1, P2 and P3.

Link stress = 52000 kg on one link

Splice bolt no. $\frac{52000}{2090}$ = 25. use 28-22φ turned bolts for one links



Moment on pin

Distributed load = $\frac{52000}{42}$ = 1240 kg/cm

Moment M: 26000 × 23 = 598,000
$\frac{1}{2}$ × 1240 × 21² = 273000
325,000 kg cm

Use 15 cmφ pin

resisting moment = 0.0982 S d³ for S = 1,000 kg/cm²
= 0.0982 × 1000 × 15³
= 331,000 kg cm > M

Diameter of bushing for average bearing value of 100 kg/cm²

Bearing area required = $\frac{52000}{100}$ = 520 cm²

For length of bushing 42 cm,

Diameter of Bushing = $\frac{520}{42}$ = 12.4 cm required < 15

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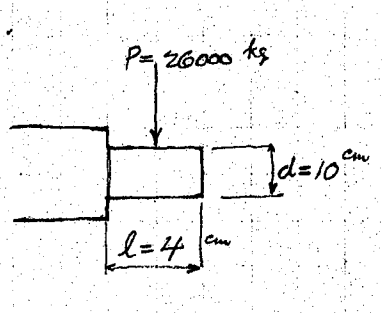
CALCULATIONS FOR

Machinery Design of Nagatsuma -O- Bashi for Ehime Ken.

Bearing of pin on link

max. load = 26000 kg on one end.



$$\text{Moment} = \frac{Pl}{2} = \frac{2SI}{d} = \frac{\pi d^3}{32} S$$

$$d = \sqrt[3]{\frac{16Pl}{\pi S}} = 1.720 S \sqrt[3]{\frac{Pl}{S}}$$

$$= 0.172 \sqrt[3]{Pl} \quad \text{for } S = 1000 \text{ kg/cm}^2$$

$$d = 0.172 \sqrt[3]{26000 \times 4} = 8.09 \text{ cm}$$

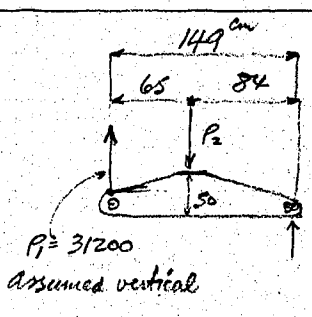
Use 10 cm dia.

Bearing stress = $\frac{26000}{10 \times 4} = 650 \text{ kg/cm}^2 < 1000$

Shearing stress = $\frac{26000}{78.54} = 330$ " < 550

Section of 2nd link

Direct tension on link = 52000 kg bridge closed.
Pull on pin 24000 × 1.3 = 31200 " " opened



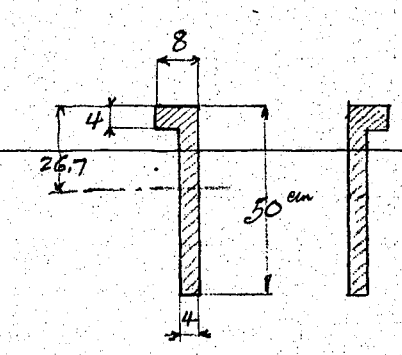
Section required for direct tension = $\frac{52000}{850} = 61.2 \text{ cm}^2$ net

$P_1 = 31200$ kg assumed to be perpendicular to link.

$P_2 = 31200 \times \frac{149}{84} = 55400$ kg.

moment = 31200 × 65 = 2,030,000 kg cm

Section modulus req'd. = $\frac{2030000}{1000} = 2030 \text{ cm}^3$



Assumed section at center of 2nd link

50 × 4 =	200	× 25 =	5000
4 × 4 =	16	× 48 =	768
	216	26.7	5768

for one link 432 cm²

Moment of inertia

$\frac{4 \times 50^3}{12} + 200 \times 1.7^2 = 41640 + 580 = 42220$

$\frac{4 \times 4^3}{12} + 16 \times 24.7^2 = 20 + 9760. = 9780$

52000

for one link $I = 2 \times 52000 = 104000 \text{ cm}^4$

Section modulus = $\frac{104000}{26.7} = 3900 \text{ cm}^3$

max. fibre stress = $\frac{2030000}{3900} = 520 \text{ kg/cm}^2 < 1000$ ✓

Bearing Block at center of 2nd link

Bearing area required = $\frac{55400}{1000} = 55.4 \text{ cm}^2$

Use Bearing surfaces 2 — 15×12 = 320.0 cm²

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CALCULATIONS FOR

Machinery Design of Nagahama — O — Hashi for Ebisuura Ken.

Design of Balance beam trunnion.

Max. load on trunnion shaft.

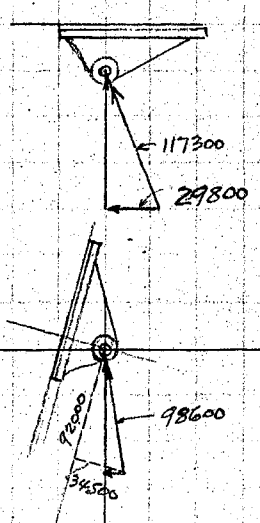
Bridge closed.

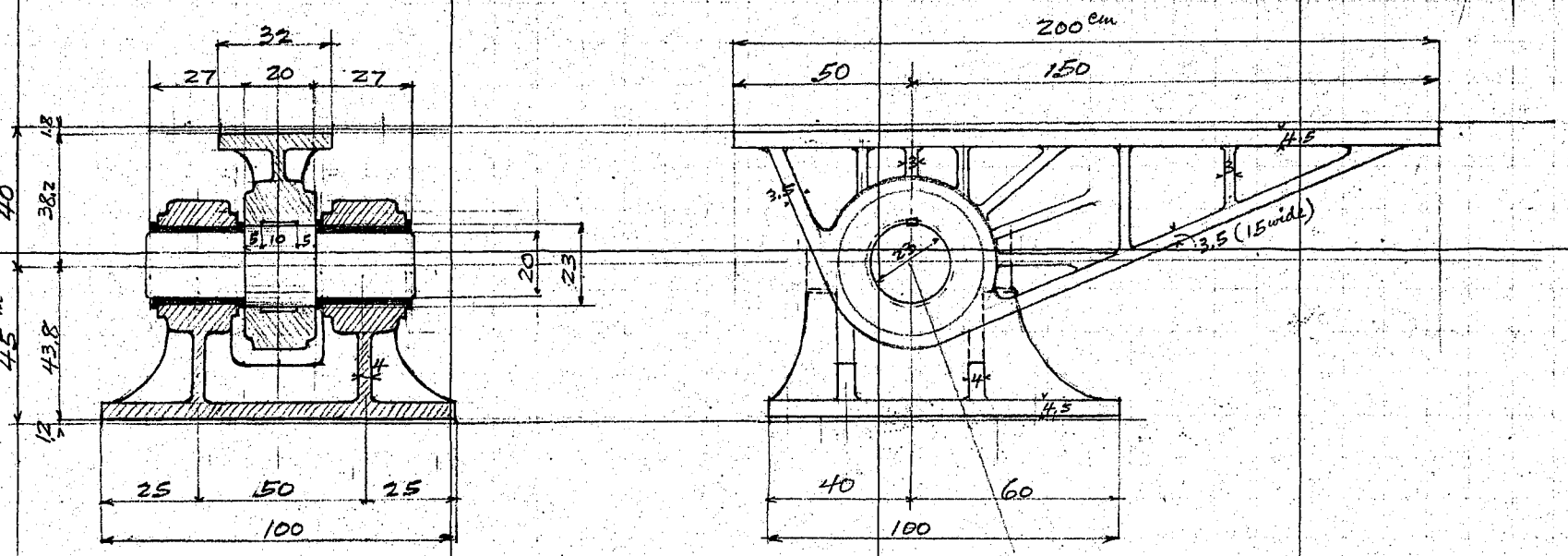
		30% imp	Total load	
Vertical load	87200	26200	113400	kg
Horizontal "	22900	6900	29800	"
Resultant "	90200	27100	117300	"

Bridge opened.

Vertical load	75600	22700	98300	kg
Horizontal "	5700	1700	7400	"
Resultant "	75800	22800	98600	"

Shear between balance beam and boss 92000 kg





Scale 1:20.

Bearing area required for Phosphor Bronze bushing = $\frac{117300}{140}$ = 838 cm^2

use 2-Bronze bushings @ 20 cmϕ × 27 cm = 1080 cm^2

average bearing pressure = $\frac{117300}{1080}$ = 109 kg/cm^2

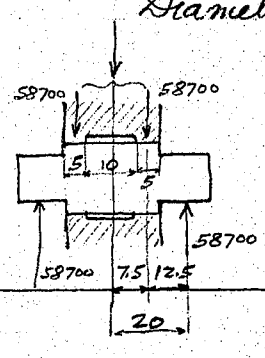
Shaft.

Diameter at both ends.

$d = 0.172\sqrt[3]{Pl} = 0.172\sqrt[3]{58700 \times 27} = 20.0$ cm Use 20 cmϕ

Shearing stress on shaft = $\frac{58700}{314.2}$ = 187 kg/cm^2

Diameter at center



moment = 58700 × 12.5 = 734000 kg.cm

Use 23 cmϕ shaft of which resisting moment = $0.0982 \times S d^3$

$= 0.0982 \times 1000 \times 23^3$

= 1,195000 kg.cm

Anchor bolt required for Boss.

= $\frac{92000}{2090}$ = 44 - 22ϕ turned bolts.

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(4m)

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MADE BY K. Inaba DATE 7-12-17 FILE NO.
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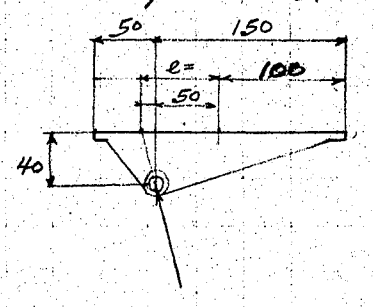
CALCULATIONS FOR

Machinery Design of Nagahama-①-Hashi for Ehime Ken.

Bearing pressure between boss and balance beam.
Bridge closed.



Vertical load = 113400 kg

Eccentricity

$40 \times \frac{29800}{113400} = 10.5$

50.0

$e = 60.5$ cm

Toe pressure $= \frac{113400}{32 \times 200}\left(1 \pm \frac{6 \times 60.5}{200}\right)$

$= 49.9$ kg/cm² C

or 14.4 " T

Bearing

Anchor bolts required for horizontal thrust.

$\frac{29800}{2090} = 14.3$ Use 20- 22φ turned bolts.

Bearing pressure between base of bearing and tower top.

Bridge closed Vertical load = 113,400 kg

Eccentricity

$45 \times \frac{29800}{113400} = 11.8$

-10.0

1.8 cm

Bridge opened. Vertical load = 98300 kg

Eccentricity

$45 \times \frac{7400}{98300} = 3.4$

-10.0

-6.6 cm

max. toe pressure $\frac{113400}{100 \times 100}\left(1 \pm \frac{1.8 \times 6}{100}\right) = 12.6$ or 10.1 kg/cm² C

$\frac{98300}{100 \times 100}\left(1 \pm \frac{6.6 \times 6}{100}\right) = 13.7$ or 5.9 " "

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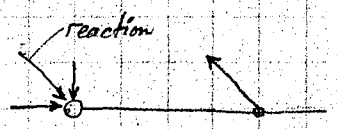
CALCULATIONS FOR

Machine Design of Nagahama-Ō-Hashi for Ebine Ken.

Design of Main trunnion.

Dead load on trunnion shaft. (See on page 87)

			30% imp.	Total load.
Bridge at start of opening operation	Vertical load.	−5400 kg	−1600	−7000 kg
	horizontal "	22800	6800	29600 "
	resultant "	23400	7000	30400 "
Bridge at start of closing operation against 50 kg wind	vertical load	4400	1300	5700 "
	horizontal load	6500	2000	8500 "



Wind load. (See page 80) 50 kg/m² wind

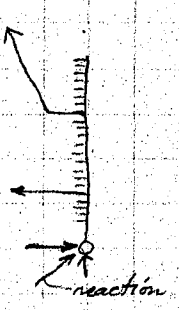
$\frac{50 \times 124 \times 9.46}{148 \times 2}$ = 19900 kg

50 × 124 ÷ 2 = −3100

16700
8500

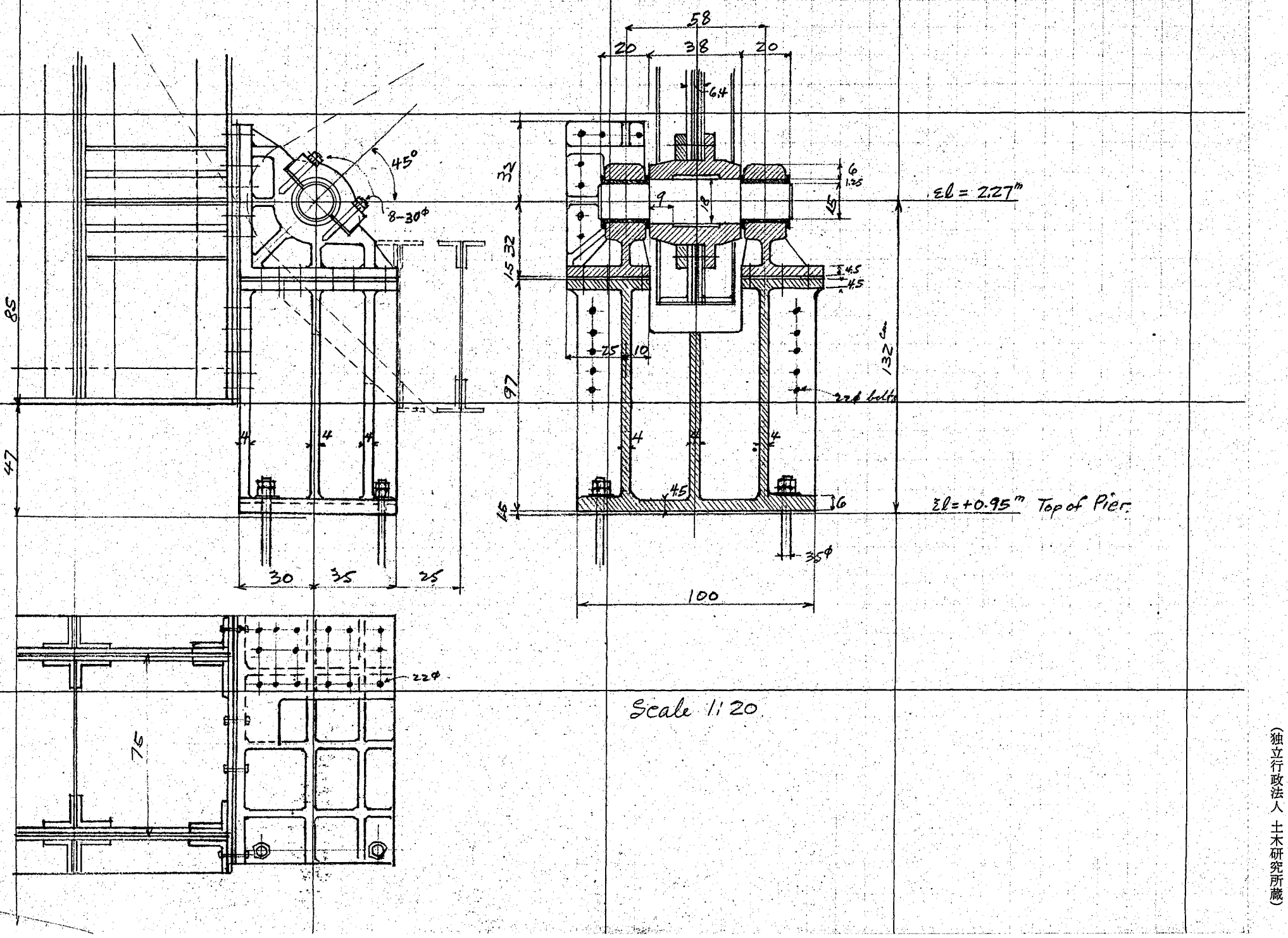
Summary of horizontal load = 25200

Resultant load = $\sqrt{5700^2 + 25200^2}$ = 25800 kg



Bridge fully opened and subject to 100 kg wind

Vertical load 4400 kg
horizontal load 6500
wind load 16700 × 100/50 = 33400
39900 "
Resultant load = $\sqrt{4400^2 + 39900^2}$ = 40200 "



Scale 1:20

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(6m)

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CALCULATIONS FOR

Machine Design of Nagahama-O-Hashi for Ebime Ken.

Bearing area of Bronze bushing required = $\frac{40200}{100} = 402\ cm^2$

Length of bushing $2 \times 20 = 40$ Diam. of shaft at ends = $\frac{402}{40} = 10.1\ cm$

Use 15 cm ϕ.

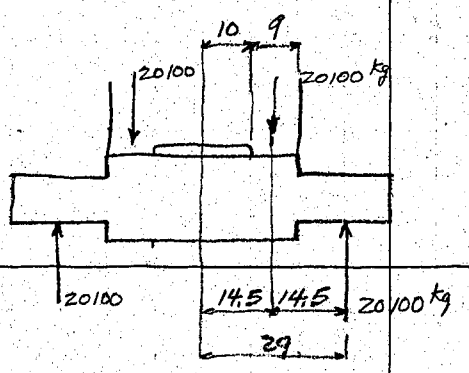
Diameter of shaft at ends req'd. for moment

$d = 0.172\sqrt[3]{20100 \times 20} = 12.7\ cm$

15 cm ϕ shaft is ample.

Shear stress = $\frac{20100}{143.1} = 141\ kg/cm^2$

Diameter of shaft at center req'd. for moment.



Max. bending moment on shaft = 20100×14.5
= 291000 kg cm

Try 18 cm ϕ shaft.

for allowance of 2 key ways dia. of shaft reduced 4%
equivalent solid shaft dia = $18 \times 0.96 = 17.3\ cm\ \phi$

Resisting moment = $0.098 z \times 1000 \times 17.3^3 = 508{,}000\ kg\ cm$

Bearing width of boss on shaft req'd.

= $\frac{40200}{1000 \times 18} = 2.24\ cm$

use 2 @ 9 = 18 cm.

Anchor bolts for Bearing

max. horizontal thrust 39900 kg

22 ϕ bolt no = $\frac{39900}{2090} = 19$ use 20 bolts.

Stud bolts for bearing caps.

use 8 – 30 ϕ bolts.

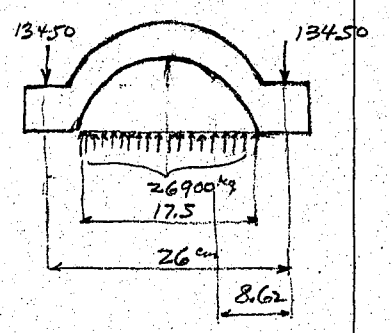
net area at bottom of screw thread = $27^\phi = 5.73\ cm^2$ net

Capacity of 1 bolt = 5.73 @ 850 = 4870 kg

Capacity of cap for pull = 8 @ 4970 = 39800 kg

Max. hor. pull = 33400 – 6500 = 26900 kg.

Thickness of Bearing cap.



max. normal pull assumed 26900 kg

width of cap assumed 17 cm × 2 = 34 cm

moment = 13450 × 8.62 = 116000 kg cm.

Section modulus required for fibre stress of 850 kg/cm²

Sm, required = $\frac{116000}{850} = 136.4\ cm^3$

Use 6 cm thickness.

Sm, = $\frac{17 \times 2 \times 6^2}{6} = 204\ cm^3$.

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(7m)

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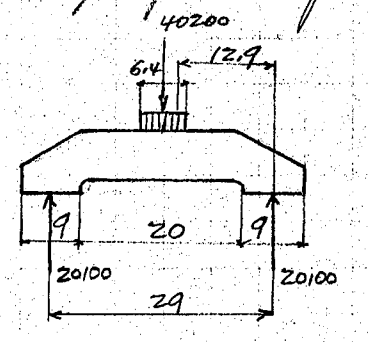
CALCULATIONS FOR

Machine Design of Nagaloma-Ō-Hashi for Ehime ken

Design of Boss of main trunnion.



max. load = 40200 kg.

let us assume the max. load to be taken care of by a flat beam 35cm wide.

moment = 20100 × 12.9 = 259000 kg cm.

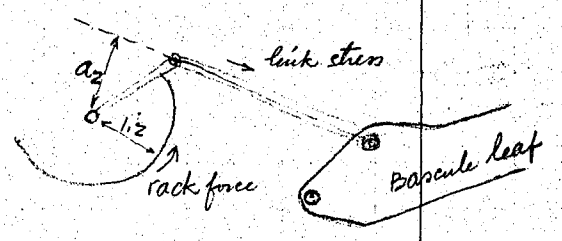
Sm. required = $\frac{259000}{850}$ = 305 cm^3

Use 7.5 cm thickness

Sm = $\frac{35 \times 7.5^2}{6}$ = 328 cm^3

Design of Operating link.

$$\text{Stress in operating} = \frac{\text{Rack force} \times 1.2}{a_2}$$



Max. Rack force for Dead load and 50 kg wind load for 2 links (see on page 90)

Angle of opening	During opening operation: Rack force		a_2		link stress		Angle of closing	During closing operation: Rack force		a_2		link stress	
0°	5940	×1.2 ÷	0.28	=	25500	kg T	90°	500	×1.2 ÷	0.28	=	2140	kg T
10°	9000	× " ÷	0.87	=	12400	T	80°	−1980	× " ÷	0.87	=	2730	kg C
20°	8640	× " ÷	1.15	=	9000	T	70°	−8520	× " ÷	1.15	=	8900	" C
28°	8190	× " ÷	1.32	=	7450	T	62°	−16730	× " ÷	1.32	=	15200	" C
30°	10170	× " ÷	1.32	=	9250	T	60°	−16870	× " ÷	1.32	=	15320	" C
40°	20670	× " ÷	1.40	=	17730	T	50°	−18710	× " ÷	1.40	=	16050	" C
50°	29040	× " ÷	1.38	=	25250	T	40°	−22440	× " ÷	1.38	=	19500	" C
60°	33180	× " ÷	1.30	=	30650	T	30°	−27720	× " ÷	1.30	=	25600	" C
70°	32080	× " ÷	1.14	=	33800	T	20°	−32640	× " ÷	1.14	=	34350	" C
80°	25740	× " ÷	0.90	=	34300	T	10°	−34420	× " ÷	0.90	=	45900	" C
90°	18220	× " ÷	0.55	=	**39700**	" T	0°	−22680	× " ÷	0.55	=	**49500**	" C

Stress in operating links due to 100 kg/m² wind pressure when fully opened and locked.

Rack force = $\pm \frac{18200 \times 100}{50}$ = ± 36400 kg. (see on page 80.)

link stress = ± 36400 × 1.2 ÷ 0.55 = 79400 kg T or C

Max. possible stress in one link = $\frac{79400}{2}$ = 39700 kg T or C

Section required for tensile stress = $\frac{39700}{700}$ = 56.8 cm^2 net

Max. possible stress during operation = $\frac{49500}{2}$ = 24750 kg C for one link

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(8m)

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CALCULATIONS FOR

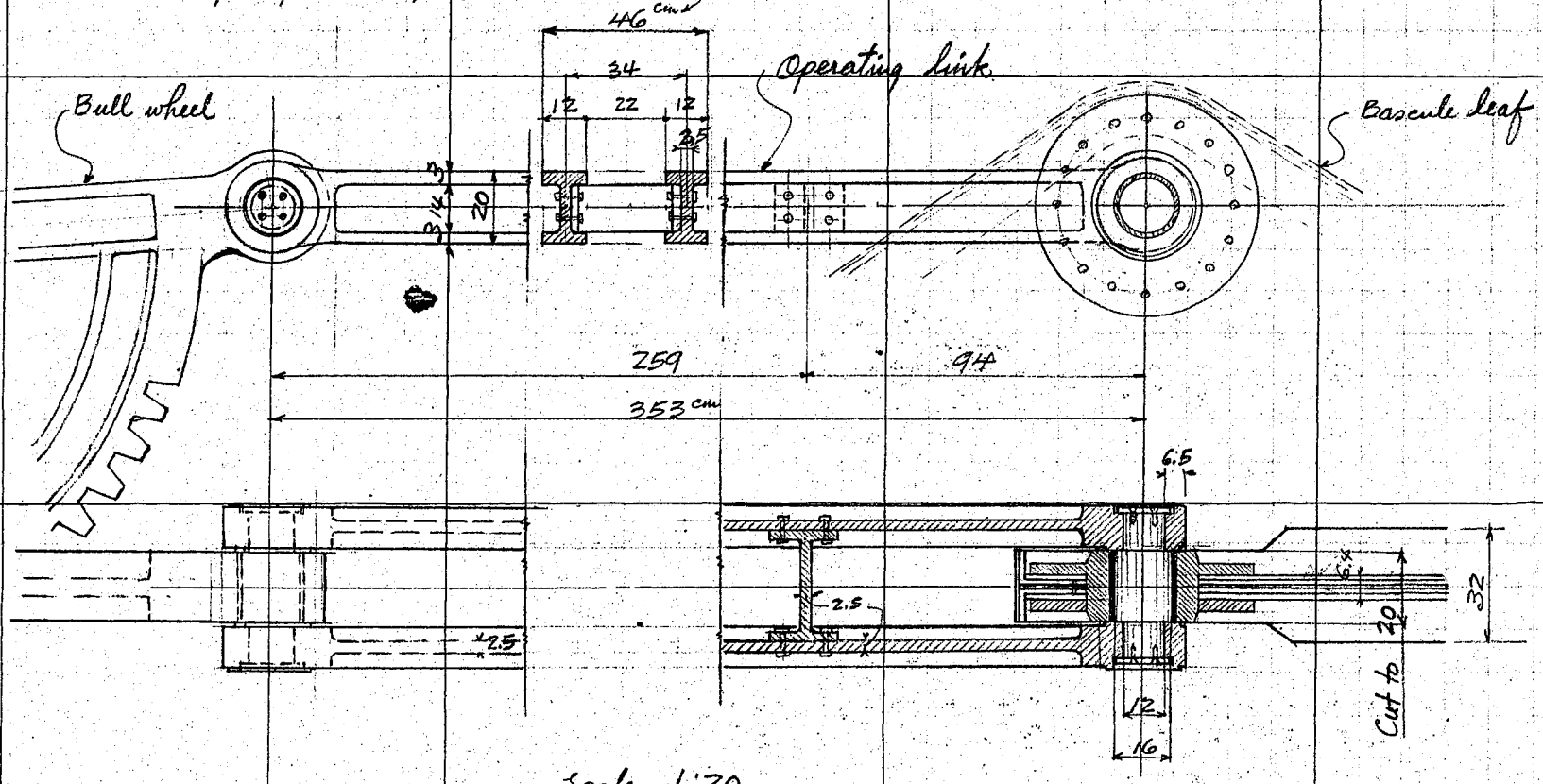
Machine Design of Nagahama-Ō-Hashi for Ekimae Ken.

Length of link = 353 cm c to c of Pins.

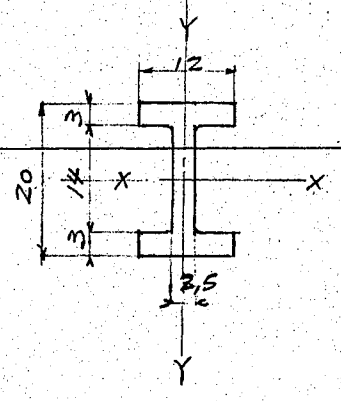
Max. possible stress in link during 100 kg wind when the moving leaf opened fully and brake applied. = ± 39700 kg for one link.

Max. possible stress in link during operation against 50 kg wind
= 39700 ÷ 2 = 19850 kg T for one link
or = 49500 ÷ 2 = 24750 kg C "

Details of Operating link. (reviced to 50 (7-12-24)



Scale 1:20



moment of inertia Iy

12×3×2	= 72.0	3×2×12³÷12	= 864
14×2.5	= 35.0	14×2.5³÷12	= 18
	107.0 cm²		882 cm⁴

$r_x = \sqrt{\frac{882}{107}} = 2.87$ cm

$\frac{l_1}{r_x} = \frac{259}{2.87} = 90.2$

Allowable unit compression = $700 - 3.2 \times \frac{l}{r} = 700 - 3.2 \times 90.2 = 411$ kg/cm²

moment of inertia Ix

$72 \times 8.5^2 + \frac{12 \times 3^3}{12} \times 2$	= 5254
$\frac{2.5 \times 14^3}{12}$	= 572
	5826 cm⁴

$r_y = \sqrt{\frac{5826}{107}} = 7.38$ cm

$\frac{l_2}{r_y} = \frac{353}{7.38} = 47.8$

Allowable unit compression = 700 − 3.2 × 47.8 = 547 kg/cm²

Net area of link 107 × 2 = 214 − 25 = 189 cm² net.

Capacity of link.

214 @ 411 = 88000 kg C for one link
189 @ 700 = 132300 kg T. "

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MADE BY K. Inaba DATE 7-12-21 FILE NO
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CALCULATIONS FOR

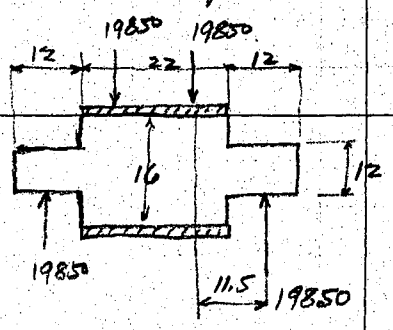
Machine Design of Nagakawa —O— Hashi for Ehime ken.

Bearing area required for Phosphor bronze bushing during operation against 50 kg wind
$= \frac{24750}{85} = 291 \text{ cm}^2$

for the length of bushing of 20 cm, Diameter of shaft required $= \frac{291}{20} = 14.6$ cm

use 16 cm ϕ shaft.

Diameter of shaft at both ends.



$d = 0.172 \sqrt[3]{19850 \times 12} = 10.7$
allowance for 1 keyway 6% $= \frac{0.6}{11.3}$ cm use 12 cm ϕ

Unit shear $= \frac{19850}{113.1} = 175.5 \text{ kg/cm}^2$

Diameter of shaft at center.
moment $= 19850 \times 11.5 = 228300$ kg cm
resisting moment of 16ϕ shaft
$= 0.0982 \times 1000 \times 16^3 = 402000$ kg cm

Design of Bull wheel Bearing.
Max. load on Bull wheel during operation against 50 kg wind.

During opening operation.

Angle of opening	Rack force ↗	Vert. comp. 0.707↑	Hor. comp. 0.707→	Link stress ↘		Vert. comp. ↓		Hor. comp. →	Bull wheel weight 2@2000↓	Summary Vert comp. ↓	Summary hor. comp. →	Resultand load on B.W.
0°	5940	4200	4200	25500	.13	3310	.99	25200	4000	↓ 3110	29400	
10°	9000	6360	6360	12400	.21	2600	.98	12150	"	↓ 2400	18510	
20°	8640	6100	6100	9000	.22	1980	"	8820	"	↑ 120	14920	
28°	8190	5790	5790	7450	.23	1710	"	7300	"	↑ 80	13090	
30°	10170	7190	7190	9250	.24	2220	.97	8970	"	↑ 970	16160	
40°	20670	14600	14600	17730	"	4250	"	17200	"	↑ 6350	31800	
50°	29040	20500	20500	25250	"	6060	"	24500	"	↑ 10440	45000	
60°	33180	23400	23400	30650	"	7350	"	29750	"	↑ [12050]	53150	54500
70°	32080	22680	22680	33800	.22	7440	.98	33100	"	↑ 11240	[55780]	[56900] ↗
80°	25740	18200	18200	34300	.19	6520	"	6390	"	↑ 7680	24590	
90°	18220	12880	12880	39700	.13	5160	.99	5100	"	↑ 3720	17980	

During closing operation

Angle of closing	↙	↓	←	↖	↑	←	↓	↓	←	
90°	500	↑ 350	→ 350	2140	280	2120	4000	3370	1770	
80°	− 1980	↓ 1400	← 1400	2730	570	560	"	4830	1960	
70°	− 8520	6020	6020	8900	1960	1920	"	8060	7940	
62°	− 16730	11830	11830	15200	3490	3420	"	12340	15250	
60°	− 16870	11920	11920	15320	3670	3560	"	12250	15480	
50°	− 18710	13240	13240	16050	3850	3740	"	13390	16980	
40°	− 22440	15850	15850	19500	4680	4540	"	15170	20390	
30°	− 27720	19620	19620	25600	6140	5950	"	17480	25570	
20°	− 32640	23100	23100	34350	7550	7400	"	19550	30500	
10°	− 34420	24350	24350	45900	8720	8540	"	[19630]	[32890]	[38300] ↙
0°	− 22680	16040	16040	49500	6430	6360	"	13610	22400	

Max. load on Bull wheel due to 100 kg wind when fully opened and locked.

								↓	→	
	± 79400	× 113	± 10300	.99	± 78600	4000		14300	78600	[79900] ↘
								− 6300	− 78600	[−78800] ↖

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CALCULATIONS FOR

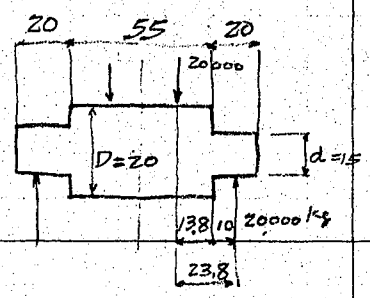
Machine Design of Nagahama—O-Hashi for Ehime Ken.

Summary of max. loads on Bull wheel shaft. (for one wheel).

	Vertical load	Horizontal load	max. load.
Opening operation during wind	↑ 6000 kg	→ 27900 kg	↗ 28500 kg
Closing " " "	↓ 9800	← 16400	↙ 19200
locked against 100 kg wind	↓ 17200	→ 39300	↘ 40000
	↑ 3200	← 39300	↖ 39400

Bearing area required for Phosphor bronze bushings = $\frac{40000}{100} = 400$ cm²

Assuming bearing length 2e20 = 40 cm diam. reqd. = $\frac{400}{40} = 10,0$ cm



Diam. at both ends. $d = 0,172\sqrt[3]{20000 \times 20} = 12.7$ cm unit shear = $\frac{20000}{336,5} \times \frac{4}{3} = 79$ kg/cm²

Use d = 15 cm.

Diameter at center.

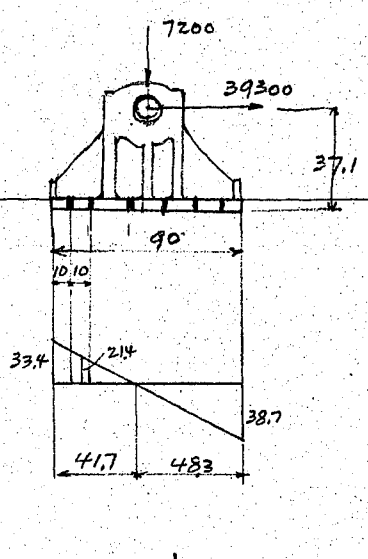
moment = 20000 × 23.8 = 476,000 kg cm

try 20 cm φ solid shaft

For 2 key ways deduct 4% of the diameter = 20 × 096 = 19.2 cm φ

resisting moment = 0.0982 × 1000 × 19.2³ = 694,000 kg cm

Bull wheel bearing.



moment = 39300 × 37.1 = 1460,000 kg cm

Eccentricity = $\frac{1460000}{7200} = 203$ cm.

max. bearing pressure = $\frac{7200}{30 \times 90}\left(1 \pm \frac{6 \times 203}{90}\right)$ (13.53) = 38.7 kg/cm² C

or = 33.4 " T

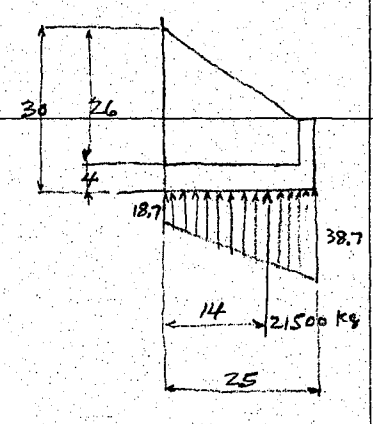
max. tension on one bolt.

$\frac{33.4 + 21.4}{2} = 27.4 \times 15 \times 15 = 6160$ kg T

for 44 mm φ turned bolts

Net area at bottom of screw thread = $\frac{\pi \times 36.5^2}{4} = 10.46$ cm² net

Capacity of 1 bolt = 10.46 @ 700 = 7330 kg T.

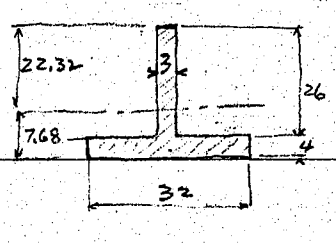


Footing stress.

Upward pressure on footing

$\frac{18.7 + 38.7}{2} = 28.7 \times 30 \times 25 = 21500$ kg

Moment on footing = 21500 × 14 = 301,000 kg cm.



Center of gravity of footing section

26 × 3 =	78	× 17 =	1326
32 × 4 =	128	× 2 =	256
	206	7.68	1582

moment of inertia

$3 \times \frac{26^3}{12}$ + 78×9.32^2 =	11160
$32 \times \frac{4^3}{12}$ + 128×5.68^2 =	4300
	15460 cm⁴

Extreme fibre stress = $\frac{301000}{15460} \times 22,32 = 435$ kg/cm² C < 1100 ✓

" = $\frac{301000}{15460} \times 7,68 = 150$ " T < 1100 ✓

Shear on web = $\frac{21500}{3 \times 30} \times \frac{3}{2} = 359$ kg/cm² < 700 ,

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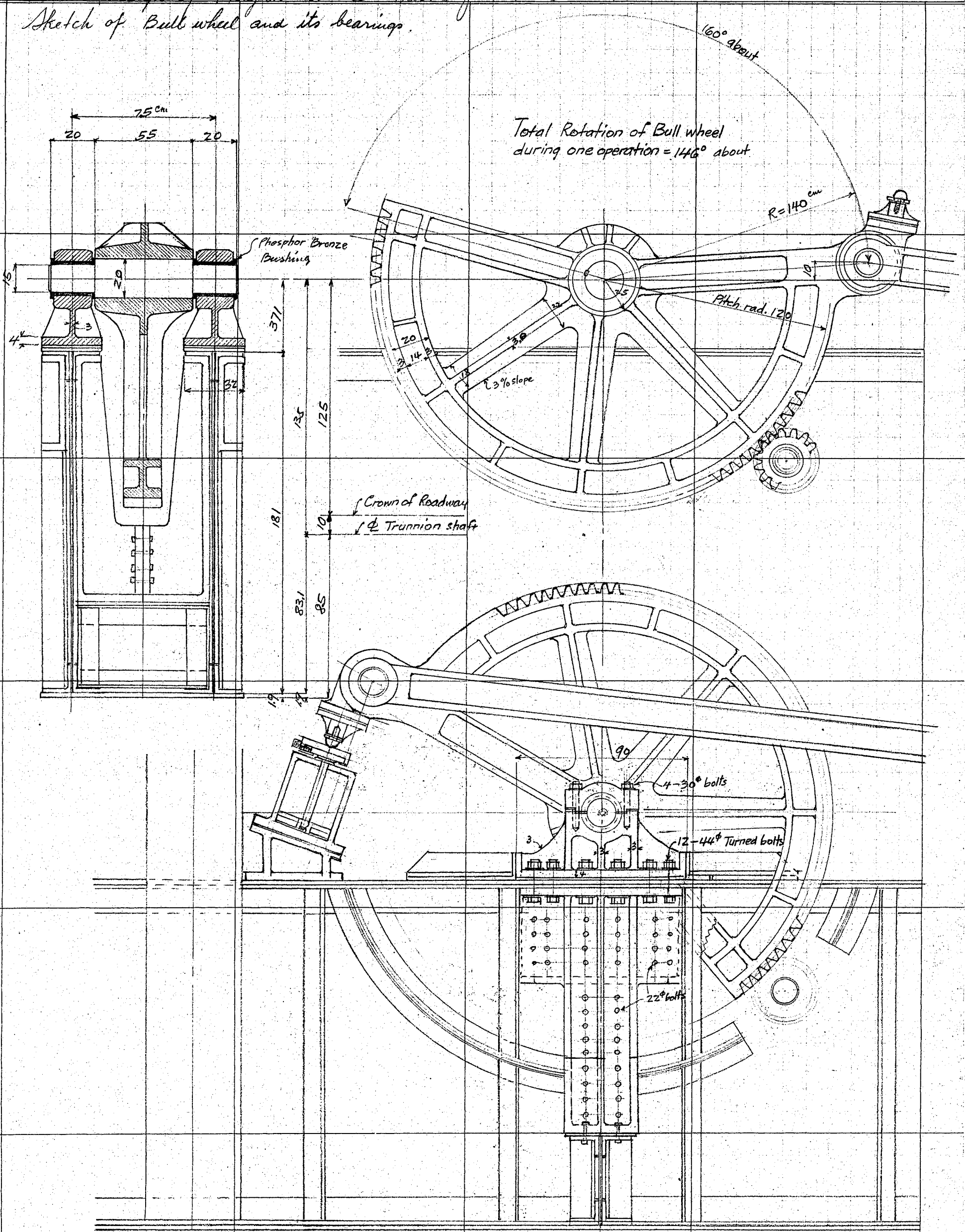
CALCULATIONS FOR

Machine Design of Nagahama-Ō-Hashi for Ehime ken.

Sketch of Bull wheel and its bearings.



Scale 1:20

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(12m)

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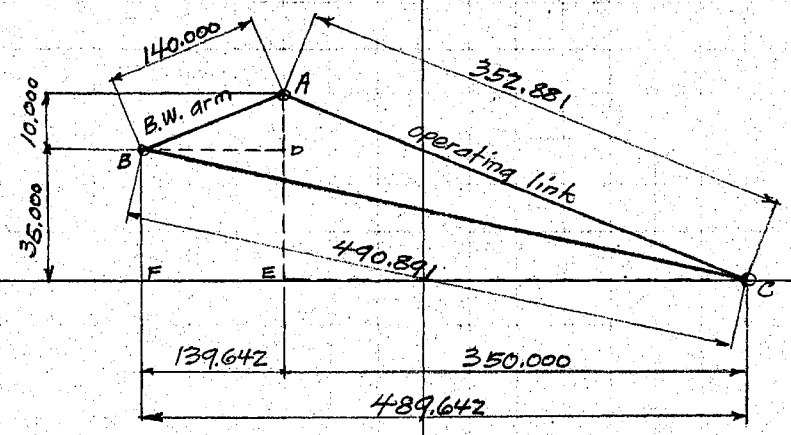
CALCULATIONS FOR

Machine Design of Nagahama-Ō-Hashi for Ebino Sen.

Design of Gearing.

Length of operating link.



Bridge closed.

$\overline{BD}$ $140.000^2 = 19600.000$
$10.000^2 = -100.000$
$\sqrt{19500.000} = 139.642$ cm

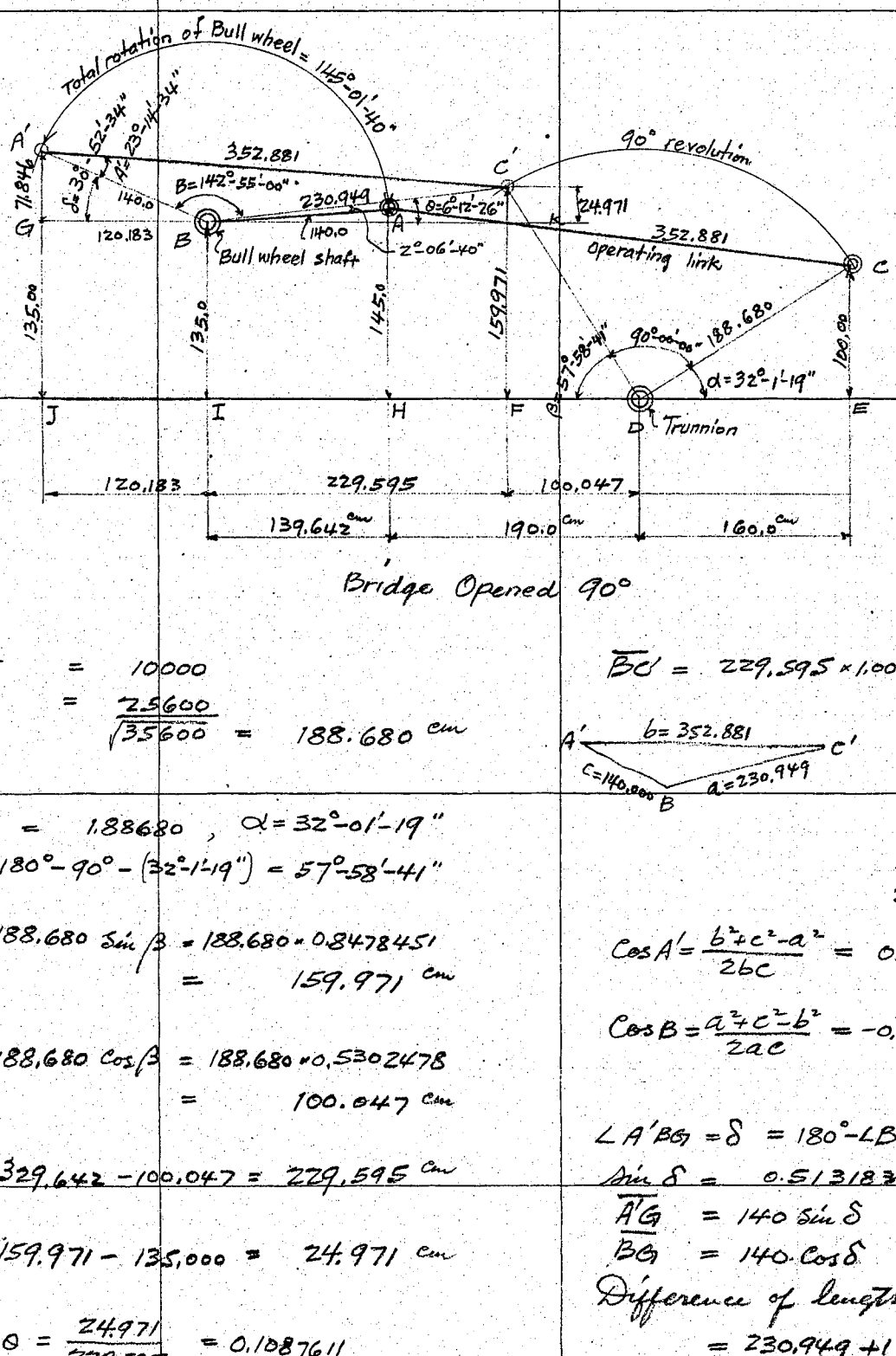
$\overline{CF}$ $139.642 + 350.000 = 489.642$ "

$\overline{AC}$ $350.000^2 = 122,500.000$
$45.000^2 = 2025.000$
$\sqrt{124525.000} = 352.881$ "

$\overline{BC}$ $489.642^2 = 239,749.288$
$35.000^2 = 1225.000$
$\sqrt{240974.288} = 490.891$ "

Difference of lengths between $\overline{BAC}$ and $\overline{BC}$.

$\overline{BAC}$ $140.000 + 352.881 = 492.881$
$\overline{BC}$ -490.891
1.990 cm



Bridge Opened 90°

$\overline{BC'} = 229.595 \times 1.0058972 = 230.949$ cm

$a^2 = 53337.4406$
$b^2 = 124,525.0002$
$c^2 = 19,600.0000$
$2ac = 64,665.7200$
$2bc = 98,806.6800$

$\overline{CD}$ $100.0^2 = 10000$
$160.0^2 = 25600$
$\sqrt{35600} = 188.680$ cm

$\angle CDE$ $\cos\alpha = 1.88680$, $\alpha = 32°-01'-19"$
$\angle C'DF$ $\beta = 180° - 90° - (32°-1'-19") = 57°-58'-41"$

$\overline{C'F} = 188.680 \sin\beta = 188.680 \times 0.8478451 = 159.971$ cm

$\overline{FD} = 188.680 \cos\beta = 188.680 \times 0.5302478 = 100.047$ cm

$\overline{FI} = 329.642 - 100.047 = 229.595$ cm

$\overline{C'k} = 159.971 - 135.000 = 24.971$ cm

$\angle C'Bk$ $\tan\theta = \frac{24.971}{229.595} = 0.1087611$

$\theta = 6°-12'-26"$

$\sec\theta = 1.0058972$

$\cos A' = \frac{b^2+c^2-a^2}{2bc} = 0.9188404$, $\angle A' = 23°-14'-34"$

$\cos B = \frac{a^2+c^2-b^2}{2ac} = -0.7977574$, $180° - \angle B = 37°-05'-00"$
$\angle B = 142°-55'-00"$

$\angle A'BG = \delta = 180° - \angle B - \theta = 30°-52'-34"$

$\sin\delta = 0.5131835$, $\cos\delta = 0.8584480$

$\overline{A'G} = 140 \sin\delta = 71.846$ cm
$\overline{BG} = 140 \cdot \cos\delta = 120.183$ cm

Difference of lengths between $\overline{A'BC'}$ and $\overline{A'C'}$
$= 230.949 + 140.000 - 352.881 = 18.068$ cm

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CALCULATIONS FOR

Machine Design of Nagahama-O-Hashi for Ebime Ken.

∠ ABK $\sin\gamma = \frac{10}{140} = 0.0714286$

$\gamma = 4°-05'-46"$

$\theta - \gamma = 6°-12'-26" - 4°-05'-46"$

$= 2°-6'-40"$

Total rotation of Bull wheel

$= \angle B + \theta - \gamma = 142°-55'-00" + 2°-06'-40"$

$= \underline{145°-01'-40"}$

Dimensions of Rack and pinion teeth required to transmit an operating power of 15 horse-power for this bridge:

Wilfred Lewis formula for the strength of gear tooth.

$W = Spfy$ where W = Safe load on the tooth, in lbs. (kg)

p = the circular pitch, in inches. (cm)

f = the face of the tooth in inches (cm)

S = the permissible fibre stress in the material at the root of the tooth, in lbs per sq. inch. (kg/cm^2)

y = a factor depending upon the form of the tooth. (Same as for F.P.S unit)

Try a pinion of Face of tooth $f = 26$ cm

pitch diameter $D = 40$ cm

no. of teeth $N = 16$

then

Circular pitch $p = \frac{40\pi}{16} = 7.854$ cm

Module $M_c = \frac{400}{16} = 25.0$

Let the tooth be of 20° involute stub cast steel (cut)

$S = 1400$ kg/cm² (20000 #/□")

$y = 0.113$ (from the prepared table).

Safe load on one tooth $W = spfy = 1400 \times 7.854 \times 2.6 \times 0.113 = 32,300$ kg

for two pinions, max rack force developed $= 2 \times 32300 = 64600$ kg

Operating power developed by a rack force of 10000 kg = 3.83 HP (Page 81)

max. operating power transmitted safely by 2 pinions

$3.83 \times \frac{64600}{10000} = 24.75$ HP.

Good for 2 - 7.5 HP motors in couple of which max. operating power including 40% excess torque $= 15 \times 1.40 = 21.00$ HP.

Rack

Face of tooth $f = 24$ cm

Pitch dia. $D = 240$

No. of teeth $N = 96$

C. P. $P = 7.854$

Module of tooth $M_c = \frac{2400}{96} = 25$

$y = 0.167$

Safe load on rack tooth $W = 1400 \times 7.854 \times 24 \times 0.167 = 44,000$ kg

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(14m)

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CALCULATIONS FOR

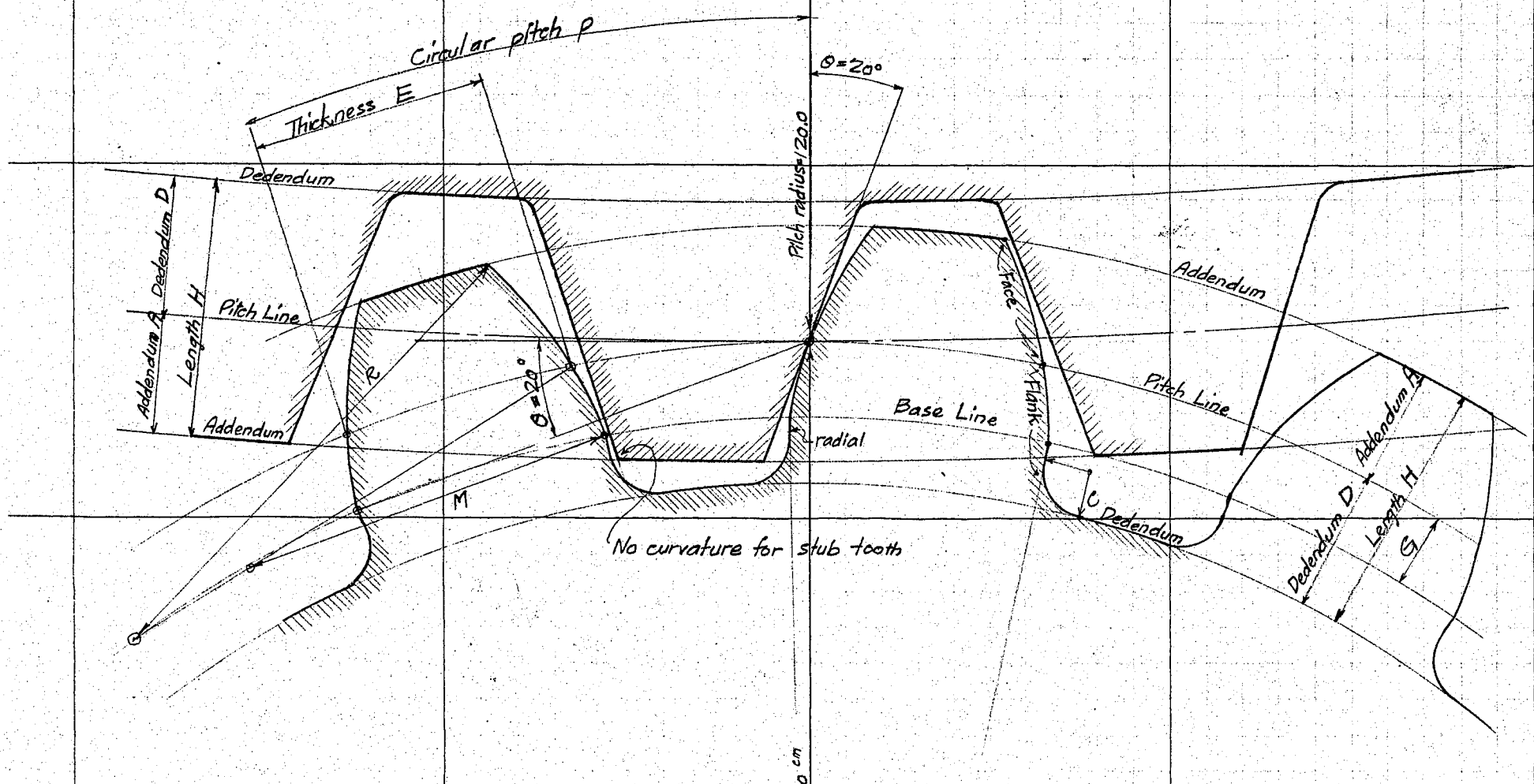
Machine Design of Nagahama-O-Hashi for Ehime Ken.

Forms of Rack and pinion teeth.
From the preparea tables of 20° involute stub cut tooth.

Part		C. P. = P = 7.854 cm	P. D. = 40 cm
Angle	θ	20° =	20°
addendum	A	0.25 P =	1.964 cm
dedendum	D	0.30 P =	2.356
height	H	0.55 P =	4.318
thickness at p. l.	E	0.50 P =	3.927
radius at root	C	0.10 P =	0.785
base line distance	G	P.D. ÷ 33 =	1.212
face radius	R	1.10 P =	8.639
flank radius	M	0.81 P =	6.362

Pitch radius of rack = 120 cm
Required no. of teeth on rack
$N_r = \frac{2\pi \times 120 \times 145.028}{360 \times 7.854} = 38.7$
allowance over both limits = 4.3
43 teeth

$N = \frac{2 \times 120 \times \pi}{7.854} = 96$



Rack and Pinion teeth.
full scale.

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(15m)

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CALCULATIONS FOR

Machine design of Nagahama-O-Hashi for Ehime Ken.

Design of Gearings.

Gear ratios.

Motors used 芝浦製 2 – 7.5HP TMC motors 828 rev./min.

Rotation of rack. $= \frac{145.0278^\circ}{360^\circ \times 3\ min} = 0.13429$ rev./m.

Total gear ratio to be used $= \frac{828}{0.13429} = 6165.76$

Let us assume ratio of each gearing as follows:

worm gear	20° inclination	74/3
1st gear		61/15
2nd gear		38/15
3rd gear		85/21
main pinion + rack		96/16

Total gear ratio

$= \frac{74 \times 61 \times 38 \times 85 \times 96}{3 \times 15 \times 15 \times 21 \times 16} = 6171.52$

∴ Call this 6172.

For the above gear ratios, total time required for one operation is as follows:

Revolution of rack $= \frac{828}{6172} = 0.13415$ r.p.m

Time for unif. speed $= \frac{1}{0.13415} \times \frac{145.0278}{360} = 3.003\ min = 3'-00''$

Extra time required for acceleration + retardation $= 0'-20''$

Total time for one operation $= 3'-20''$

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

Gearings	wheels	no. of rev./m. n	Pitch diam. Dp m.m.	Speed V m/min	Efficiency η	H.P. transmitted H.P.×η
Worm gear	worm	828.00	71.6	186.30	1.000	15.00
	worm wheel	$828 \times \frac{3}{74} = 33.57$	598.3	63.15	0.700	10.50
1st gear	pinion	33.57	150	15.83	0.700	10.50
	wheel	$33.57 \times \frac{15}{61} = 8.25$	610	"	0.658	9.87
2nd gear	pinion	8.25	240	6.22	0.658	9.87
	wheel	$8.25 \times \frac{15}{38} = 3.26$	608	"	0.618	9.27
3rd gear	pinion	3.26	336	3.44	0.618	2@ 4.64
	wheel	$3.26 \times \frac{21}{85} = 0.805$	1,360	"	0.580	2@ 4.35
main pinion		0.805	400	1.01	0.580	2@ 4.35
rack		$0.805 \times \frac{16}{96} = 0.1334$	2,400	1.01		

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CALCULATIONS FOR

Machine design of Nagahama —O— Haski for Ehime Ken.

Dimensions of gear teeth. 15° involute cast steel cut teeth

Gearing	Pitch dia D_p mm	Outside dia D_o mm	Module $M_c=\frac{D_p}{N}$	Face f mm	Cir. pitch P mm	Addendum $H_1=M_c$	Length H	no. of teeth N	Load on tooth $W=\frac{4560\times HP\times y}{v}$
1st gear									
pinion	150	170 abt	10	120	31.416	10 abt.	21.666 abt	15	3030 kg
wheel	610	630 "	10	100	31.416	10 "	21.666 "	61	"
2nd gear									
pinion	240	272 "	16	180	50.265	16 "	34.666 "	15	7230
wheel	608	640 "	16	160	50.265	16 "	34.666 "	38	"
3rd gear									
pinion	336	368 "	16	180	50.265	16 "	34.666 "	21	6150
wheel	1360	1392 "	16	160	50.265	16 "	34.666 "	85	"

Strength of above teeth from Wilfred Lewis's formula.

$$W = S\,p\,f\,y$$

in which

$$S = S_b \frac{600}{3.28v+600}$$

S_b = basic unit fibre stress of tooth for zero speed. = 1400 kg/cm² for cast steel (for forged steel add 10%)

for $v = 15.83$ $\quad S_1 = 1400 \times \frac{600}{15.83\times 3.28+600} = 1290$ kg/cm² for 1st gear

$v = 6.22$ $\quad S_2 = 1400 \times \frac{600}{6.22\times 3.28+600} = 1350$ 2nd gear

$v = 3.44$ $\quad S_3 = 1400 \times \frac{600}{3.44\times 3.28+600} = 1375$ 3rd gear

$v = 1.01$ $\quad S_4 = 1400 \times \frac{600}{1.01\times 3.28+600} = 1390$ main pinion + rack

values of y from prepared table.

no. of teeth n	values of y for 15° involute teeth
15	0.078
38	0.106
61	0.113

$$y = 0.124 - \frac{0.684}{N}$$

Strength of teeth.

					Cast steel	forged steel (半硬鋼)
1st gear	pinion	$W_1 =$	1290 × 3.1416 × 12. × 0.078 =	3800 kg ×1.1 =	4180 kg
	wheel	$W_1' =$	1290 × 3.1416 × 10 × 0.113 =	4580	—
2nd gear	pinion	$W_2 =$	1350 × 5.0265 × 18 × 0.078 =	9530	10,480
	wheel	$W_2' =$	1350 × 5.0265 × 16 × 0.106 =	11520	—
3rd gear	pinion	$W_3 =$	1375 × 50.265 × 18 × 0.091 =	11320	12450
	wheel	$W_3' =$	1375 × 50.265 × 16 × 0.116 =	12820	—

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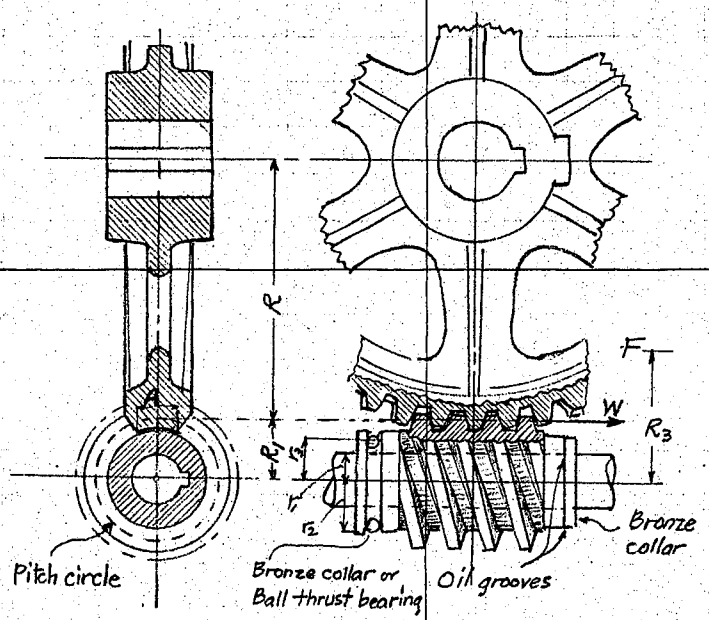
CALCULATIONS FOR

Machine design of Nagahama-O-Hashi for Zhine Kan

Design of worm gear.



Let
- W = The force at the pitch line of worm and wheel in kg;
- R = the radius of the wheel;
- R_1 = the radius of the worm;
- P = the circular pitch of the teeth on the wheel;
- r_1 = the radius of the inner circle of the thrust collar at the end of the worm;
- r_2 = the outer radius of the collar;
- r_3 = the radius of the ball thrust bearing if used instead of thrust collar;
- F = the force acting to rotate the shaft in kg;
- R_3 = the lever arm of F;
- f = the coef. of friction between the teeth;
- f_1 = the coef. of friction between the collar and the worm or of a rolling friction for ball bearing;
- A = the arc of contact at the pitch circle, in cm;
- F_w = the force required to move the load W, neglecting friction in kg;
- F_t = the force required to overcome the friction between the teeth in kg;
- F_c = the force required to overcome the collar friction in kg;
- F_b = the force required to overcome the rolling friction of the ball bearing if it be used instead of thrust collar.

Then

$$F = F_w + F_t + F_c \quad \text{in case of the thrust collar being used.}$$
$$\text{or } F = F_w + F_t + F_b \quad \text{in case of the ball bearing being used.}$$

in which

$$F_w = \frac{WP}{2\pi R_3} \quad \text{for single thread worm}$$
$$= \frac{WP}{\pi R_3} \quad \text{for double thread worm}$$
$$= \frac{3WP}{2\pi R_3} \quad \text{for tripple thread worm.}$$
$$F_t = \frac{fWR_1}{R_3}$$
$$F_c = \frac{f_1 W\left[\frac{2}{3}\times\frac{r_2^3-r_1^3}{r_2^2-r_1^2}\right]}{R_3} \quad \text{for thrust collar.}$$
$$F_b = \frac{f_1 W r_3}{R_3} \quad \text{for ball thrust bearing.}$$

Efficiency of worm gear

$$E = \frac{P}{P+2f\pi R_1} \quad \text{for single threaded worm} \quad \text{(Friction of thrust collar or rubber bearing not included)}$$
$$= \frac{P}{P+f\pi R_1} \quad \text{for double threaded worm}$$
$$= \frac{3P}{3P+2f\pi R_1} \quad \text{for tripple threaded worm.}$$

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CALCULATIONS FOR

Machine design of Nagakawa-Ō-Hashi for Ehime ken.

We have decided as follows:

Worm. (半枝合図)

Pitch diameter = 71.6 mm, R_1 = 3.58 cm;
number of thread = 3.
lead of worm = 3@25.4 = 76.2 mm, P = 2.54 cm;
angle of lead 20°
rotation per min n = 828 transmitting 15 HP. = N

Worm wheel (phosphor bronze)

Circular pitch P = 2.54 cm;
no. of teeth N = 74;
pitch diameter = $\frac{25.4 \times 74}{\pi} = 598.30$ mm, R = 29.915 cm;
Arc of contact for 90° A = $\frac{3.58\pi}{2} = 5.62$ cm

Diameter of worm shaft.

Torsional moment on the shaft = $T = 72600 \frac{N}{n} = \frac{72600 \times 15}{828} = 1315$ kg cm.

Diameter of worm shaft $d = 2r_1 = \sqrt[3]{\frac{16T}{S_s \pi}} = \sqrt[3]{\frac{16 \times 1315}{550\pi}} = 2.30$ cm use 50 mm

$\therefore F R_3 = 1315$ kg cm

$F_w R_3 = \frac{3WP}{2\pi} = \frac{3W \times 2.54}{2\pi} = 1.212\,W$

$F_t R_3 = f W R_1 = 0.10\,W \times 3.58 = 0.358\,W$

$F_b R_3 = f_1 W r_3 = 0.01\,W \times 4.30 = 0.043\,W$

Summary $= 1.613\,W$

$F R_3 = F_w R_3 + F_t R_3 + F_b R_3$

$\therefore 1315 = 1.613\,W$

or $W = \frac{1315}{1.613} = 815$ kg

Worm wheel tooth.

a coef. $k = \frac{W}{PA} = \frac{815}{2.54 \times 5.62} = 57.1 < 600$ ✓

Speed at pitch line = 63.15 m/min
for which allowable value of k = 600 from prepared diagram.

Efficiency of worm gearing.

$E = \frac{3P}{3P + 2f\pi R_1} = \frac{3 \times 2.54}{3 \times 2.54 + 2 \times 0.10\,\pi \times 3.58} = \frac{7.62}{9.87} = 77.2\,\%$

Efficiency of ball bearing 99.0 %
" " bearings 0.98^2 = 96.0 %

Total efficiency = $77.2 \times 0.99 \times 0.96 = 73.3\,\%$

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(19m)

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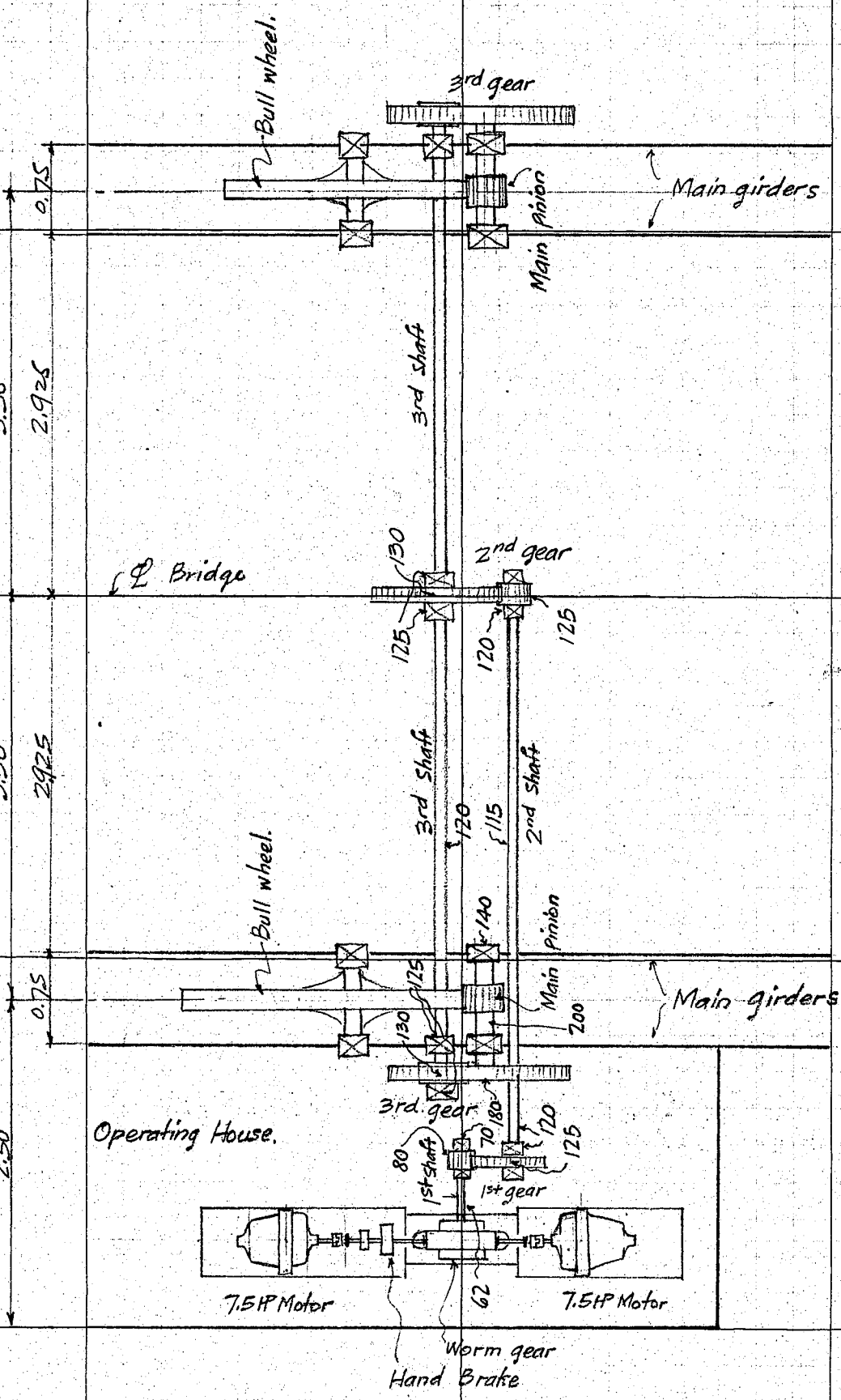
CALCULATIONS FOR

Machine design of Nagahama-Ō-Hashi for Ehime Ken.
Design of shafts,
Arrangement of shafts.



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CALCULATIONS FOR

Machine design of Nagahama-Ō-Hashi for Ehime ken.

Load on shafts.

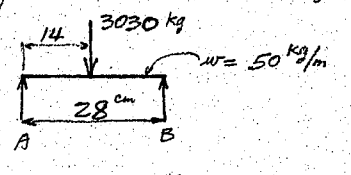
Shafts	H.P transmitted N.	no. of rev. per min n	load on tooth W		Coef. of equivalent Combined moment. Km	Kt
1st. Shaft	10.50	33.57	3030	kg	1.50	1.50
2nd. Shaft	9.87	8.25	7230		"	"
3rd. Shaft	4.64	3.26	6150		"	"
Main pinion Shaft.	4.35	0.805	19650		"	"

Torsional moment on shafts. $T = 72600 \frac{N}{n}$ kg.cm.

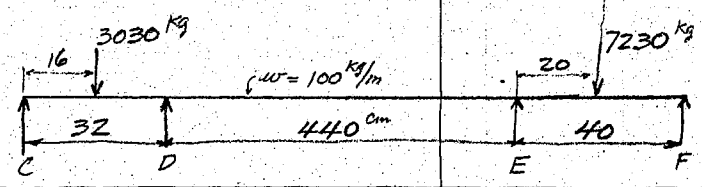
Shafts.	N/n	T
1st shaft	0.313	22700
2nd shaft	1.197	86800
3rd shaft	1.424	103400
main pinion shaft.	5.400	392000

Bending moment on shafts. M kgcm.

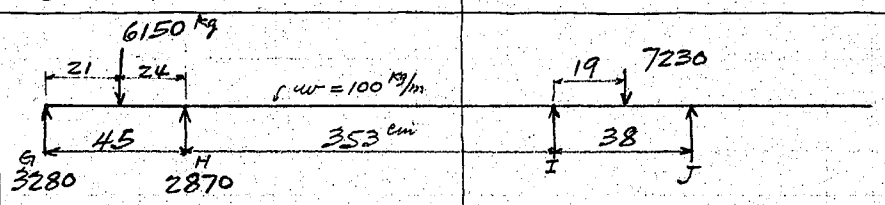
1st. shaft.



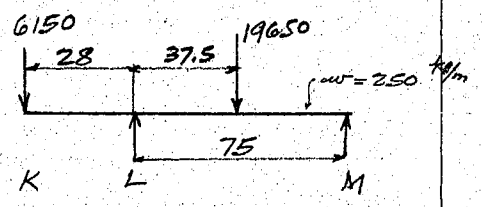
2nd. Shaft.



3rd. Shaft.



Main pinion shaft.



Moments.

1st. Shaft. (A-B)	Tooth load.	W	,	1/4 ×	3030 × 28	=	21200
	pinion weight	say W'	,	1/4 ×	30 × 28	=	210
	Shaft weight	" w	,	1/8 ×	0.5 × 28²	=	50
							21500 kgcm in round number.
2nd Shaft. (C-D)	Tooth load	W	,	1/4 ×	3030 × 32	=	24250
	wheel weight say	W'	,	1/4 ×	80 × 32	=	640
	Shaft weight	w	,	1/8 ×	1.0 × 32²	=	130
							25000 " "
(D-E)	Shaft weight	w	,	1/8 ×	1.0 × 440²	=	24200
	flange coupling say	W''	,		200 × 60	=	12000
							36200 " "
(E-F)		W	,	1/4 ×	7230 × 40	=	72300
		W'	,	1/4 ×	100 × 40	=	1000
		w	,	1/8 ×	1.0 × 40²	=	200
							73500 " "

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CALCULATIONS FOR

Machine design of Nagahama-O-Hashi for Ehime Ken.

3rd. Shaft.

(G-H)	Tooth load	W,	3280 × 21	=	68900	
	Pinion weight say	W',	60 × 21	=	130	not same direction as for W take them in consideration for safety
	Shaft weight say	w,	1/8 × 1.0 × 45²	=	250	kg cm in round number.
					69300	
(H-I)	Shaft weight say	w,	1/8 × 1.0 × 353²	=	15580	
	flange couplings say	W",	200 × 115	=	23000	
					38600	" "
(I-J)		W,	1/4 × 7230 × 38	=	68700	
		W',	1/4 × 120 × 38	=	1140	
		w,	1/8 × 1.0 × 38²	=	180	
					70000	" "

Main pinion shaft.

(K-L)	Tooth load	W,	6150 × 28	=	172000	
	wheel weight say	W',	500 × 28	=	14000	
	Shaft weight	w,	1/2 × 2.5 × 28²	=	1000	
					187000	" "
(L-M)	Tooth load	W,	1/4 × 19650 × 75	=	368000	
	pinion weight say	W',	1/4 × 300 × 75	=	5600	
	Shaft weight	w,	1/8 × 2.5 × 75²	=	1800	
	Negative pressure of boss		1/2 × 19650 × 6.5	=	− 63900	
					311,500	" "

Combined moment due to torsion and bending.

Equivalent torsional moment $T_E = \sqrt{(k_m M)^2 + (k_t T)^2} = 1.50\sqrt{M^2+T^2}$ for $k_m = k_t = 1.50$

Equivalent bending moment $M_E = \frac{3}{8}k_m M + \frac{5}{8}\sqrt{(k_m M)^2+(k_t T)^2} = 0.1875(3M+5\sqrt{M^2+T^2})$ " "

	M	T	M^2	T^2	$\sqrt{M^2+T^2}$	T_E	M_E
1st. Shaft.							
A-B	21,500 kg cm	22,700 kg cm	462(10)⁶	515(10)⁶	31,200	46,800	41,400
2nd. shaft							
C-D	25000	86,800	625(10)⁶	7530(10)⁶	90300	135500	98,700
D-E	36,200	"	1310(10)⁶	"	94500	141700	109,000
E-F	73.500	"	5400(10)⁶	"	113,700	170,500	148000
3rd. shaft.							
G-H	69300	103400	4800(10)⁶	10690(10)⁶	124.500	186,700	159,500
H-I	38.600	"	1490(10)⁶	"	110.400	165,500	125000
I-J	70.000	"	4900(10)⁶	"	124800	187300	156300
Main pinion shaft.							
K-L	187.000	392,000	34950(10)⁶	153600(10)⁶	434200	651,000	512,000
L-M	311.500	"	96700(10)⁶	"	500.000	750000	644000

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CALCULATIONS FOR

Machine design of Nagahama-Ō-Hashi for Ehime Ken.

Required diameter of shafts.

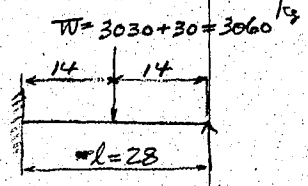
For equivalent torsional moment $d_t = \sqrt[3]{\frac{16T_E}{S_s\pi}} = 0.210\sqrt[3]{T_E}$ for $S_s = 550$ kg/cm²

for equivalent bending moment $d_m = \sqrt[3]{\frac{32M_E}{S\pi}} = 0.210\sqrt[3]{M_E}$ for $S = 1100$ "

				allowance for keyways.	Total diameter	Finish from
Required diameter.						
1st Shaft.	A-B.	$d_1 = 0.210\sqrt[3]{46800} =$	7.57 cm	6% (1 key)	80.1 mm	85 mm φ
2nd Shaft	C-D	$d_2 = 0.210\sqrt[3]{135500} =$	10.78	6% "	114.2	115
"	D-E	$d_2' = 0.210\sqrt[3]{141700} =$	10.95	" "	116.0	120
"	E-F	$d_2'' = 0.210\sqrt[3]{170500} =$	11.65	" "	123.5	125
3rd. shaft.	G-H	$d_3 = 0.210\sqrt[3]{186700} =$	12.00	6% "	127.1	130
"	H-I	$d_3' = 0.210\sqrt[3]{165500} =$	11.52	" "	122.0	125
"	I-J	$d_3'' = 0.210\sqrt[3]{187300} =$	12.01	" "	127.3	130
Main pinion Shaft	K-L	$d_p = 0.210\sqrt[3]{651000} =$	18.20	4% (2 keys)	189.3	200
"	L-M	$d_p' = 0.210\sqrt[3]{750000} =$	19.08	" "	198.5	200

Check for Critical speed of shaft.

1st shaft. (AB)

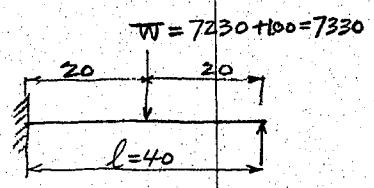


Critical speed $n = 988000\frac{d^2}{l}\sqrt{\frac{1}{We}} = 988000\times\frac{8.5^2}{28}\sqrt{\frac{1}{3060\times28}}$

$= 8720$ rotation per minute.

Actual max. speed = 33.57 " "

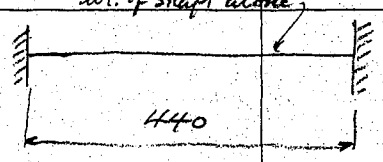
2nd shaft. (EF)



Critical speed $n = 988000\times\frac{12.5^2}{40}\sqrt{\frac{1}{7330\times40}} = 7120$ rotation/min

Actual max. speed = 8.25 rev/min.

(DE)



Critical speed $n = 26,960,000\frac{d}{l^2} = 26960000\times\frac{12.5}{440^2}$

$= 1740$ rev/min.

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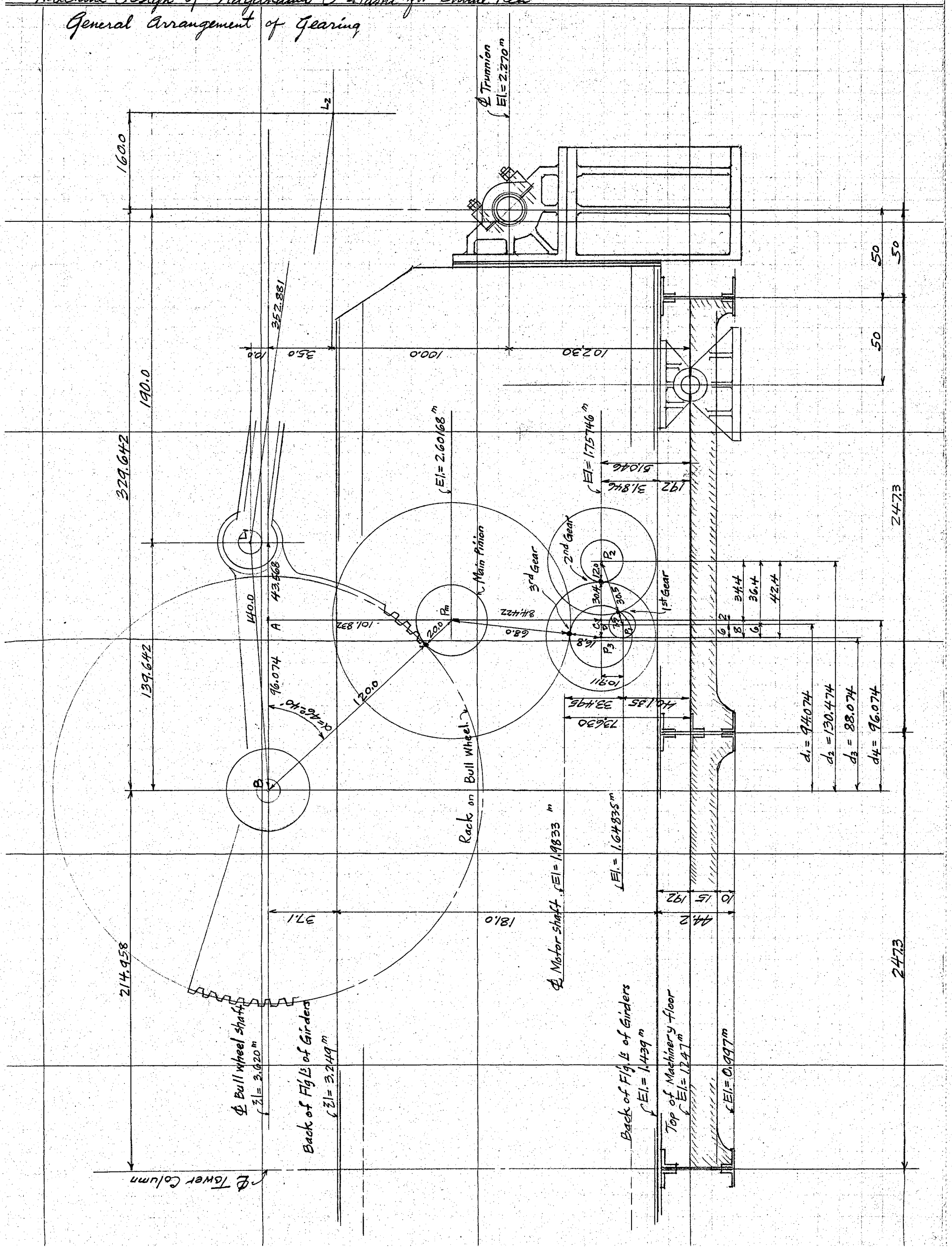
CALCULATIONS FOR

Machine design of Nagahama O Hashi for Ehime Ken

General Arrangement of Gearing



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(23m)

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CALCULATIONS FOR

Machine design of Nagahama-O-Hashi for Shimo Kem.

Main dimensions.

P_m $\overline{BP_m}$ = 120 + 20 = 140.0 cm

α = 46°-40′ $\sin\alpha = 0.7273736$, $\cos\alpha = 0.6862416$

$\overline{BA}$ = 140. × 0.6862416 = 96.074 cm

$\overline{AP_m}$ = 140 × 0.7273736 = 101.832

P_3. $\overline{P_mP_3}$ = 680 + 16.8 = 84.8

$\overline{P_3C}$ = 8.0

$84.8^2 = 7191.04$

$8.0^2 = -\ 64.00$

7127.04 $\sqrt{7127.04} = 84.4218$

$\overline{P_mC}$ = 84.422 cm

P_1. $\overline{P_2D}$ = 42.4 − 6.0 = 36.4

$\overline{P_2P_1}$ = 30.5 + 7.5 = 38.0

$38.0^2 = 1444.00$

$36.4^2 = -1324.96$

119.04 $\sqrt{119.04} = 10.9105$

$\overline{P_1D}$ = 10.911 cm

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CALCULATIONS FOR

Machine design of Nagahama-Ō-Hashi for Ehime Kenn.

Design of shafts.

Shafts	H.P transmitted N	no. of rotation per min. n	Torsional moment $T = 72600 \frac{N}{n}$ kgcm	Load on tooth kg	span length cm	Bending moment M kgcm	Cantilever-moment at end (25 cm)	Coeff. K_m	Coeff. K_t
1st shaft	10.50	33.57	22800	3030	40	30400		1.50	1.50
2nd "	9.87	8.25	86900	7230	40	72400		"	"
3rd "	4.64	3.26	103400	6150	40	72400	215300	"	"
main pinion shaft	4.35	0.805	392000	19650	60	295500	215800	"	"

Equivalent torsional and bending moments on the shafts.

$$T_E = \sqrt{(K_m M)^2 + (K_t T)^2} = 1.50 \sqrt{M^2 + T^2}$$

$$M_E = \frac{3}{8} K_m M + \frac{5}{8} \sqrt{(K_m M)^2 + (K_t T)^2} = \frac{15}{80} \left(3M + 5 \sqrt{M^2 + T^2} \right) \quad \Big\} \text{ for } K_m = K_t = 1.50$$

	M	T	M^2	T^2	$\sqrt{M^2+T^2}$	T_E	M_E
1st shaft	30400	22800	$924(10)^6$	$519(10)^6$	38000	57000 kgcm	53000 kgcm
2nd shaft	72400 (19000)	86900	$5240(10)^6$ ($361(10)^6$)	$7550(10)^6$ (")	113100 (89000)	170000 (133500)	148000
3rd shaft	72400	103400	$5240(10)^6$	$10690(10)^6$	126200	189000	160000
End of 3rd shaft	215300	103400	$46200(10)^6$	$10690(10)^6$	238500	358000	345000
main pinion shaft	295500	394200	$87400(10)^6$	$155500(10)^6$	493000	740000	629000

Diameter of shaft.

for equiv. torsional moment $d_t = \sqrt[3]{\frac{16 T_E}{S_s \pi}} = \sqrt[3]{\frac{16 T_E}{550 \pi}} = 0.21 \sqrt[3]{T_E}$ for $S_s = 550$ kg/cm²

for equiv. bending moment $d_m = \sqrt[3]{\frac{32 M_E}{S \pi}} = \sqrt[3]{\frac{32 M_E}{1100 \pi}} = 0.21 \sqrt[3]{M_E}$ for $S \doteq 1100$ "

				allowance for 1 keyway 6%		Use
Required diameter of 1st shaft.	d_1	$= 0.21 \sqrt[3]{57000}$	$= 8.1$ cm	$+ 0.5$	$= 8.6$	90 mm φ
2nd shaft	d_2	$= 0.21 \sqrt[3]{170000}$	$= 11.6$	$+ 0.7$	$= 12.3$	125
		$0.21 \sqrt[3]{133500}$	$= 10.7$	$+ 0.6$	$= (11.3)$	
3rd shaft	d_3	$= 0.21 \sqrt[3]{189000}$	$= 12.0$	$+ 0.7$ (2 keyways 4%)	$= 12.7$	125
(If cantilever used) End of "	d_3'	$= 0.21 \sqrt[3]{358000}$	$= 14.9$	$+ 0.6$	$= 15.5$	160
main pinion shaft	d_4	$= 0.21 \sqrt[3]{740000}$	$= 19.0$	$+ 0.8$	$= 19.8$	200

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CALCULATIONS FOR

Gear ratio.

motors 7.5HP TMC motors 828 rev 1min.

rack. $\frac{145.0278}{360^\circ \times 3_{in}} = 0.13429$ rev/min

Total gear ratio $= \frac{828}{0.13429} = 6,165.76$

No of teeth on racks for complete circle $= \frac{2\pi \times 120}{7.854} = 96$

	Pinion	
worm		
1st gear	16	$\frac{96}{16} = 6.0$
2nd gear		
3rd gear		
main pinion & rack		

worm $\frac{74}{3}$

1st gear $\frac{61}{15}$

2nd gear $\frac{38}{15}$

3rd gear $\frac{61}{15}$

main pinion & rack $\frac{96}{16}$

$\frac{74 \times 96 \cdot 61 \cdot 38}{3 \times 15^3 \times 16} = \frac{100,449,792}{162,000} = 6200$ ✓

worm $\frac{74}{3} = 24.667$

1st gear $\frac{54}{15} = 3.60$

2nd " $\frac{31}{15} = 2.067$

3rd " $\frac{54}{15} = 3.60$

660

Pinion $\frac{828}{660} = 1.25$ rev/m.

rack. $\frac{152}{15} = 10.13$

total gearratio $= 660 \times 10.13 = 6690$

Rack $\frac{828}{6690} = 0.124$ rev/m

one rev. $\frac{60}{.124} = 484$ sec.

for 90° $\frac{484}{4} = 121$ sec.

Rack.

$\frac{828}{6200} = 0.1336$ rev. per. m

Time for rotation of 145°-01'-40" $= 145.0278^\circ$

$= \frac{1}{0.1336} \times \frac{145.0278}{360} = 3.015$ min

or $= 3$ min + 1 sec average.

Total time 3'-21"

100 449 1392 ÷ 15 × 30 = 6200564

15400

16200

No. of rev./min

			rev/m.	P. Diam mm.	Speed in m/min	Efficiency
worm gear.	worm.		828			
	worm wheel	$828 \times \frac{1}{74} =$	33.55			1.00
						0.700
1st gear	pinion		33.55	150	15.8	
	wheel	$33.55 \times \frac{15}{61} =$	8.25	610	"	0.700
						0.658
2nd gear	pinion		8.25	240	6.22	"
	wheel	$8.25 \times \frac{15}{38} =$	3.26	608	"	0.618
3rd gear	pinion		3.26	240	2.46	"
	wheel	$3.26 \times \frac{15}{61} =$	0.80	976	"	0.580
main pinion			0.80	400	1.005	
rack	~~off~~	$0.80 \times \frac{16}{96} =$	0.1336		1.01	0.580

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CALCULATIONS FOR

$FR_3 = 1315$ kgm

$F_w R_3 = \frac{3WP}{2\pi} = \frac{3W \times 2.54}{2\pi} = 1.212\,W$

$F_t R_3 = fWR_1 = 0.10\,W \times 3.58 = 0.358\,W$

$F_b R_3 = f_1 W r_3 = 0.010\,W \times 4.30 = 0.043\,W$

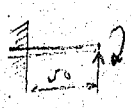
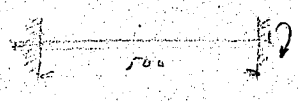
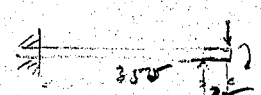
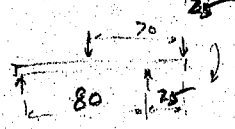
$1.613\,W$

$FR_3 = F_w R_3 + F_t R_3 + F_b R_3$

$1315 = 1.613\,W$

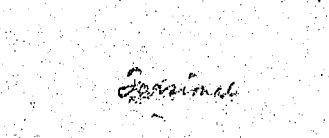
$W = \frac{1315}{1.613} = 815$ kg.

$k = \frac{W}{PA} = \frac{815.}{2.54 \times 5.62} = 5.71$

Shafts	HP transmitted N	no. of rotation/m n	length of shaft l		Torsional moment T		W
1st shaft	10.5	33.57	50 cm		2.5"	80 mmϕ	50.27 cm^2 × 0.470 kg/cm^2
2nd ″	9.87	8.25	500.		3.63	120	113.1 (0.89)
3rd. ″	2@4.64	3.26	380		5.67	120	113.1 (0.89)
main (minimum shaft	2@4.05	0.801	65			200	314.1 (2.47)

Torsional moment $T = 72600 \frac{N}{n}$

	$\frac{N}{n}$	T	Load on tooth
1st	0.313	22800 kgcm	3030 kg
2nd	1.197	86900	7230
3rd	1.424	103.400	8600
main	5.430	394200	19650



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CALCULATIONS FOR

Bending moment M.

1st. $\frac{0.4 \times 40^2}{10} = 60$

$\frac{3030}{2} \times 20 = 30300$

30360 kgcm

2nd. $\frac{0.9 \times 40^2}{10} = 140$

$\frac{7220}{2} \times 20 = 72300$

72440 kgcm

or $\frac{0.9 \times 460^2}{10} = 19050$ kgcm

3rd. $\frac{0.9 \times 40^2}{10} = 140$

$\frac{7320}{2} \times 20 = 72300$

72440

or $8600 \times 25 = 215000$

$\frac{0.9 \times 25^2}{2} = 300$

215300

Main shaft $\frac{25 \times 60^2}{10} = 900$ kgcm

$\frac{19650}{2} \times 30 = 294750$

295650

or $8600 \times 35 = 215000$

$\frac{215 \times 25^2}{2} = 8000$

215800

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CALCULATIONS FOR

Bearing pressure on Phosphore bronze

Trunnion ——————— 140 kg/cm²

Slow moving shaft (main pin shaft) — 70 "

ordinary speed shaft ——— 53

Finished bolts. shear 530 kg/cm²

22φ — 2090 kg
19φ — 1560
25φ — 2700
30φ — 3890
35φ — 5300
40φ — 6900

385 × 0.45 — 170

281 × 47 = 128

62

190

94

1450 × 0.05 — 62.5

100/d²

3.75

220500

526500
581100
789000

850400
667800
834000

2732000
3434500

0.009/25

1st

3060

14

28

7230

20

60

$$n = 9880w \frac{d^2}{l^2}\sqrt{\frac{1}{wl}}$$

$$= 9880w \frac{8^2}{28}\sqrt{\frac{1}{3060 \times 28}} = 8720$$

$$n = \frac{9880w \times 12^2}{40}\sqrt{\frac{1}{7330 \times 40}} = 7180$$

712

538

100 3600

1000

30

112

30×2

60

90.4

29.5

3.14

30

30

538

0.5 kg/cm² ordinary speed 74000

70 kg/cm² slow moving shaft journal or main shaft

2307000 × $\frac{11.2}{11.02}\sqrt{\frac{1}{1390 \times 11}}$ = 8720 / 1900

6730

122.6

74100

272

85

1 7000

2 8.27

20000

300,000,000

200,000

1740

33.57

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CALCULATIONS FOR

Nagahama – O – Hashi

Approximate weight of mechanical parts.
Sheet no. 31.

Bull wheel

rim	6.2 cm × 24	= 149			
	3.5 × 13	= 46			
	3 × 10	= 30			
	rib	13			
			238 × 400 = 95,000		
Arms.	42 × 3 × 72 × 4		= 35300		
"	22 × 3 × 2	= 132			
	16 × 3.5	= 56			
			188 × 90 = 16900		
Boss	50φ – 20φ	= 16500	× 55 = 91000		
Link boss	30 × 40 = 1200				
	18φ = 254				
		946 × 25 =	23500		
	7.5 × 3.5 × 60		= 16000		
			263300 @ .00786 =	2060 kgs	C.S. (2)
Phosphor bronze bushing	18φ – 15.8φ = 77.8 × 25 =		1950 @ .0082 =	16 kgs	Ph. Br (2)
Shaft.	20φ = 314 × 96 =		30200 @ .00785 =	237 kgs	#12 (2)
Bearing	3.5 × 32 × 90 =		10060		
	5.5 × 32 × 2.5 × 2 =		880		
rib	25 × 25 × 3.5 ÷ 2 × 2 =		2190		
	25 × 18 × 3.5 =		1580		
	16 × 17 × 3 × 3 =		2450		
	26 × 34 × 16 =		14130		
	– 18φ × 16 =		– – 4080		
			27340 @ .00786 =	215 kgs	C.S. (4)
	Bushing			15 kgs	住友PB P.B (4)

Sheet no 32.

Bull wheel Bearing casting.

BWC1.	14 × 3.5 × 90 =		4410		
	46.5 × 2.5 × 90 =		10470		
	34 × 2.5 × 150 =		12750		
	3 × 14 × 86.5 × 3 =		10900		
	30 × 37.5 × 3 × 3 =		10130		
			250		
			48910 @ .00786 =	385 kgs	C.S. (4)
BWC2.			4410		
			10470		
	9 × 2.5 × 46.5 × 3 =		3140		
	9 × 2.5 × 55 =		1240		
			250		
			19510 @ .00786 =	154 kgs	C.S. (4)

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CALCULATIONS FOR

Kaeahama – O – Hashi

Sheet no 33.

Main pinion

44φ × 30 =
− 20φ × 30 =
45600
9400

36200 @.00785 = 284 kg ✓ #12 (2)

Shaft.

20φ × 125 = 39300 @ " = 308 " ✓ " (2)

Boss. PB1.

38φ = 1134
24φ = 452
682 × 30 = 20460

54φ = 2290
38φ = 1134
1156 × 7 = 8090
20
28750 @.00785 = 226 kg ✓ C.S. (2)

Bushing

24φ = 452
20φ = 314
138 × 30 = 4140

28φ 616
20φ 314
302 × 2 = 610
4750 @.0082 = 39 kg ✓ P.B. (2)

Boss PB2.

27φ 573
17φ 227
346 × 20 = 6920

43φ 1452
27φ 573
879 × 6 = 5270
12190 @.00785 = 96 kg ✓ C.S. (2)

Bushing

17φ 227
14φ 154
73 × 20 = 1460

20φ 314
14φ 154
160 × 2 = 320
1780 @.0082 = 15 kg ✓ P.B. (2)

Collar pc

30φ − 20φ = 393 × 5.5 = 2160 @.00785 = 17 kg ✓ C.S. (2)

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CALCULATIONS FOR

Nagahama – O – Hashi.

Sheet no. 34.

Gearings.

1st gear.

W = P.F.D.C

Pinion W = 3.142 × 12. × 15. × .0388 = 22 × 3.83/2.5 = 34 kgs. # 32 (1)

wheel. W = 3.142 × 10 × 61 × .1044 = 84 × 3.18/2.5 = 107 kgs C.S. (1)

2nd gear.

Pinion W = 5.03 × 18 × 24 × .0388 = 84 × 3.56/2.5 = 120 kgs # 32 (1)

wheel W = 5.03 × 16 × 60.8 × .0407 = 200 × 3.18/2.5 = 255 " C.S. (1)

3rd gear

Pinion W = 5.03 × 18. × 33.6 × .0388 = 118 × 3.56/2.5 = 168 " # 32 (2)

wheel W = 5.03 × 16 × 136 × .0452 = 495 × 3.18/2.5 = 630 " C.S. (2)

Sheet no 35

Gear Bearings.

1st Bearing

19 × 3.4 × 76.4 = 4940
14 × 24 × 3 = 1010
8 × 17 × 2 = 270
10 × 10 × 2 = 200
10 × 12 × 2 = 240
14 × 13 × 3 × 2 = 1090
11 × 7 × 2 × 2 = 310
21 × 27 × 15 = 8550
14.4φ × 15 — 2490
13 × 19 × 12 = 2970
8.8φ × 12 — 730
16360
16360

8 × 3 × 2 = 48
5 × 2 × 2 = 20
68 × 14 = 950

33670 @ .00725 = 245 kgs C.I. (1)
25 kgs P.B. (1)

Bushing

2nd Bearing

19 × 3.5 × 89.4 = 5940
17 × 62 × 3. = 3170
14 × 3 × 16.4 = 2690
14 × 2.5 × 15 = 5250
22 × 28 × 15 × 2 = 18470
14.8φ × 15 × 2 — 5160
25630
25630

30 × 3.5 = 105
9 × 3 × 2 = 54
159 × 22 = 3500

54760 @ .00725 = 400 kgs C.I. (1)

Bushing 14.9φ − 12.5φ = 50.7 × 15.6 = 791
17.3φ − 12.5φ = 112.4 × 2.4 = 270
1061 @ .0082 = 8.7
8.7/17.4 × 2 = 35 kg P.B. (1)

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3rd Bearing.

Sheet no 37

	31 × 3.5 × 45 =	4880		
	15 × 3 × 25 × 2 =	2250		
	19 × 3 × 14 × 2 =	1600		
	9 × 3 × 14 =	380		
	22 × 27 × 14 × 2 =	16620		
	14.9φ × 14 × 2 =	4870		
	25 × 3.5 × 21 =	1840		
	9 × 3 × 2 × 23 =	1240		
		23940 @ .00786 =	190 kg. ✓ C.i.	(2)
Bushing	14.9φ − 12.5φ = 51.7 × 14.6 =	755		
	17.3φ − 12.5φ = 112.4 × 2.4 =	270		
		1025 @ .0082 =	8.5 × 2 = 17 ✓ kg. P.B.	(2)

Sheet no 38.

Base frames for motors + gear bearings.

for 1st Bearing	1BF	210 × 894/764 ≒	210 kg	Steel.	(1) 210
2nd "	2BF		250 "	"	(1) 250
3rd "	3BF		60 kg	"	(2) 120
motors + worm	MF		650 "	"	(1) 650 ✓
			(合計 = 1230 kg ✓ = 60 kg ✓		Steel (1) C.i. (1)

Bed casting

Sheet no. 39.

Worm gearing.

190 kg ✓	C.i.	} (1)	重り用
70 ✓	予備		取付用
50 ✓	P.B.		

motor shaft bearing	18 kg ✓	C.i.	(1)
Claw clutch — 31 —	20 kg ✓	C.i.	} (1)
	32 ✓	steel	

Sheet no 40.

Shafts.

1st shaft.		80φ × 92.7 = 4660 @ .00785 =	37 kg ✓	予校	(1)
2nd shaft		12.5φ × 165 = 20200 @ " =	159 ✓	"	(1)
		11.7φ × 359 = 3860 @ " =	303 ✓	steel	(1)
3rd shaft	S3a	13φ × 95 = 12600			
	"	12600			
	S3c	13φ × 164 = 21800			
		47000 @ .00785 =	370 kg ✓	予校	(1)
	S3b	12.2φ × 246 = 2880			
	"	2880			
		57600 @ " =	452 kg ✓	steel	(1)

Flanged couplings.

C_2		22φ − 11.5φ = 276 × 38 = 10500			
		42φ − 22φ = 1005 × 7.6 = 7640			
		5.4 × 1.3 × 128 = 900			
		19040 cm² × .785 = 138 kg			
		bolts 2	145 kg × 2 = 290	✓	
C_3		say	160 × 4 = 640		
			930 kg	C.i.	(1)

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Air Buffers.
Sheet no. 44.

Front air buffer.			
Cyl.	20.5$^{\phi}$ − 16.5$^{\phi}$ = 116 × 29.	= 3360	
	16.5$^{\phi}$ × 5.2 =	= 1120	
	7 × 1 × 18 × 2	= 250	
	23 × 2.2 × 27.5	= 1390	
	17 × 1.6 × 2 × 8	= 435	
	7 × 2 × 22	= 310	
		6865 e.w7s × 50	kg. e.i.
piston	16.5$^{\phi}$ × 7.0	= 1200 e.w7s = 11	c.i
Bearing blocks	27 × 27 × 3 =	2200	
	12.6 × 12.6 × 5.5 =	880	
	8.6 × 8.6 × 5.5 = —	410	
		2670 e.w7s = 20	c.i
	Bolts + rings say	9	
		90 kg c.i.	(2)
Piston rod.	5.0$^{\phi}$ × 42 = 820		
nut.	7.0$^{\phi}$ × 8.5 = 330		
	1150 e.w7s =		9 kg ∮ 22 (2)
Rear air buffer.			
	cyl. Piston bearing blocks &c. say		120 kg c.i. (2)
	Cut casting 20$^{\phi}$ × 24 = 7540 e.w7s = 55		
	bolts &c. 5		60 kg c.i. (2)
Piston rod	say		11 kg. P.B. (2)
Pulley	16$^{\phi}$ × 3 = 603 × $\frac{1}{3}$ = 402		
bearing	14 × 17 × 2 = 480		
	8 × 8 × 1 × 2 = 130		
	3 × 6 × 12 × 2 = 43		
	5.8$^{\phi}$ − 2.5$^{\phi}$ = 21 × 4.4 = 92		
pin	2.5$^{\phi}$ × 9 = 45		
	1192 e.w7s =		9 kg c.i. (2)
Connection			110 kg steel (2)
Rear stopper	bearing blocks	say	20 kg c.i (2)
steel framing			500 steel (2)

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Sheet no.			Cast steel	Phosphor bronze	
26	Balance beam trunnion boss BS.		605 kgo		②
"	Balance beam Trunnion shaft BT		212 (半硬鋼)		②
'	Balance beam trunnion Bearing BB.				
	Base 104.0 × 4.0 × 100.0 =	40,080			
	Bear. 2 c 31.5 × 24.0 × 49.0 =	74,000			
	Rib. 2 c 13.0 × 4.0 × 28.5 =	2,960			
	' 2 c 30.0 × 4.0 × 35.0 =	8,400			
	' 9.0 × 3.0 × 72.0 =	1,945			
	' 15.0 × 4.0 × 80.0 =	4800			
	' 18.0 × 3.0 × 80.0 =	4320			
	' 20.0 × 4.0 × 80.0 =	6,400			
	less hole 24.0$^{\phi}$ × 48.0 = -	21,700			
		121,125 × 0.00786 = 950			②
	Bushing 24.0$^{\phi}$ × 48.0 =	21,700			
	29.0$^{\phi}$ × 8.0 =	5280			
	less 20.0$^{\phi}$ × 56.0 = -	17600			
		9,380 × 0.0082	=	77 kgo	②
25	Link boss LB3		130	25	②
"	Link boss LB2		275	25	②
"	Link boss LB1		188	24	②
"	2nd link L2		642		②
"	Pins P1, P2, & P3		63 (半硬鋼)		各②合⑥
"	Bearing casting LC1		17		④
"	Bearing casting LC2		62		②
"	First link L1		2,300 (構造鋼)		②
27	main Trunnion bearing TB				
	Base 39.5 × 3.0 × 126.0 =	14,930			
	Bear. 26.5 × 17.0 × 29.0 =	13,050			
	rib 2 c 23.0 × 2.5 × 14.0 =	1,608			
	' 23.0 × 2.5 × 24.0 =	1,310			
	' 2 c 23.0 × 2.5 × 12.5 =	1,437			
	' 9.5 × 3.0 × 7.0 =	200			
	' 2 c 14.5 × 3.0 × 19.5 =	1,695			
	' 2 c 16.8 × 3.0 × 15.5 =	1,560			
	less 18.0$^{\phi}$ × 17.0 = -	4325			
		39,465 × 0.00876 = 276			④
	18.0$^{\phi}$ × 17.0 =	4325			
	23.0$^{\phi}$ × 3.0 =	1,246			
	less 15.0$^{\phi}$ × 20.0 = -	3,535			
		2,036 × 0.0082 =		17	④
"	Boss TS		215		②
"	shaft TS		132 (半硬鋼)		②

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CALCULATIONS FOR

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sheet no.						
			cast steel	phosphor bronze		
27	Shoe of trunnion bearing TBS					
	Top 2 e	39.5 × 3.5 × 62.0 =	17,140			
	Bottom	65.0 × 3.5 × 54.5 =	12,400			
	back	92.0 × 3.0 × 100.0 =	27,600			
	rib 2 e	36.5 × 5.5 × 88.5 =	35,550			
	〃	27.0 × 5.5 × 57.0 =	8,460			
	Bottom 2	65.0 × 5.0 × 45.5 =	14,780			
	projection	4.5 × 5.0 × 116.0 =	2,610	✓		
			118,540 × 0.00786 =	932 Kg		②
30	Operating link OL			712 ✓		③
〃	Pins P4 e P5			57 ✓ (半硬鋼)	左⑤ 右④	④
〃	Boss LB4			136 ✓	16 ✓	③
46	Indicator					
	gear 2 e	12.5ϕ × 4.0 =	978			
	〃 2 e	7.0ϕ × 7.0 =	269			
	〃	6.5ϕ × 4.0 =	133			
	〃	7.0ϕ × 8.0 =	308			
	less	2.5ϕ × 23.0 = −	113			
			1,575 × 0.00786 =	12 ✓		
	shaft	2.5ϕ × 58.0 =	285			
	〃	2.5ϕ × 69.0 =	339			
	〃	2.5ϕ × 305.4 =	1,500			
		15.0ϕ × 2.0 =	353	✓		①
			2477 × 0.00786 =	20 (半硬鋼)		
	Bearing	26.0 × 2.0 × 31.0 =	1,610			
	〃 2 e	8.5 × 2.0 × 17.0 =	578			
	2 e	5.0 × 2.0 × 12.0 =	240			
		18.0 × 2.0 × 26.0 =	937			
		6.0ϕ × 4.0 =	113			
		8.0 × 3.0 × 14.0 =	336			
		9.0ϕ × 6.0 =	382			
		7.0ϕ × 7.0 =	269	✓		
			4,465 × 0.00725 =	33 (鋳鉄)		
43	Hand brake			91.1 (鋳鉄)		①
				26.0 (structural steel)		
				11.2 (半硬鋼)		
				2.1 (砲金)		
47	Front gate					
	bar	5.5 × 3.5 × 6.0 =	116	193 × 0.00786 = 1.5 (土質)		
	shaft	3.5ϕ × 16.0 =	154 77			
	rod	4.0ϕ × 6.5 × 419 =	1,090	1703 × 0.00786 = 13.4 (土質)		
	lock	5.0ϕ × 6.5 × 16.5 =	536			
			1893 × 0.00786 =			

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CALCULATIONS FOR

Sheet no 47

Rear gate

Base
26.5 × 2.5 × 53.5 = 3,540
26.5 × 2.5 × 34.5 = 2,275
17.5 × 3.5 × 34.0 = 3,270
22.5 × 2.0 × 56.5 = 2,540
11,625 × 0.00725 = 84.2
÷2
168.4

80 × 2.0 × 46.0 = 735 × 0.00725 = 5.4
173.8 kg (e.l)

Summary for rear gate

gate bar 1 @ 34.5 = 34.5 + (支地金物)

751.7 / 173.8 } = 925.5 kgs (cast iron) ✓

bushing 3.7 kgs (phosphor bronze) ✓

96.0 / 17.5 } 97.5 kgs (半硬銅) ✓

20.5 (cast steel) ✓

motor 1 HP 1台 ①

Front lock & gate

gate bar 1 @ 34.5 = 34.5 + (支地金物)

1,175. kgs (cast iron) ✓

25 kgs (phosphor bronze) ✓

165 kgs (半硬銅) ✓

20.5 kgs (cast steel) ✓

motor 1 HP 1台 ①

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CALCULATIONS FOR

参考

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Summary of weight for mechanical parts.

		550 半硬鋼	650 鋳鋼	鋳鉄	(200) 軟鋼	2600 鍛造鋼	4 組立	4 本
1	Balancing link	378 Kg 210 円	2662 Kg 1730 円		4600 Kg 960 円	148 ~~302~~ Kg 370 円	3270 円	3400 円
2	Balance beam shaft bearing + boss	424 230	3110 2020			154 385	2635	2600
3	Trunnion shaft, bearing, boss + shoe	264 150	3398 2210			68 170	2530	2400
4	Operating link + boss	228 120	1696 1100			32 80	1300	1300
5	Bullwheel, shaft, bearing + bearing casting	474 260	7136 @750 5350			92 230	5840	5300
6	Main pinion shaft, boss + collar	1184 650	678 440			108 270	1360	1300
7	1st, 2nd + 3rd gears.	490 @1500 740	1622 @1200 1950				2690	2600
8	do bearings			1025 (500) 510		94 235	745	700
9	Base frames for motor + bearings			60 (500) 30	1230 250		280	250
10	Worm gear.	70 40		190 (½) 95		50 125	260	300
11	1st, 2nd, + 3rd Shafts	566 310		930 (500) 465	~~755~~ 755 @560 380		1135	1100
12	Claw clutch + motor shaft bearings			38 (½) 19	32 6		25	150
13	Front + rear air bufferes	18 10		478 (600) ~~315~~ 120 cut. 315 (200)	1220 245	22 55	625	800
14	~~Hand~~ brake	11 ~~5~~		91 (500) 45	26 5	2 10	65	150
15	Indicator mechanism	20 10	12 8	33 (½) 17			35	150
16	Front end hook + front + rear gates	263 150	41 30	2100 (300) 630		29 75	860	1000
		4390	20,355	5065	7863	~~953~~ 799	23675	23100
			29,810					

38,626

四日市陸事ノ部案

半硬鋼	4.390 ton	@ 1550	= 6800	800	3500
鋳鋼	20,355	@ 1380	28000	650	13200
鋳鉄	5.065	@ 720	3600	450	2300
軟鋼	7.108	@ 300	2100	200	1400
〃 shaft	0.755	@ 1000	800	500	400
鍛造鋼	~~0.953~~ 0.799	@ 3300	2600	1500	1200
			43900		22000

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CALCULATIONS FOR

Nagahama-O-Hashi.

参考

月島、幸橋と比較
橋軸直角一式小出し如し

1		233	2125		1335 @2m	442	4135	4100
2		262	2480			460	3202	3200
3		163	2710			203	3076	3000
4		140	1353			96	1089	1600
5		292	7136 @10m			276	7704	7700
6		730	541			320	1591	1600
7		302	2285				2488	2500
8				545		280	825	800
9				32	308 @2m		340	300
10		43		101		150	294	300
11		350		495	426 @2m		1271	1200
12				20	6		26	200
13		11		315 @8m	305	66	696	900
14		7		49	6	15	77	200
15		12	10	18			40	200
16		163	33	840 4m		87	1123	1300
								29100

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CALCULATIONS FOR

跳ね橋及バスキュール橋 第一次概算

Structural steel for Bascule Span

Roadway area. 5.5 × 22.0 = 121 m²

Bascule leaf	121 m² @ 0.25	=	30.0
Balance Beams + laterals			35.0
Cut girders			10.0
Trunnion girders			5.0
Operator's house framing + maschinery framing			10.0
Girders + posts			10.0
		100.00 tons @ 200 =	20,000
Floor + pavement	121 m² @ 13	=	1600
Operators house	1 @ 600	=	600
Counterweight	25 m³ @ 200	=	5000
Maschinery	1 @	=	12,000
			800

Superstructure of Bascule span complete = 40000 円

Fixed span
Road way area 5.5 × 56 = 310 m²

Structural steel	310 m² @ 0.48 = 150.0 tons.		
	for 4 spans @ 120.0 = 600 tons @ 150 =		90,000
Floor + pavement	4 @ 310 =	1240 m² @ 11 =	13,700
Handrails	56 × 4 × 2 = 450 m @ 10 =	45 tons @ 200 =	9000
鋲打及び溶接取付人夫			5,000
Drains construction			1,500
misc say			1000
			1800

Superstructure of fixed spans complete = 122000 — 340
上部工2基分 = 162,000 円

Substructures.
Bascule Pier

Concrete well	8.0 × 7.0 − 6 × 5 = 26.0 × 15.0 =	390.0	
	file 30 × 5.0 =	150.0	
Shaft.	5.0 × 4.0 × 7.5 =	540	
		150	
		690 m³ @ 15 =	10,400
		40 tons @ 100 =	4000
		120 m² @ 20 =	2,400
		@ 6 =	5700
			5,000
			5,000
			2,000
			30,000 円
Reinforcement	say 4		6600
forms.			3000
excavation	7 × 8 = 56 × 17 = 950 m³		
埋戻及び盛土	(掘削土ハ捨ル)		
土砂防止設備			
misc.			
			126,000 円.
Fixed span piers	@ 270 m	下部工2基	
Abutments	2 @ 150 m	総工費 =	288,000 円

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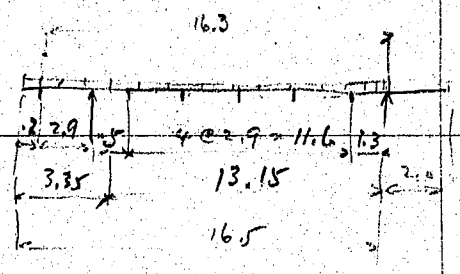
6.3×9.6 = 60.5 felt. 2.5 63.

Bascule Bridge for Nagahama Cho.

Dead load of moving leaf. River conn.					Hor m.		vert m.	abt. crown.
floor 6.3m w. b. pavement	5.5×17.5	@ 63. kg	=	6070	8.75		.057	346
10cm planking	6.0×17.5	@ 83.	=	8720	"		.107	933
Coping 20×21.5 cm =	2@.043×17.5	@ 830	=	1250	"	156,600	.008	10
facing plank	2@.3×.04×17.5	@ 830	=	350	"		.135	47
railing pieces	7@.15×.10×17.5	@ "	=	1530	"		.207	317
" on F.B.	8@.30×.10×5.0	@ "	=	1000	9.1	9,100	.207	207
handrails	2×17.5	@ 100	=	3,500	8.75	30600	-.55	-1,925
Steel. Stringers	7×17.5	@ 42	=	5140	8.75	45000	.41	2,190
floor beams.	6	@ 900	=	5400	8.33	45000	.74	3990
"	2	@ 2200	=	4400	11.50	50600	.89	3915
cable connection	2	@ 800	=	1600	11.50	18400	.25	400
lateral bracing	17.5	@ 110	=	1930	8.75	16900	1.45	2795
main girder	2	@ 8000	=	16,000	6.50	104000	.85	13600
machinery	17.5	@ 40	=	700	8.75	6100	.60	420
Racks	2	@ 600	=	1200	-1.50	-1,800	-.15	-180
trunnion bears	2	@ 300	=	600	0.0	0	1.15	690
				59,390 kg.	8.10	480,500	0.47 m	27,755

14m clear / c.l.

Dead load on main girder = $\frac{59390}{18 \times 2}$ = 1650 kg/m of one girder.



Dead load moment
$\frac{1}{8} \times 1650 \times 11.15^2$ = 35,700
$\frac{1}{2} \times 1650 \times 3.35^2 \times \frac{1}{2}$ = − 460
31,100 kg-m.

Live load moment
$\frac{1}{8} \times 1375 \times 16.3^2$ = 45600
$\frac{1}{4} \times 1000 \times 16.3$ = 410
4970
80800 kg-m

500 × 2.75 = 1375 kg
Concentration

t my web pl 1200×9 = 108. $\frac{1}{8}$ web = 13.5 cm²
eff depth say 121 − 8 = 112 cm

flg. stress = $\frac{8080}{1.12}$ = 71,500 kg

net area req'd. = 71500 ÷ 1200 = 59.6
13.5
46.1 cm² net

Use 150×150×12 = 69.12 − 12 = 57.12 net.

16.5m
1375
2062.5

moment as a simple span of 16.3m
$\frac{1}{8} \times 2062.5 \times 16.3^2$ = 10,050 m

$\frac{100400}{112 \times 12}$ = 74.0 net
13.5
60.5 net

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CALCULATIONS FOR

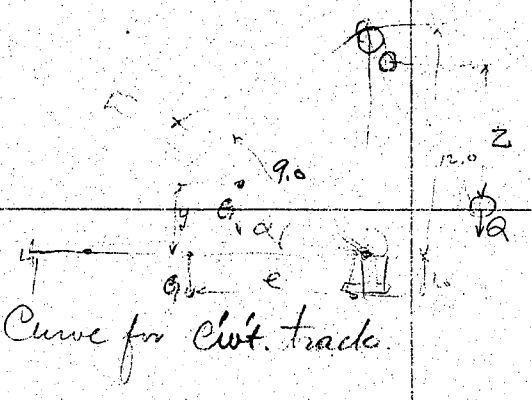
Rascule bridge for Nagahama-cho.

approx. weight of main girder

flange	69.12					
	69.12					
web	108.cm					
	246.24 @.785 =	193.0				
details say 32% =	62					
		255. × 15.2 =	3880	× 8.8 =	34,100	
		10m × 3.3 =	3320	× 0.6 =	2cm	
			7,200 kg.		4.45m	32,100 kg.m

Center of gravity of moving leaf.

				her arm	m	vert arm from crown	m
floor. 6.3cm wood block	15.5 × 15.5 @ 60 kg	=	5120	8.65		.057	290
10cm planking	6.0 × 15.5 @ 83	=	7720	"	135,000	.107	880
Coping 20 × 21.5cm	2 × .043 × 15.5 @ 830	=	1110	"		.008	10
facing plank	2 × .3 × .04 × 15.5 @ 830	=	310	"		.135	40
nailing piece	7 @ .15 × .10 × 15.5 @ "	=	1350	"		.207	280
" on F.B.	8 @ .3 × .10 × 5.0 @ "	=	1000	8.11	8110	.207	210
handrails	2 @ 15.5	@ 70 =	2170	8.65	18,770	- .55	- 1190
Steel Stringers	7 × 15.5	@ 42 =	4560	8.65	39450	.41	1870
floor beams	5	@ 900 =	4500	7.73	34800	.74	3330
"	2	@ 180 =	360	13.15	4740	.89	320
cable conn.	2	@ 80 =	160	13.15	2100	.25	40
lateral br.	15.5	@ 110 =	1710	8.65	14800	1.45	2480
main girders	2	@ 7200 =	14400	4.45	64100	.85	12,250
machinery	15.5	@ 50 =	780	8.65	6750	.60	470
Racks	2	@ 60 =	120	-1.80	- 2160	0	0
trunnion bears	2	@ 30 =	60	0	0	.85	510
			51,730 kg	7.50m	388,070	0.484m	25040



Curve for Cwt. tracks.

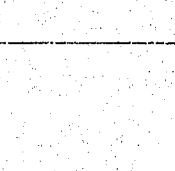
Cwt. reqd. = $\frac{388070}{9.0}$ = 43,000 kg

$Z = \frac{G}{Q} y = \frac{G}{Q} e \sin\alpha$

$e = 7.50^m$, $\frac{G}{Q} = \frac{51730}{43,000} = 1.203$

$Z = 1.203 \times 7.5 \sin\alpha = 9.02 \sin\alpha$

α	Sin α		Z
0°	0.00000	× 9.02 =	0.000
10°	0.17365		1.566
20	0.34202		3.088
30	0.50000		4.510
40	0.64279		5.800
50	0.76604		6.910
60	0.86603		7.810
70	0.93969		8.480
80	0.98481		8.890
90°	1.00000		9.020
5°	0.08716		.786
2°-30'	0.04362		0.393
82°-30'	0.99144		8.94



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CALCULATIONS FOR

Bascule Bridge for Nagahama

(2)

Cwt. required (Q) = $\frac{388070}{9.90}$ = 39,200 kg G = 51,730 kg e = 7.50 m

$\frac{G}{Q} = \frac{51730}{39200} = 1.320$

Cwt. track curve $Z = \frac{G}{Q} e \sin\alpha = 9.90 \sin\alpha$.

α	$\sin\alpha$		Z
0°	0.00000	× 9.90 =	0.000
2°-30	0.04362		0.432
5°	0.08716		0.863
10°	0.17365		1.718
20	0.34202		3.385
30	0.50000		4.950
40	0.64279		6.360
50	0.76604		7.580
60	0.86603		8.570
70	0.93969		9.300
80	0.98481		9.750
82°-30'	0.99144		9.810
90°	1.00000		9.900

Cwt. truck girder.

span length 2.5 m Cwt. 20,000 × 1.3 = 26,000 kg

Moment $\frac{26000 \times 2.5}{4}$ = 16250 kgm

Appl. force $\frac{16250}{.45}$ = 36100 kg ÷ 120 cm = 3.0 kg/cm

r_{min} = 0.4 × 50 = 20

I = 385 × 4 cm = 154,000 cm⁴

Bending Stress: $\frac{16250 \times 100 \times 30}{154000}$ = 317.0 kg/cm²

Direct stress $\frac{26000 \times 15.0}{4} = \frac{90000}{2.3}$ kgm = 39,000 kg

$\frac{39000}{383} = 102.0$

$\frac{317}{420}$ kg/cm²

Ptes	9.5 × 12 =	114.
2 web plates	1.0 × 100 × 1.0 =	100
6 angles	2 × 15.5 × 100 × 1.2 =	171.4
		385. cm²

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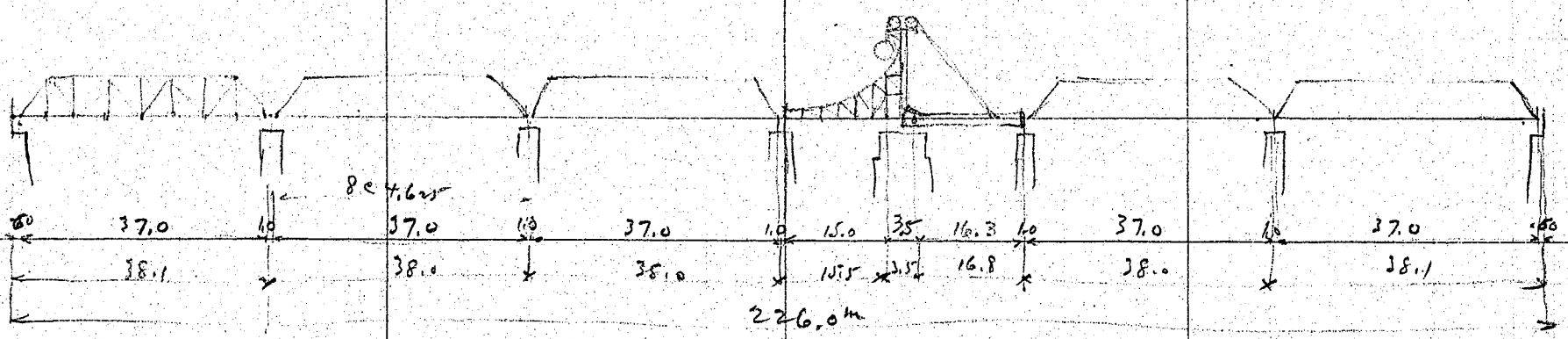
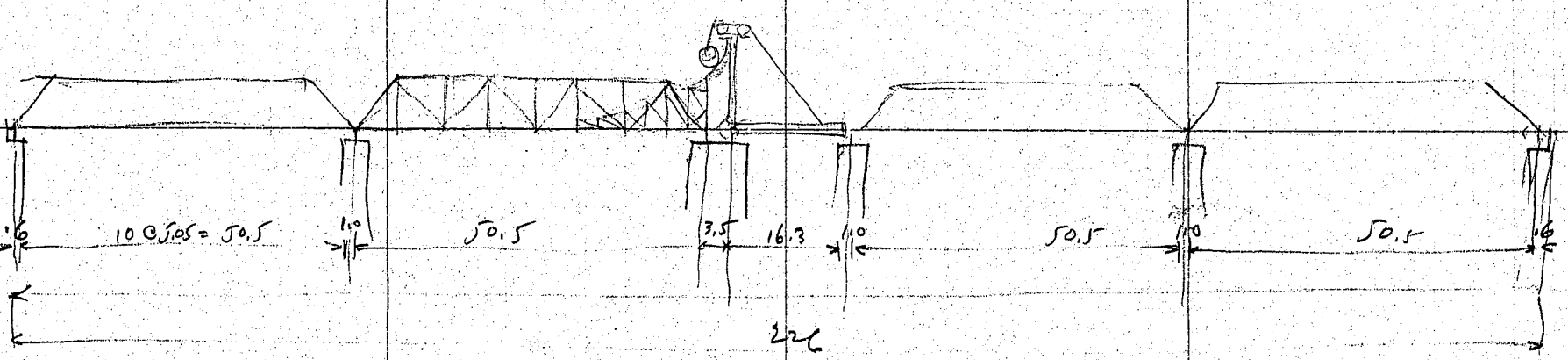
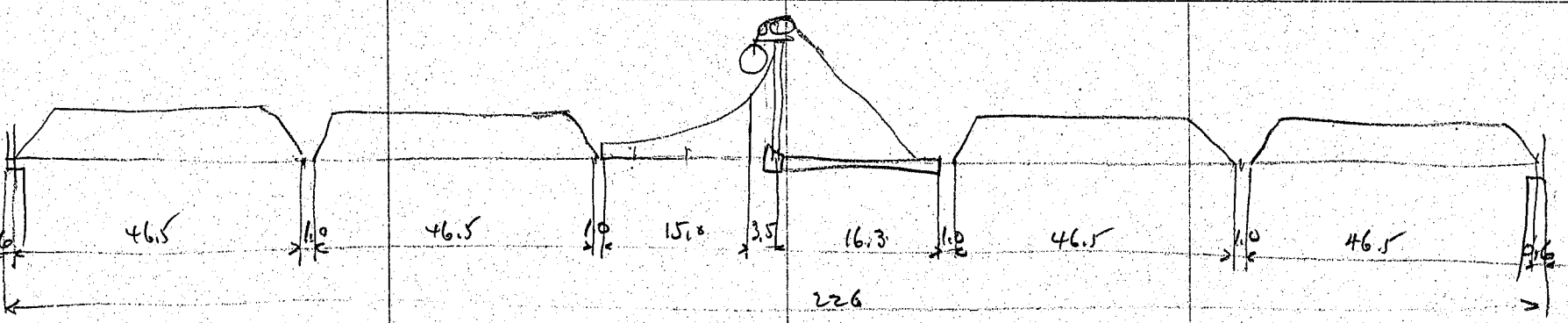
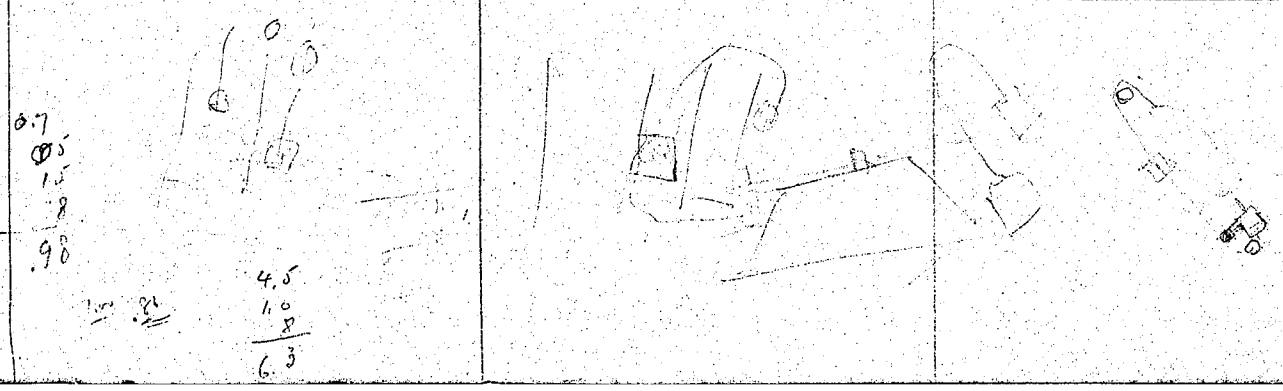
CALCULATIONS FOR









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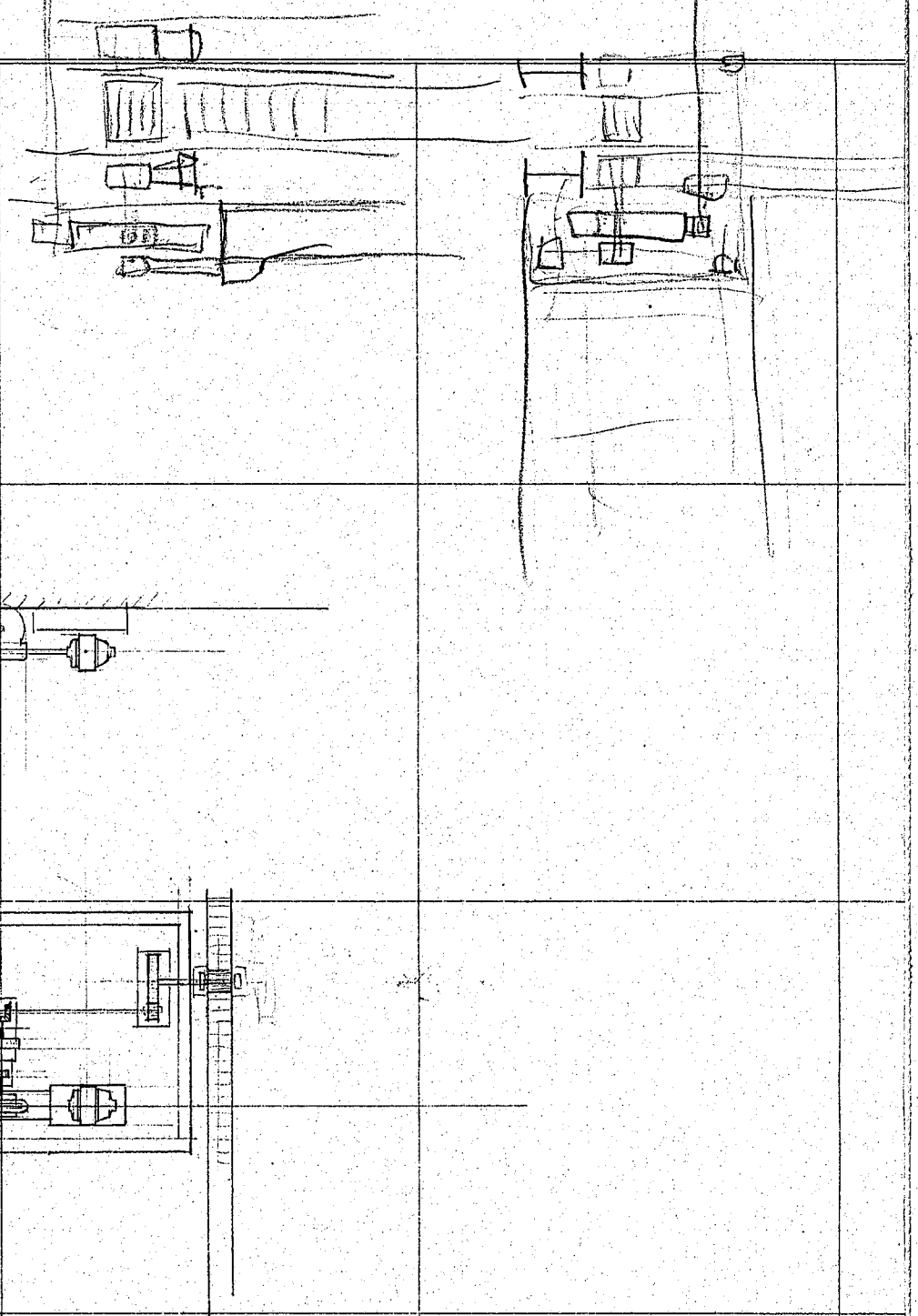

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CALCULATIONS FOR

Estimate of Bascule Bridge for Shinmachi.

T. 鈑桁 Structural steel

Bascule span.

	Stringers	7 - 15.5 @ 42	= 4560
	floor beams	5 @ 900	= 4500
	"	2 @ 1800	= 3600
	Cable connection	2 @ 800	= 1600
	lateral bracings	15.5 @ 110	= 1710
	main girders	2 @ 7200	= 14400
	Rack circle fillers + boss	2 @ 900	= 1800
	Exp joint Say		1000
	floor break Say		3000
	Shoes Say	2 @ 500	= 1000
	misc Say		830
			38,000 kg.

Tower + Cwt. track span.

	Tower columns.		20,000
	Sheave bearing gallage	2 @ 1500	3000
			23,000
	Stringers	4 @ 20 @ 52	= 4160
	floor beams.	5 @ 1100	= 5500
	lateral bracing	20 @ 150	= 3000
	tap lateral bracing	Say	= 2000
	main trusses	2 @ 14000	= 28,000
	Cwt. track	2 @ 1500	= 3000
	Exp jt Say		1000
	Shoes "	2 @ 600	= 1300
	misc "		1140
			49,000
			110,000 kg.

Cast steel.

	Sheaves with bearings	2 @ 1000	= 2000
	trunnion bearings	2 @ 1000	= 2000
	Rack + boss castings	2 @ 1000	= 2000
	Cable conn	2 @ 500	= 1000
			7,000
	Cwt. casting (castiron)	2 @ 20000	= 40,000

Handrails.

2 × 36 @ 70 = 5,000 kg.

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CALCULATIONS FOR

$\frac{1}{2}P = 42 + 62 = 104$

Estimate of Bascule Bridge for Shime ken.

Roadway area. 16 × 5.5 = 88 sq. m. for moving leaf

Estimate of cost.

Structural steel	110.00 tons	@	200 =	22,000
Steel castings	7.00 "	@	350 =	2,500
Cwt. castings	40.00 "	@	80 =	3200
				27,700
floor + pavement	88.0 m²	@	13 =	1100
Handrails with gate.	5.0 tons	@	250 =	1300
drains + misc. say				1100
				2,500
Operation house say				800
machinery complete say				1200
Electric arangement complete say				1,350
			(T)	46,500

Overhead type, add extra expense of 2000 ¥ total (T) 48,500 ¥

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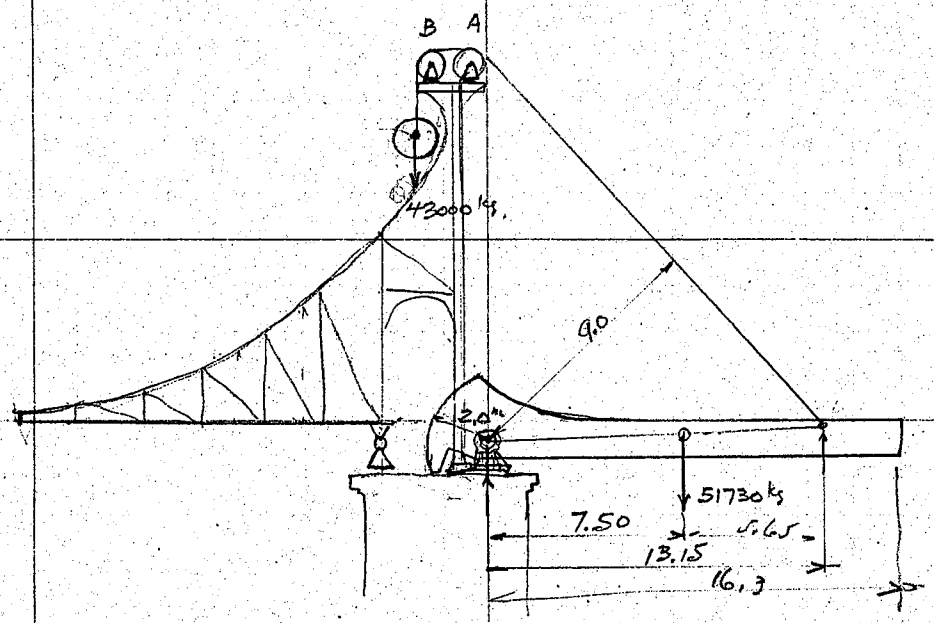
CALCULATIONS FOR

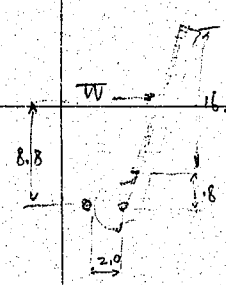
Bascule Bridge for Ehime Ken

Approximate calculation of Operating power.



	Bridge closed.		Bridge opened.	
Load on trunnion	$\frac{51730 \times 5.65}{13.15} = 22200$ kg.		say	51730 kg
" " Cable pin	= 43000		$\frac{51730 \times 1.0}{10.25}$ =	5050 kg.
" " A sheave	= 43000 × 0.78 =	33500	say	4000
" " B "	= " × 1.414 =	60800	"	4000
" " Roller pin	=	43000		5050

Wind. 25 m/s wind wind pressure = 61 kg/m² (12.5 #/ft²)



Wind pressure $W = 6.7 \times 16 \times 61 = 6540$ kg.

Wind load on trunnion $= \frac{6540 \times 8.8}{2.0} = 28800$ kg

Wind load on trunnion $= \sqrt{6540^2 + 28800^2} =$ 29500 kg.

$\frac{D}{d} = 50$

$\theta = 0.145$

$\frac{20,000 \times 0.6}{29,500} = 39$.

Rack force due to journal friction.

		Bridge closed	Bridge opened.	
Load on Trunnion	$22200 \times 0.15 \times \frac{0.3}{2.0} =$	500	$51730 \times 0.15 \times \frac{0.3}{2.0} =$	1165
" Cable pin	$43000 \times 0.15 \times \frac{0.15}{2.0} =$	485	$5050 \times 0.15 \times \frac{0.15}{2.0} =$	57
" A sheave (T)	$43000 \times 0.4 \times \frac{1}{46} \times \frac{9.0}{2.0} =$	1680	$5050 \times 0.4 \times \frac{1}{46} \times \frac{10.25}{2.0} =$	225
" B " (T)	43000 × " × " × " =	1680	5050 × " × " × " =	225
" Roller pin	$43000 \times 0.15 \times \frac{0.15}{1.0} \times \frac{9.0}{2.0} =$	4355		0
" roller friction		0	$43000 \times \frac{1}{100} \times \frac{10.25}{2.0} =$	2205
		8700 kg.		3880 kg
Unbalancing say	500 kg at front shoe.			
	$500 \times 16.3 \div 2.0 =$	4070	$500 \times 1.0 \div 10.25 =$	50
wind		0		28800
Summary of rack force		12770 kg		32730 kg.

Time of operation open or close 180 sec each.

		Equivalent Time of uniform speed.
Time of acceleration	20 sec	$\times \frac{1}{2} = 10$
" " uniform speed	140	$= 140$
" " retardation	20	$\times \frac{1}{2} = 10$
	180	160 sec.

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CALCULATIONS FOR

Bascule Bridge for Edajima Ko.

Speed of rack circle = $\pi \times 2.0^{m} \times \frac{80^{\circ}}{180^{\circ}} \times \frac{60^{sec}}{160\,sec} = 1.048\,^{m}/min$

$33000^{\#} = \frac{33m}{7.2331} = 4560^{Kgm}$

Theoritical HP required

at no wind $HP = \frac{12770 \times 1.048}{4560} = 2.94$

against 25" wind $HP = \frac{32730 \times 1.048}{4560} = 7.52$

Gear efficiency assumed. worm gear gear
$0.70 \times 0.94^3 = 0.58$

Required actual HP.

No wind $HP = 2.94 \div 0.58 = 5.07$ HP. Call this 5.0 HP

against 25" wind $HP = 7.52 \div 0.58 = 12.97$ HP. " 13.0 HP.

Operation by Human power.

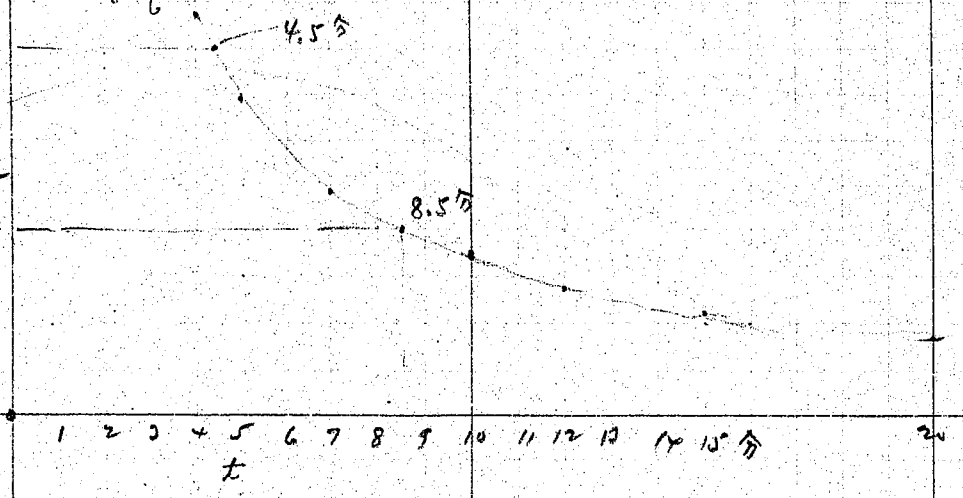
Hor. force by one man assumed 30 kg. } 1800 kgm/min
Speed 60 m/min }

HP exerted by one man $= \frac{1800}{4560} = 0.395$ HP.

n = no. of man.
t = time of operation in sec. (assu

Then $n = \frac{5.07 \times 160}{0.395 \times t} = \frac{2055}{t}$

t		n.
5 min	= 300 sec	6.9 ÷0.58=12
10	= 600	3.5 " 6.0
15	900	2.3 " 4.0
20	1200	1.7 " 3.0
25	1500	1.37 2.4
30	1800	1.14 2.0



33000 #

3.28 × 2.2

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CALCULATIONS FOR

Estimate of cost of Bridge over Tsurumi at Nagahama Shimaken

Total length of bridge 236 metres over all in which 1 bascule span required. Roadway 5.5 metre wide.
After the study we allowed to estimate for the following layouts.

No 1. layout { Bascule proper (16.3 + 3.5 + 15.0) = 34.8 including counter weight truss
fixed span 5 fixed spans of 37.0 metres each c/c to c/c of end bearings.

No 2 layout Bascule span same as above fixed spans consist of 4 spans of 46.4 c/c of end bearings

No 3 Layout Bascule span same as above one counter weight truss combined with one of fixed span fixed portion divided into 5 equal span of 40.2 metres each

No 4 Layout do - fixed portion divided into 4 equal span of 50.5 metres each

Layout No 3 and Layout No 4 shall be overhead machinery type for bascule instead of machinery on pier - and same layout as for No 1 and No 2 respectively -

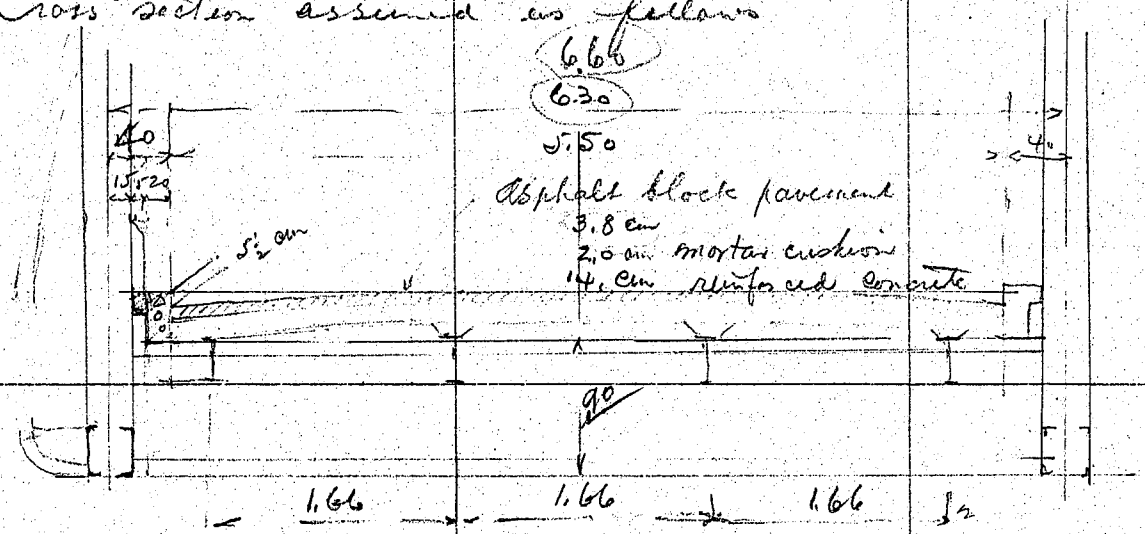
We shall estimate the cost of fixed spans

First	37.0	metre fixed span
Second	46.4	" " "
Third	40.2	" " "
Forth	50.5	" " "

in which 37.0 and 40.2 metre spans shall be pony truss and 46.0 and 50.5 metre spans shall have top lateral bracings and sway bracings.

1. 37.0 metre fixed span clear roadway 5.5 metres reinforced concrete slab paved with Asphalt block, loading class III for perfectural highway bridge.

Cross section assumed as follows



6.30
5.50
8.0

1.6
3
48
55
7

1.66
.3
4.98

5.50
4.98
.52
.26

The span is divided into 8 panels of 4.63 metres and the height of truss 4.5 metres

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11.3
2.5
14.0

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CALCULATIONS FOR

Estimate of Cost of the Bridge over Hijikawa at Nagahama, Ehime-ken.

Dead Load of floor.

Pavements	3.8 cm Asphalt block	@ 2.1	=	80 kg
	2 cm mortar cushion	@ 17	=	34
	14 cm reinforced concrete	@ 24	=	336
	misc say			20
				470 kg per sq meter

Dead load slab	470 × 5.50	=	2580	
Copings	2 @ 185	=	370	
Handrails	2 @ 75	=	150	
			3000	kg per lin meter

Stringer spacing 1.60 span length 4.63

I I 300 × 150 × 10 @ 65.5 kg per meter.
including details say 75. kg " "

4 @ 75 = 300 kg per meter.

Floor beam

flanges	4 L 125 × 75 × 9	@ 17.19	=	68.8
web.	.900 × 10.			90.0
			158.8 @ .785	= 125 kg
	weight . 125 × 6.0	=	750	
	Details and variation		200	
			950	

65.5
4.83
172

950 ÷ 4.63 = 205 kg per lin meter

Bottom lateral bracings say 55 kg per lin meter.

Dead Load for truss

Dead Load slab ↑c	3000
stringers	300
Floor beams	205
Bottom laterals	55
	3560 kg per lin meter
trusses assumed 2 × 420 =	840
	4400 per lin meter

D.L. Bending moment at center = 8 · $\frac{4400}{2}$ × 37.² = 378,000 kg-m for 1 truss

L.L. 700 × 5.5 = 2750

L.L. m = 8 × $\frac{2750}{2}$ × 37² = 236000

Concentration at center panel 3000 kg · 1500 × $\frac{37}{2}$ = 28000
264000

D.L. shear	378.000	÷ 4.5	= 84.000
L.L. shear	264.000	÷ 4.5	= 58600
			142.600

used section say Top 160
Bottom 160
diag + vert. 130
450 @

.785 = 35 %
30 % = 100
450 kg per lin meter

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CALCULATIONS FOR

Bridge over Kiji Kawa at Nagahama Ehime Ken.

approximate weights of steel

Stringers		300	
Floor beams say		220	
Bottom laterals		55	
Bracing	20 450 =	900	
		1475 × 37.0 =	55.0 tons
Shoes & misc steel say			3.0
5 Spans @ 58 =	290 tons		58.0 tons

Load on shoe.

Dead Load Deck construction $\frac{3.00}{2} \cdot \frac{38.0}{2}$ = 28.5 tons

Structural steel 58.0 ÷ 4 = 14.5

Live Load say 1500 × $\frac{38}{2}$ 28.5 28.5

71.5

add concentration 3.0

74.5 tons on one shoe.

On one pier 74.5 × 2 = 149 tons

2. 46.4 meter span with top lateral bracings.

The span is divided into 8 panels @ 5.80 meters; truss height 6.5 meters about

Stringers span length 5.80 spacings 1.60 meter

Dead load stringers.

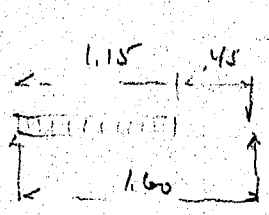
470 × 1.60 = 750 kg per meter

$m = \frac{1}{8} \cdot 750 \cdot 5.80^2 = 3150$ kgm.

Live Load motor trucks rear wheel with impact 2925 kg

front wheel " " 975 "

Uniform live load 500 kg per sq meter.



Unif load $\frac{500 \times 1.15^2}{2 \times 1.60} = 207.$ kg

$m = \frac{1}{8} \cdot 207 \cdot 5.8^2 = 870$

Automotor concentration $m = \frac{2925}{2} \times \frac{5.8}{2} = 4250$

5120

add misc. 380

5500

Total moment 5500
3150
8650

$S_m = \frac{86500}{11.00} = 785.$

Misc Beam 450 × 150 × 10 @ 65.5 kg. S_m = 848.7

4 @ 75.0 = 300 kg per li meter.

Floor beam say 950 ÷ 5.8 = 165" " " "

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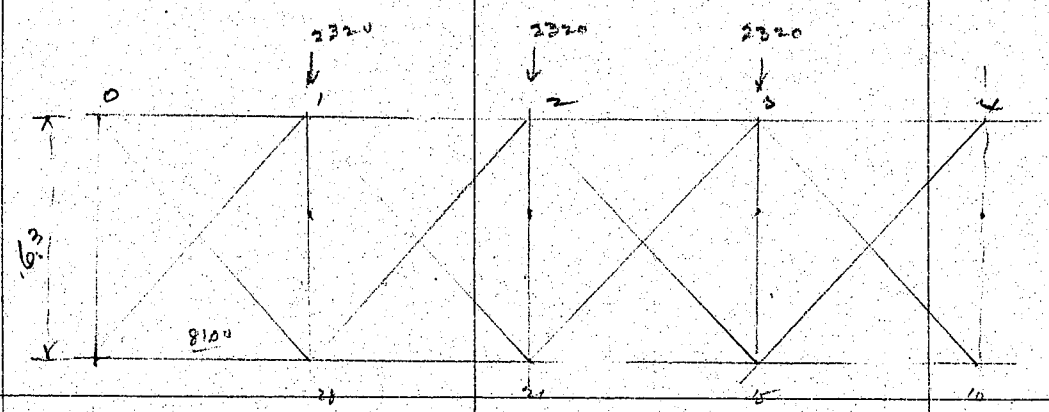
CALCULATIONS FOR

Bridge over Hijikawa at Nagahama, Ehime Ken.

Bottom Lateral Bracing



5.8 =

Wind load

400 × 5.8 = 2320 kg.

$6.3^2 = 39.7$
$5.8^2 = 33.6$
$73.3 - 8.55$

$\sin\theta = \frac{8.55}{6.30} = 1.36$

0-1	8100 × 1.36	=	11000	L 125 × 90 × ~~10~~ 9 @ 16.1 kg.
1-2	6100		8300	"
2-3	4350		5900	"
3-4	2900		3900	"

2 @ 16.1 × 8.5 = 274

Center connection - 26

$300 \div 5.8 =$ say 55 kg per lin meter. ∴

Top Lateral Bracing × 2L ~~150 × 90 × 10~~ 150 × 90 × 9 @ 16.3 kg = 36.6 kg. per meter.

$\frac{L}{r} = \frac{8.55}{4.75} = 180$

2 @ 36.6 × 8.5 = 621

Center connection 39

$660 \times \frac{6}{8 \times 5.8} =$ 85 kg per lin meter.

Sway Bracing - Required radius of gyration $\frac{630}{150} = 4.2$

4L 100 × ~~10~~ 75 × 10 ○ 13.0 × 6.0 = 312

web members

and details say 300

612 say 650 kg/piece

Portals 1000

5 @ 650 = 3250
2 @ 1000 = 2000

$5250 \div 46.4 = 135$ kg.

Summary for Top Lateral 85
Sways & portals 135
220

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CALCULATIONS FOR

Bridge over Fujikawa at Nagahama, Shizuoka

Dead Load on truss

Dead load floor		300
Stringers	300	
Floor beams	165	
Bottom bracing	55	
Top "	83	
Sway + portals	133	
	740	
Trusses 2 @ 500	1000	
		1740

1740 + 2 = 2370 kg. per truss.

Dead Load stress at centre $\frac{1}{8} \times 2370 \times 46.4^2 = 640.00$ tm

$\frac{640.00}{6.5} = 98,500$ kg.

Live Load stress $\frac{500}{2} \times 5.5 = \frac{2750}{2} = 1375$

$m = \frac{1}{8} \times 1375 \times 46.4^2 = 370.00$ tm

Concentration $\frac{300}{2} \times \frac{46.4}{2}$ 35.00 tm

$\frac{405.00}{6.5} = 62.5$ tm

405.00 tm

98.5 tm

761.0 tm

Top chord	165	
Bottom chord	165	
web + wind	200	
	530	$\times 0.785 = 410$
	300	120
		530

Summary of steel

2@530 =	740	
	1060	
	1800	kg

Total weight of steel $1800 \times 46.4 = 83.5$

Shoes and misc. say $\frac{3.5}{87.0}$ tons

of Span @ 87.0 = 348 tons say 350 tons

Load on one truss floor $1500 \times \frac{47.4}{2} = 35.5$

Steel $87.0 \div 4 = 22.0$

Live load say $1500 \times \frac{47.4}{2} = 35.5$

93.0 tons

On one truss say 186.0 tons

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CALCULATIONS FOR

Bridge over Kiso-kawa at Nagahama, Shimane Ken

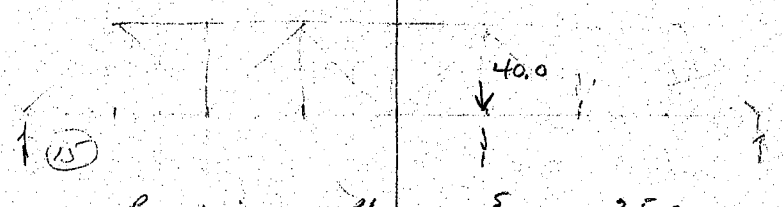
3. 40.2 meter pony truss span.

approximate weight = $58. \times \frac{40.2^2}{37.0^2} = 68.5$ tons.

4 spans @ 68.5 = 274.0 tons.

Span carrying Cwt truss. panel length 5.02

Cwt truss and Cwt assumed 40 tons for one truss.



Reaction = $400. \times \frac{5}{8} = 25.0$

moment = $25.000 \times 3 \times 5.02 = 377.000$

shear = $\frac{377.000}{4.5} = 84.000$ kg.

Extra weight for truss = 84 cm

84

42

$\frac{1}{2}$ 21.0 cm $\times 0.785 = 165$ kg

details say 30%

50

215 kg $\times 40.2 = 8.6$ tons

and miscellaneous say 20.0 tons for one span.

weight of one truss 88.5 tons

4@68.5 = 274.0

362.5 tons

Dead load on shoe (one).

Ordinary fixed span

floor $1500 \times \frac{41.2}{2} = 31.0$

Steel. $\frac{68.5}{4} = 17.0$

Live load say $1500 \times \frac{41.2}{2} = 31.0$

79.0 tons on one shoe

2 × 79 = 158 tons on pier.

Truss carrying Cwt truss.

79.0
15.0
5.0
99.0

on one end

2@99 = 198 tons

79.0
25.0 extra load
5.0 extra steel
109.0

On other end

2@109 = 218 tons

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CALCULATIONS FOR

Bridge over Tsurumi at Nagahama, Tsurumi Ku

4 ~~50.5~~ meter span panel length 50.5 meters

approximate weight of steel = $80.0 \times \frac{50.5^2}{46.4^2} = 103.5$ tons

Span carrying Cwt truss.

Extra wt assumed 40 tons $R_1 = 40 \times \frac{3}{10} = 12$ tons

$R_2 = 28$ tons

moment = 28000 × 3 × 5.05 = 425.000

Stress $\frac{425.000}{6.5} = 65.000$ kg.

S.R. 65
65
40
160 C 0.785 = 125.
38
163 × 50.5 = 8.5

Say 20.0 tons for one span.

Weight of one span 103.5 + 20.0 = 123.5 tons

Total steel. ~~3~~ @ 103.5 = 310.5
123.5
434.0 tons

Total.

Dead load on one shoe

Ordinary span floor. 500 × 51.5 = 38.5

Steel. 103.5/4 = 26.0

dwl load 38.5
103.0 tons

On one pin 2 × 103 = 206 tons

Span carrying Cwt truss

	103.0	103.
extra Stub	5.0	5.0
Extra reaction	12	28
	120.0 tons	136.0
On pin.	2@120 = 240 tons	2×136 = 272 tons

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CALCULATIONS FOR

Bridge over Kiji Kawa at Nagahama Shimaken

No. 1	layout	structural steel	5 fixed span 37.0	=	290.0 tons	}
No 2	layout	" "	4 spans 46.4	=	348.0 tons	}
No 3	layout	(with Cwk trusses)	4 fixed span 40.2	=	363.0 tons	} combined with Cwk trusses
No 4	layout	do	4 fixed b/span 50.5	=	434.0 tons	}

Estimate of Deck Construction

No 1. 210.0 meters
No 2. "
No 3. "
No 4. "

Concrete in floor. .14 × 5.50 = 0.77
2.35 × .22 = 0.15
misc = .08
1.00 cubic meter per meter.

210.0 Cubic meters.

Reinforcing Steel. 210.0 × 5.5 × 20/2 = 23.1 tons
say 25.0 tons

Area of pavement & 3.8 cm Asphalt block. with cushion.

5.5 × 210 = 1155 sq meters.

Handrails
Drains &c

150 × 210 = 31.5 tons

Electric wiring lamp Post &c

Estimate

Concrete	210.0	@ 14.00	=	2950.
forms. on	210 × 7.0 = 1470	@ 1.20	=	1760 -
reinforcing steel	25.0	@ 100	=	2500 -
pavement	1155	@ 35	=	4020 -
Drains &c finish				350 -
				13180
Handrail -	31.5	@ 200	=	6300
Lamp and electric wiring				3000
Entrance post				2000
				24480

Say 25000 Yen

11316 Concrete

90 @ 135 121

45 @ 1.39 0.62
44 Sand @ 1.13 4.97
2 @ 1.00 2.00
8.89

Mortar

Sand 0.9 × 1.25 gallon thin

3.0 6
1.20
10.00
14.20

15 9

2.16
1 cubic meter 36

109 1/3.3

2600 -
1760 -
2500 -
4020 -
350 -
1680 -
12910

75.00
25.00
80.00
4.20
12910
7500
2000
3000
25410

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CALCULATIONS FOR

Bridge over Hijikawa at "Nagahama, Shime-Kan

No 2 layout load on pier. 186 × 2 = 372 tons

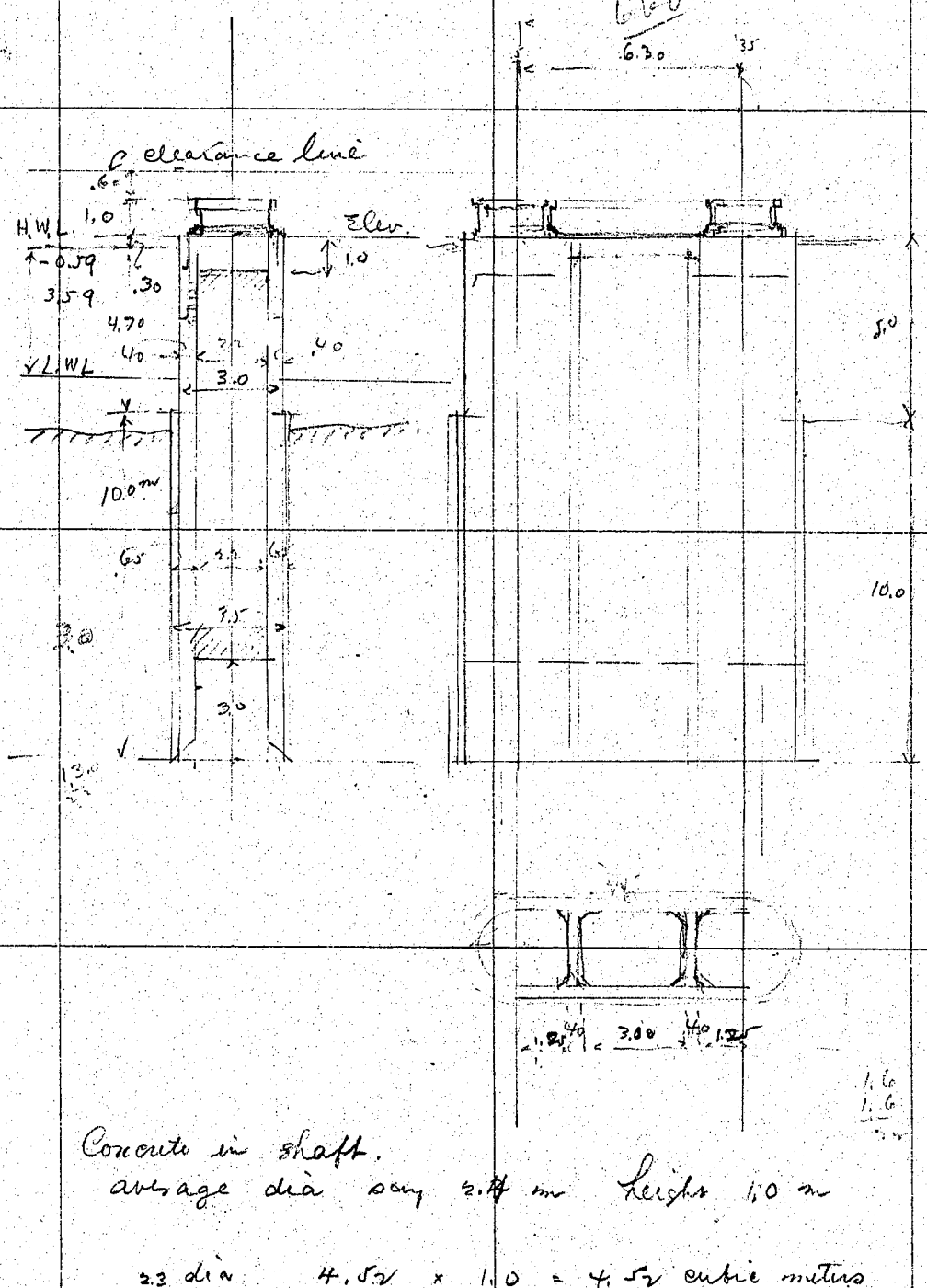
max height of well 15.0 meters.
well. 3.00 meters wide.

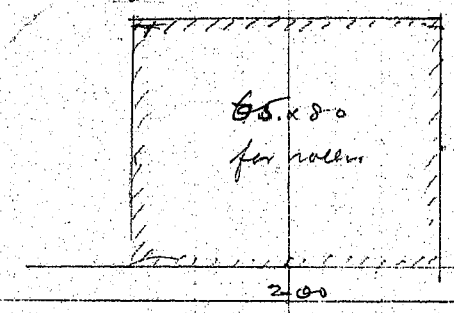
93. tons roller 10cm 45.0

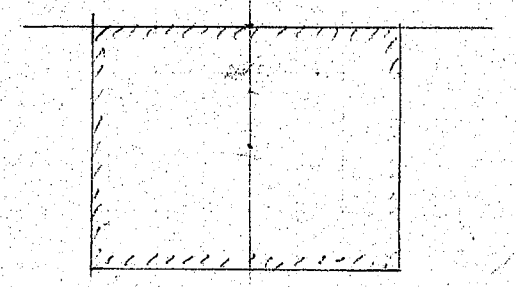
$\frac{93000}{450} = 206^{cm}$

$\frac{206}{5} = 40$

$75 \times 80 = 6000$







6.30
3.30
3.0

Concrete in shaft.
average dia say 2.4 m height 1.0 m

2.3 dia $4.52 \times 1.0 = 4.52$ cubic metres

vol. $= 2 \times 4.52 = 9.00$ cubic m

well. shell. upper portion 5.0 metres

Outside dia	3.0 ×	=	7.06
inside	2.2		3.80
both ends.			3.26
	6.30 × .80 =		5.04
			8.30 m²
Partition			2.12
			10.42 × 5.0 = 52.1 m³

Partition 2-.40 × 2.2 = 1.76
filler .30 .36
2.12

52.1
161.4
213.5

well shell lower section 10.0 high

outside dia	3.5	=	9.62
inside	2.2		3.80
			5.82
	6.30 × 1.30 =		8.20
			8.20
Partition			2.12
			2.12
			16.14
			16.14 × 10.0 = 23.4 m³

161.4
213.5

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CALCULATIONS FOR

Bridge over Kijikawa at Nagahama, Ekimae-ku.

inside filling Bottom fill. Dam

22 ϕ =	3.80	
2.2 × 6.3 =	13.86	
	17.66	
less partition	2.12	
	15.54 sq. meter	Vol = 15.53 × 3.0 = 46.6 m³

Dop filling

2.2 ϕ =	3.80	
2.2 × 2.5 =	5.50	
	9.30 m²	vol = 9.30 × 1.0 = 9.30

Center coring 3.0 × 2.2 × .50 = 3.3 m³ — 3.30 / 12.60 m³

Intermediate filling. 148 concrete both ends only

Vol. 9.30 m² × 11.0 = 102.2 m³.

15 / 11

Water filling 15 / 3.5 / 11.5 m vol = 3 × 2.2 × 11.5 = 76.0 m³.

Summary 124 Concrete

shaft		9,000
shell	upper	52.10
	lower	213.50
Bottom filling		46.60
Dop "		12.60
		333.80
~~331.70~~	@ 2400	= ~~888~~.000
102.20	@ 2200	= 225.000
		76.00
		1159.000
		230.000
		1389.
		142.
~~1473~~	tons.	
		284
		1189 tons net

148 Concrete
water 76.00

400 × 10.7 / 2.7 = 300 #/0'

Super imposed load dead load only ~~57.5~~ × 4 =

live load 4 × 35.5

Frictional resistance 150 × 23.6 × 8 m = 284. tons

Section area = 3.5 × 9.62 = 22.00 / 31.62 sq meters

unit p = 1189 / 31.62 = ~~397~~ tons

or 3.50 tons per sq ft.

area of forms.
shaft say 7.5 × 2 = 15.0 m²

well shell. top.

3 ϕ =	9.4	
2.2 ϕ =	7.0	
	16.4	
6.3 × 4 =	25.2	
partition. 4 × 2.2 =	8.8	
	50.4	

50.4 × 5.0 = 250 m²

35 ϕ = 11.0 / 7.0 / 25. / 10. / 53.

53. × 10 = 530. m²

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CALCULATIONS FOR

Bridge over Hijikawa at Nagahama, Ehimeken

Reinforcing bars 0.6 × 15 = 9.0
add 1.0
10.0 tons

curb shoe. 2.0 tons.

Excavation. bottom area = 32 m². × 10 = 320 cubic metres

Estimate of cost for one pier 15.m well

Concrete	1:2:4	~~360~~ 334 m³	@	14.00	=	~~5050~~ 4680 yen
	1:4:8	100 m³	@	9.00	=	900
Reinforcing steel		10 tons	@	100.00	=	1,000.00
forms		800 m²	@	2.00	=	1600
curb shoe		2 tons	@	150.00	=	300
Excavation ordy		320	@	7.00	=	2240
沈下促進費						3910
miscl 10%						1090
						16000 yen

Height of well.

Pier no 1	9.0	Bascule abutment	10000
no 2	13.5		16000
no 3	15.0		34000
no 4	15.0		16000
no 5	15.0		16000

91000

Bascule Pier.

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CALCULATIONS FOR

Bridge over Tojikawa at Nagahama, Ehime Ken

Concrete in shafts

5.5 ϕ — 19.3
11 × 5.0 = 55.0
74.3 m³

Shell of well. H 0

Outside dia 5.5 ϕ — 23.7
inside " 4.7 — 17.3
6.4
11.0 × .80 8.8
Partition 8.2
23.4 × 5.0 = 117.0 m³

Outside dia 6.0 — 28.2
17.3
10.9
11.0 × 1.3 14.3
Partition 8.2
33.4 × 10.0 = 334.0 m³

Partitions 4 × 4.7 × 40 = 752
fillers .091 .72
824

Inside filling

Bottom fill 4.7 ϕ 17.3
11 × 4.7 51.7
69.0
less partition 8.2
60.8 × 3.0 = 182.4 m³

Top fill 60.8 × 1.0 = 60.8 m³
243.2 m³

Summary for concrete

1:2:4 shaft	74.
shell	117
"	334
fillers	243
	768 m³
148 Concrete	134 m³

Intermediate filling 148 Concrete

2.6 × 4.7 × 11.0 = 134.0 m³
6.8

water fill

4.7 ϕ — 17.3
4.7 × 4.2 = 19.8
37.1 × 11.0 = 409. m³.

16.
2.6
4.2

Forms.

shaft. 5 ϕ 16.0
22
38.0 m² —
41.0
36.8
37.6
115.4 × 15.0 = 1730
38
1768 say 1800 m²

well. 6.0 ϕ — 19.0
22.0
41.0

4.7 ϕ 14.8
22.0
36.8
8 × 4.7 = 37.6

Reinforcing Bars

10.0 × 768/360 = say 22.0 tons

Curb shoes 2.0 × 41/23 = 3.6 tons.

19.0
22
41

11.0.
12
23

Excavation 6 ϕ = 28.3
11 × 6. 66.0
94.3 × 10. = 943 cubic metres

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53 cr

2.6

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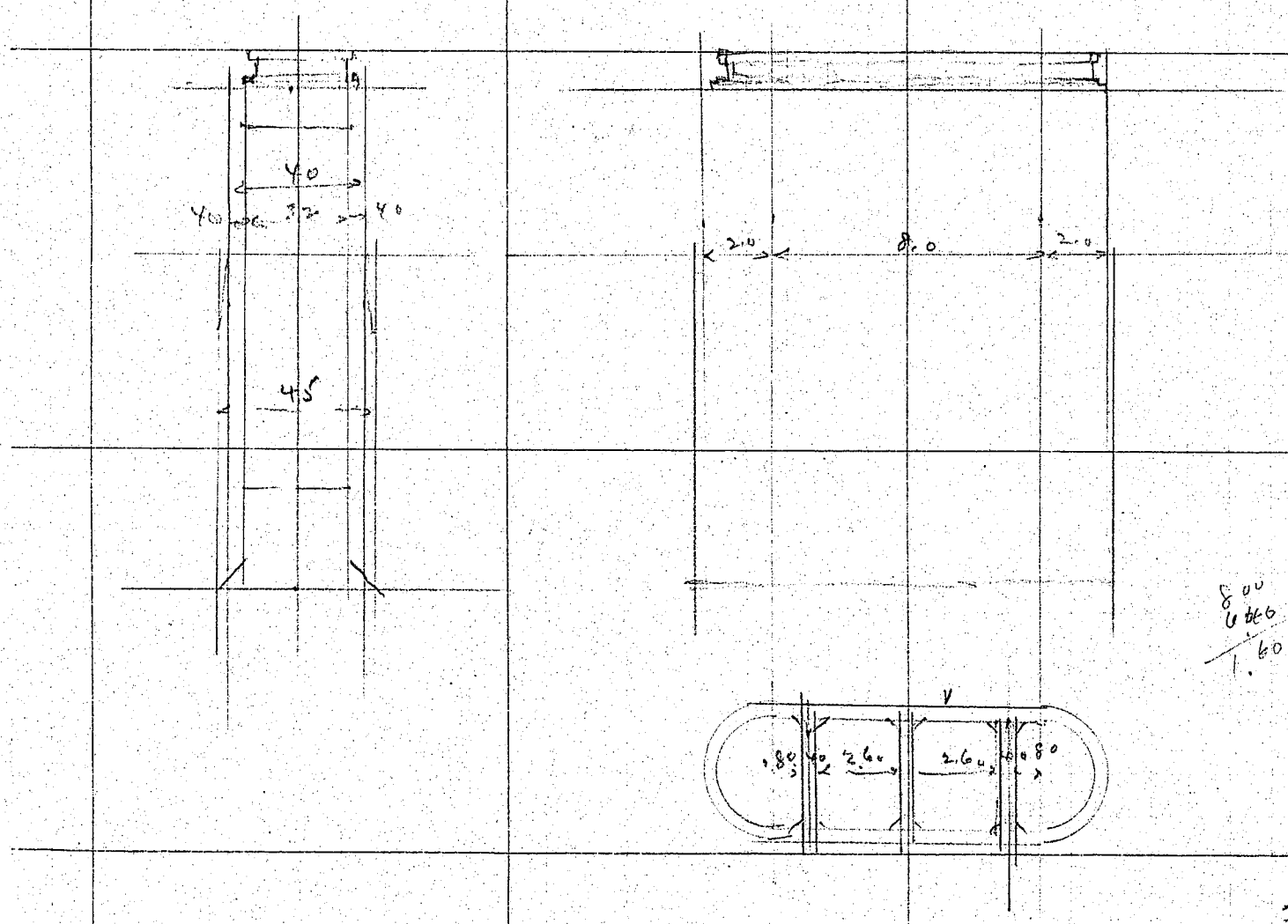
CALCULATIONS FOR

Bridge over Fujikawa at Nagakawa, Shimotsu

Estimate of cost

Concrete	12cr	768 m³	@ 14 cr	=	10750
	14cr	134 m³	@ 9 cr	=	1200
Reinforcing steel		22 ton	@ 100 cr		2200
forms		1800 m²	@ 2.50	=	4500
Curb shoe		38 m	@ 150 cr		570
Excavation 25 cr 掘下げ 埋戻		950	@ 7 cr	=	6650
misc					700
					100
					33870
			Call this		34000 cr

Execute Pier for overhead type.



8.00
0.66
1.60

Shaft.	3.5 φ —	7.0	
	3.5 × 8	28.0	
		35.0 m³	
			3×3.40 × 3.2 = 38.6
			1.2
			46.3
			.27
			4.13
Well.	4.0 φ —	12.6	
	3.2 —	8.0	
		4.6	
4.0 × 2 × 8.0 =		6.4	
Partition		4.1	
		15.1 × 5.0 = 75.5	
	4.5 —	15.9	
		8.0	
		7.9	
		6.4	
		4.1	
		18.4 × 10.0 = 184.0	
		259.5	
		say 260 m³	

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CALCULATIONS FOR

Bridge over Tejikawa at Nagakawa, Ibaraki-ken

Inside filling

Bottom fill. 3.2φ

8.00
20.60
33.60
- 4.1
29.5 × 3.0 = 88.5 m³.
× 1.0 = 29.5
118.0

~~2.5~~ 3.5
260
118
378

Top fill.

Intermediate fill.

3.2
1.6 × 3.2

8.00
5.1
13.1 × 11.0 = 144.0 m³.
131

wall fill.

2.6 × 3.2 × 2 = 16.7 × 11. = 184.0 m³.
167
1837

forms.

3.5 φ 11.0
8 × 2 = 16.0
27.0 — 27.0

4.5φ say 14.0 3.8 — 12.0
2 × 8. 16. 16.0
30.0 28.0
28.0
20.0
78. × 15 = 1170
27
1197 say 1200 m²

16 × 3.2 = 19.6
20.

Reinf bars

10 × 378/534 = say 12. tons

Curb shoes say 2.5 tons

Excavation. Bottom area 4.5φ 15.9
4.5 × 8.0 36.0
51.9 say 52.0

52 × 10 = 520 m³

Estimate

Concrete	1:2:4	378 m³	@ 14	=	5300
	1:4:8	120	@ 9	=	1080
Reinf steel		12 tons	@ 100	=	1200
Forms		1200 m²	@ 2	=	2400
Curb shoes		25	@ 150	=	3800
Excavation		520	@ 7	=	3640
Sundry Equip't etc					5000
misc say					1000
					20000

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CALCULATIONS FOR

Estimate of Bridge on Nijitawa Shimeken

No1 to No4 Bascule machinery in Deck

No 1. Layout 5 fixed span, 1 Bascule and Cwt truss.

Structural steel in fixed span. 290 tons @ 180^{00} = 52200^{00}
Deck construction fixed portion complete 25000

77200^{00}

Bascule span and Cwt truss 46500

Superstructure 123700
substructure 117000
240700

Substructure.

Pier	no1	8.0	9000
	no2	12.5	14000
	no3	15.0	16000
	no4	15.0	34000
	no5	15.0	16000
	no6	15.0	16000
			105000
abutment			12000
			117000^{00}

No2 Layout 4 fixed span 1 Bascule and Cwt truss

Structural steel in fixed span 348 tons @ 180^{00} = 62600
Deck construction 25000

87600

Bascule span and Cwt truss 46500

superstructure 134100
substructure 103000
237100

Substructure

Pier no 1.	9.0	10.000
2		15000
3		34000
4		16000
5		16000
		91000
Abutments		12000
		103000

No3 Layout 5 fixed spans Cwt truss combined with ajoining truss.

Structural Steel 363^{00} @180^{00} = 65300
Deck construction 25000

90300

Bascule span and Cwt truss 46500

Superstructure 136800
substructure 101000
237800

Substructure 117000
one pier less 16000
101000

No4 Layout 4 spans Cwt truss combined with ajoining truss

Structural Steel 434 @ 180^{00} 78200
Deck construction 25000

103200

Bascule and Cwt truss 46500

Superstructure 149700
substructure 87000
236700

Substructure 103,000
one pier less 16000
87000

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CALCULATIONS FOR

Estimate of Bridge over Hijikawa Ehime-ken

No 5 Layout 5 fixed span 1 Bascule + Cut truss

Fixed super structure — 77200
Bascule — 48500

Super structure 125700
Substructure 103000
2287 00

Substructure
Reduced for Bascule pier 117000
− 14000
103000

No 6 Layout 4 fixed span 1 Bascule + Cut truss

Fixed super structure 67600
Bascule span 48500

Super structure 136100
Substructure. 89000
225100

Substructure
Less 103000
14000
89000

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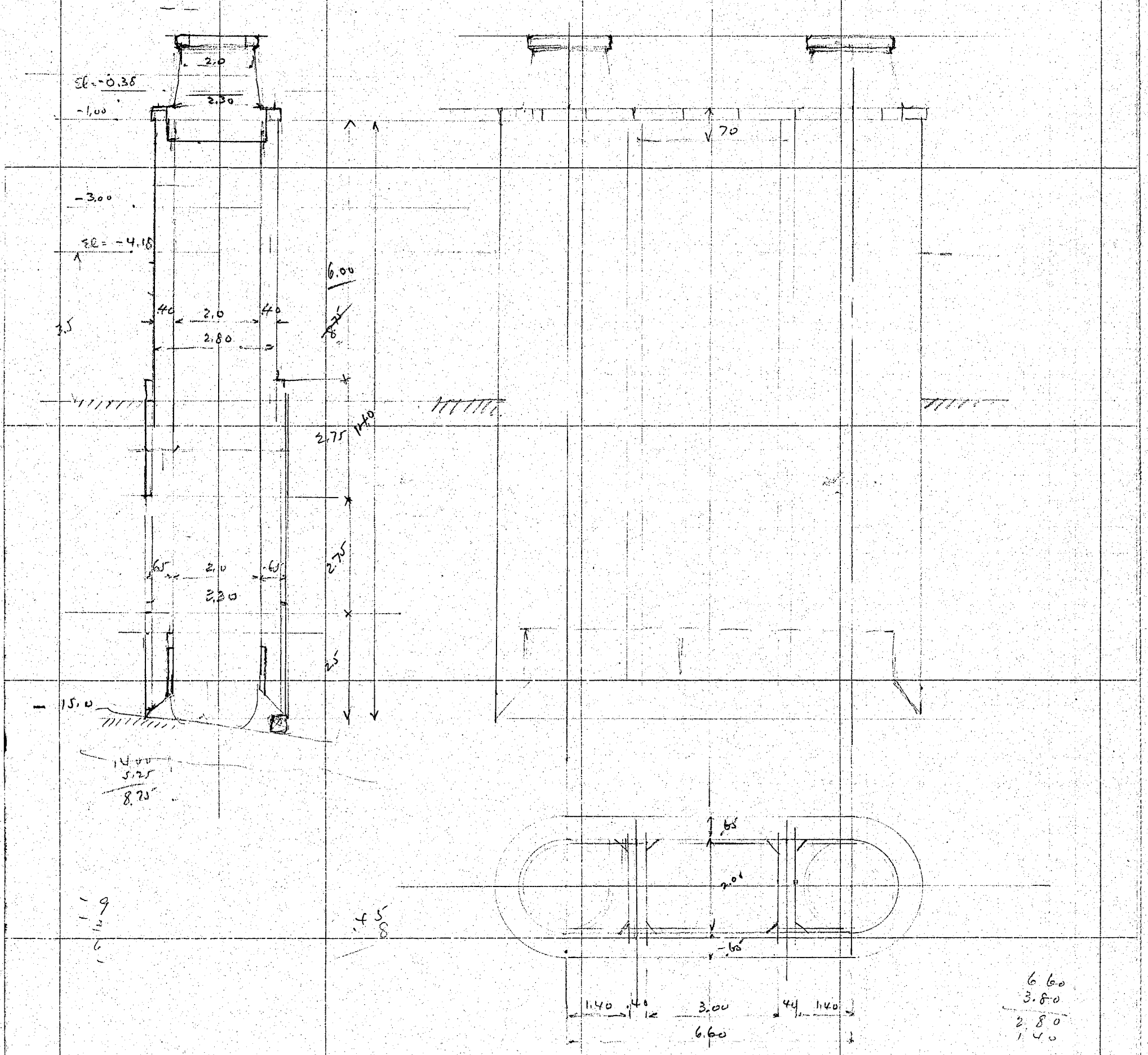
CALCULATIONS FOR

Nagakawa-Okashi for Ehime-ken.



Concrete in shaft.
average dia say 2.20 height 2.0
2 - 3.50 × 2.0 = 15.2 cubic metres

well shell
upper portion 6.00 m

Outside dia	2.8 ϕ	6.2
Inside dia	2.8	3.1
		3.10
Earth cushn.	6.60 × .80 =	5.29
Partition		.196
		10.35 × 6.0 = 62.0 m³

2 - .40 × 2.0 = 1.60
fillet .36
1.96

6.60
3.80
2.80
1.40

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CALCULATIONS FOR

Nagahama - Okashi for Shime-ken

well shell lower portion - 8.0 metres

outside dia	3.3 ϕ	8.56
inside	2.0 ϕ	3.1
Both ends		5.46
6.60 × 1.30 =		8.58
Partation		1.96
		16.00 × 8.0 = 128.0 m³

Inside filling bottom

2 ϕ —		3.10
6.6 × 2 —		13.20
		16.30
less partation		1.96
	14.34 m² ×	2.00 = 28.6 cubic metres

Top filling 14.3 × 1.0 = ~~28.6~~ 14.3 m³.

Intermediate filling 9.0 m³ 148 concrete both ends only

14.0
3
11.0

3.1
2 × 2.8 = 5.6
8.7 ×

16 = 96
~~8~~ = ~~78.0~~ m³

Sand filling. 6.0 × 11 = ~~54.0~~ m³
8 66

124 concrete below cone 128.0
62.0
190.0 m³ — well shell — 190
43
15
248
78
326 m³

Portland cement bottom fill 28.6
Top fill 14.3
42.9 say 43.0

148 concrete
~~8.0~~
96
15.0

shafts -

weight of pier. concrete 326 @ 2400 = 78.000
sand filling 54 @ 1700 = 92.000

872.000
230.000 } 1102 ton
142.000
1244 ton

Superimposed Dead load.
live load.

10.3
13
23.3

frictional resistance 7m. 300 lb. = 1500 kg/m²
1500 × 23.3 × 7.0 = 247.000
997.000 kg

bottom area = 3.5 ϕ = 9.6 m²
3.5 × 6.6 = 23.10
32.72

unit p = 997.000 / 32.72 = 30.500 kg/cm²

2.84 tons/□'

123.500 × 3.5 = 432.000
say 400.000

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CALCULATIONS FOR

Nagahama Ohashi for Shimo-Ten.

Area of forms
shaft say. 7.0 × 2 × 2 = 28.0 m²

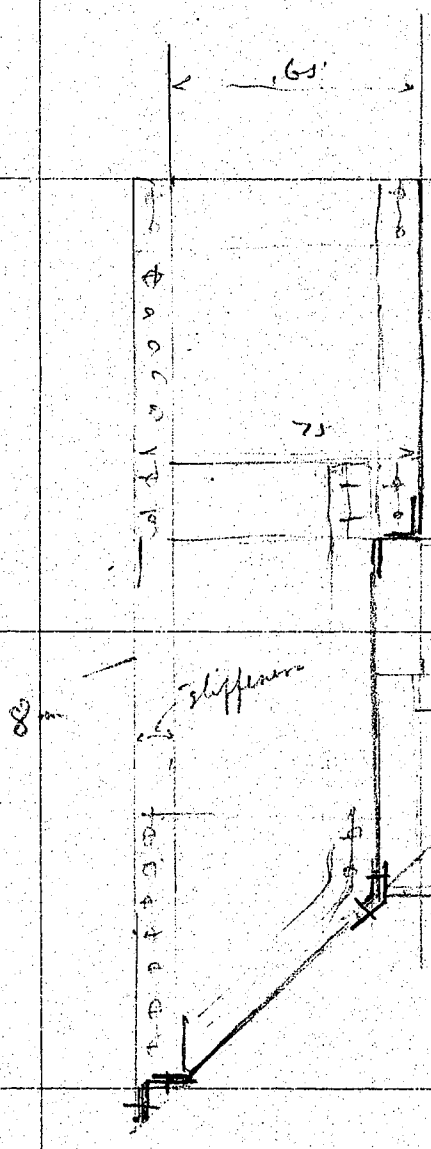
well. shell. inside. 6.0
13.2
8.0
27.2 27.2
22.5
49.7

Cell sides. say 3 9.2
13.2
22.5 say 50.0 × 11.5 = 575 m²
28
603

14.0
2.5
11.5

Reinforcing Bars. say 9.0 tons

curb shoe.



8m.	2500	a	117.8	=	117.80
8 ×	260	a	122.5	=	122.50
12 ×	12.5	a	11.77		11.77
130 × 130 × 12		a	23.4		23.40
250 × 8 ×			15.7		15.70
2L 90 × 90 × 10 –			13.3		26.60
					317.77 say 320.0 kg.
					1.35.0
					455.0 kg
					80.0
					535 kg per lin. metre

Diaphragm- 75 × 75 × 6 — 2.5
2L 90 × 90 × 10 — 6.78
Pl. 750 × 6 × 1,00 — C 13.2 × 5.5 = 74.50
bottom plate say — C 35.33 = 35.33
25.00
134.83

Misc details say 80

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CALCULATIONS FOR

Nagahama Oyashi for Shimo-kuro

3.5φ = 11.0
6.6 × 2 = 13.2
24.2 × 3.35 = 13.000 kgs
Call this 14.0 tons

Excavation 12.0
bottom curve = 3.5φ — 9.62
6.6 × 3.5 23.10
32.72 × 12 = 392.

Shim 204.40 1200 × 35.0 = 4,20 cubic meters

Estimate of Cost of One pier. 14.0 well.

Concrete -	124 velo	190 @	13.6	=	2600
	124 "	58 @	12.3	=	750
	140	96 @	8.1	=	778
Sand filling.		66 @	.50		330
cut shim					
Reinf. steel		9 tons @	100	=	900
forms		600 @	1.50	=	900
Curb shoe		14 tons @	150	=	2100
Excavation -		392. @	6.00	=	2400
Rock excavation -					300
					11060
					2154
					13214
					630
					13840
					8

4 Span 6A Layout.

8.0 meter well - 2.5 m curb shoe.
Shaft. 15.0 m³.
Well Shell
Top. 5.5 m high.

Concrete	10.35 × 5.5	=	57.0	m³
Bottom section.	Concrete.	16.00 × 2.5	=	40.0
				97.0 m³

Top and bottom filling 43.0 m³
intermediate filling 8.7 × 5.0 = 43.0 m³
Sand filling 6.0 × 5.0 = 30.0

148. Velo cement — 97.0
Heat cement — 15.0
43.0
58.0
43.0

Area of forms.
well. shell - shaft say 28.0 m²
50.0 × 5.5 = 275.0
303.0

Reinf. bars say 0.6 × 8 = 48 tons.

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CALCULATIONS FOR

Nagahama - Otaki for Shimo-kura

Excavation - 6.00 - 32.72 × 6 = 196 m³.

Stone - 4.0 cubic meters

Estimate of Cost of one pier - 8.0 meter well.

Concrete.	124 cubic	97.0	@	13.62	= 1320
	124	58.0		12.32	= 720
	148 -	43.0		8.12	= 350
Sand fill		30.0		.50	= 150
Reinf. bars -		4.8 tons	@	100	= 480
Forms		300	@	1.50	= 450
Curb shoe		14 tons	@	150	= 2100
Excavation -		200	@	6.00	1200
Rock excavation -					300
stone					630
copper.					2150
					9850

8. 13.5 15.0

1350

4 fixed span Bridge.

Pier no.	1	9800
Pier no	2	12500
	3	14000
	4	13500
	5	13500
		63300 cu
Abutment		12000
		75300

5 fixed span bridge.

75300
13500
88800 cu

Deck construction 2600 cu

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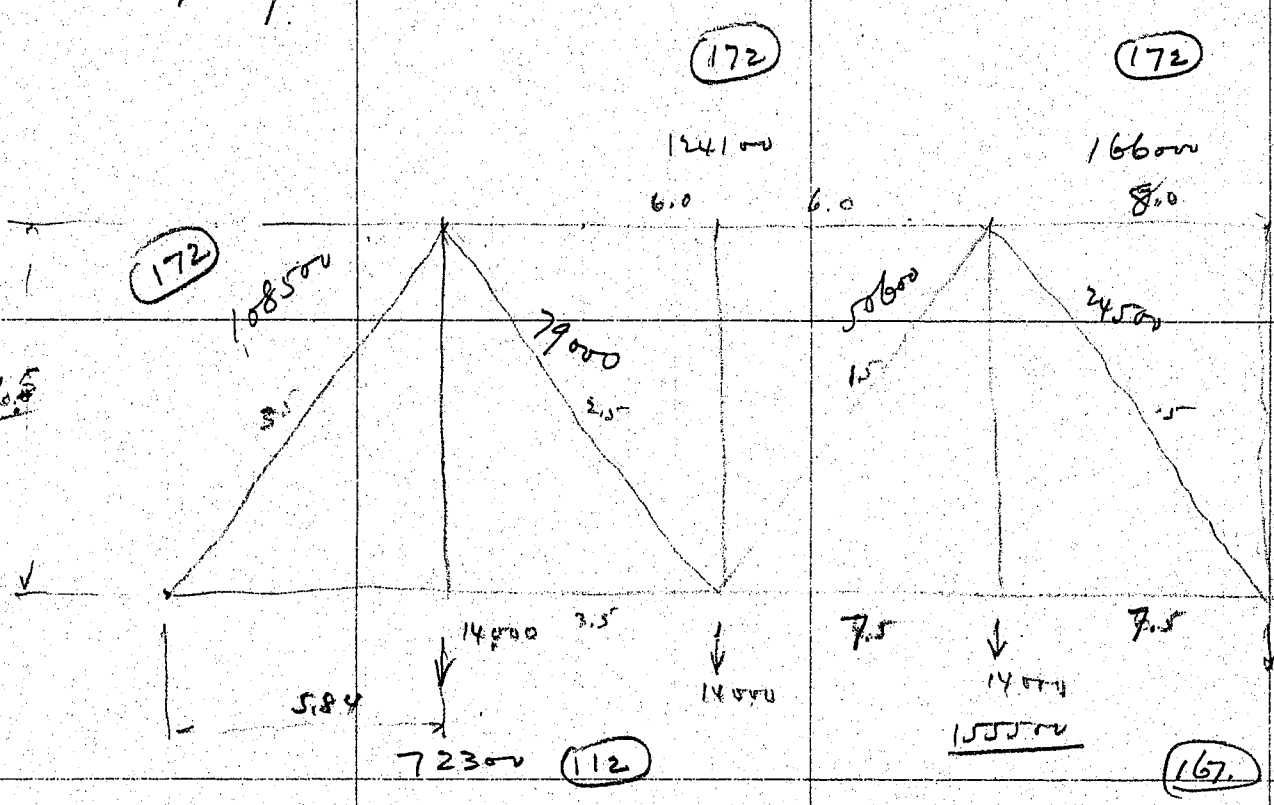
CALCULATIONS FOR

Nagakawa Ohashi for Ebina-Kan.

span length 46.72
Renewed weight of truss.



$\sec\theta = \frac{8.74}{6.5} = 1.34$ $\quad 6.5^2 = 42.25$ $\quad 5.84^2 = 34.14$ $\quad 76.35 - 8.74$

$\tan\theta = \frac{5.84}{6.5} = .90$

Dead load stress - chord stress -

Live load chord stress -

3.5	× 14000	× .90	=	44000 + 2830	=	72300
6.0			=	7560 + 4850	=	124100
7.5			=	9450 + 6100	=	155500
8.0			=	10100 + 6500 (101)	=	166000

Live load 1500 × 5.84 = say 9000

Dz web members.

					LL.	Total
3.5	× 14000	× 1.34	=	66000	42500	108500
2.5			=	47000	32000	79000
1.5			=	28500	22600	50600
.5			=	9400	15100 (15/24 × 94)	24500

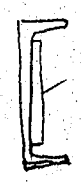
~~2@ 51.17 = 102.1~~

2<80 × 90 × 10 @ 55.74 = 111.48
1PL. 510 × 12 61
172.

320
180
500

Bottom chord.

155500 ÷ 1200 = 130.0 unit
7200 ÷ 120 = 60.0 unit



111.48 −
22.40
89.08

230 ×

20
8.80
13.60
22.40

111.48
55.20
166.68

2 Pls. 230 × 12 = 460
880
3720
89.08
12628

− 55.2
10.6
44.6
89.08
133.68

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CALCULATIONS FOR

Nagatama. Ohashi for Chiba-Ken.

Diagonals. 7900m ÷ 120m = 66.0

~~4LS~~ 125 . 90 × 10 = 2050
82.0
17.6
64.4

20.79
83.16
27.m
110.16

18.54 — 4LS 150 × 90 × 9
74.16
27.m
101.16

Unsupported length. 8.7x / 120 = 7.3

Approximate of truss.

3 @	172 cm²	×	5.84	× .785	=	2,360
	172	×	8.74	×	=	1,180
2 @	112	×	5.84	×	=	1,030
2 @	167	×	5.84	×	=	1,530
3 @	110	×	8.74	×	=	2,260
35 @	102	×	6.50	×	=	1,820
						10,180
						× 4
						40,720
						14 cm
						54,720 ÷ 46.72 = 1170
						740.
						1910

35%

Shoes. 2.0 tons

1910 × 46.72 = 89.00
2.0
91.0 tons.

91.0 × 4 = 364.0 @181 ≒ 66000 ≒

180

	100 ≒
	35 ≒
	5 ≒
	140
	20
	15
	6
	181

Summary for cost.

Steel structure	660 m
Deck	25 m
Substructure	753 m
	1663 m ≒
	443 m
	2106 m
	164 m

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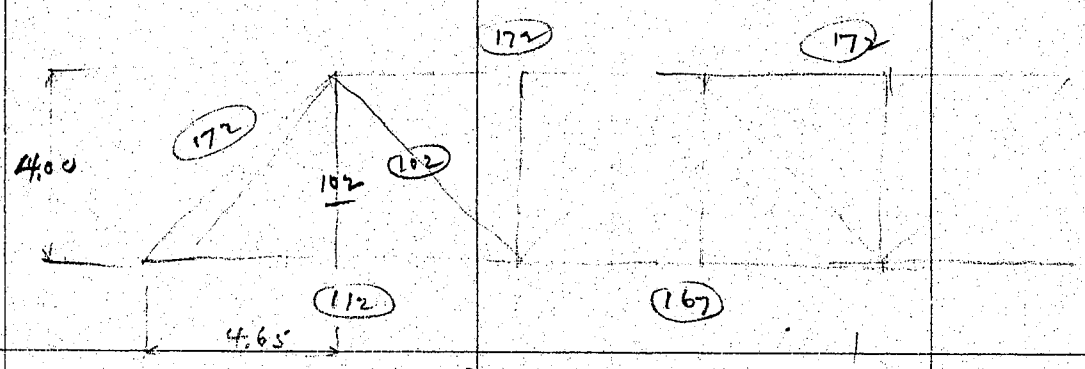
CALCULATIONS FOR

Nagahama - Otashi for Shimo-ku

37.2 meter fixed span.



$Y^2 = 16.0$

$4.65^2 = 21.62$

$37.6^2 - 6.14$ $\sec\theta = \frac{6.14}{4.00} = 1.53$ $\tan\theta = \frac{4.65}{4.00} = 1.16$

Dead load concentration. 220m × 4.65 = say 1100m

Live load concentration say 150m × 4.65 = 700m

chord stress.

		DL.	LL	Total
3.5 × 11000 × 1.16	=	44700	28400	= 73100
6.0	=	76600	49000	= 125600
7.5	=	96000	61000	= 157000
8.0	=	102000	65000	= 167000

Diagonal -

		DL		LL	Total
3.5 × 11000 × 1.53	=	59000	3.5	38000	= 97000
2.5		42000	2.625	28000	= 70000
1.5		25000	1875	20000	= 45000
1.5		8400	1.250	13500 (84)	= 22900

Diagonal 70.0m ÷ 120 = 58.3 m/t

1-	3 @	172	×	4.65 @ .785	=	1,850	2.0 2.9
		172	×	6.14 @ "	=	830	
2-4	2 @	112	×	4.65	=	820	
3-4	2 @	167	×	4.65	=	1220	
3-6	3 @	102	×	6.14	=	1.470	
3-7	3.5 @	10	×	4.00	=	1120	
						7.340	
						29.36	
			add for top chord details say 35%			1.050	
						3086	
						1080	
						41.66 ÷ 37.2 =	1090
						Stringer	30
						Floor beam	220
						Batt. laterals	55
						1665 × 37.2 =	62.0
							4
							66.0 tm

Shear + misc.

5 @ 66.0 = 330

330 × 1.8 = 595 m/t

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CALCULATIONS FOR

Nagakawa Ohashi for Shimo-ken

Structural Steel.
Deck construction.
Substructure

	5 span	4 span
	5950 m =	6600 m
	2500 m	2500 m
	8880	753 m
	17330	16600
	443 m	443 m
	21760	21060
	163 m	158 m
	23390 m	22640 m

7½%

	21760 m	21060 m
	6500 m	6500 m
	1100 m	1000 m
	23410 m	22710 m

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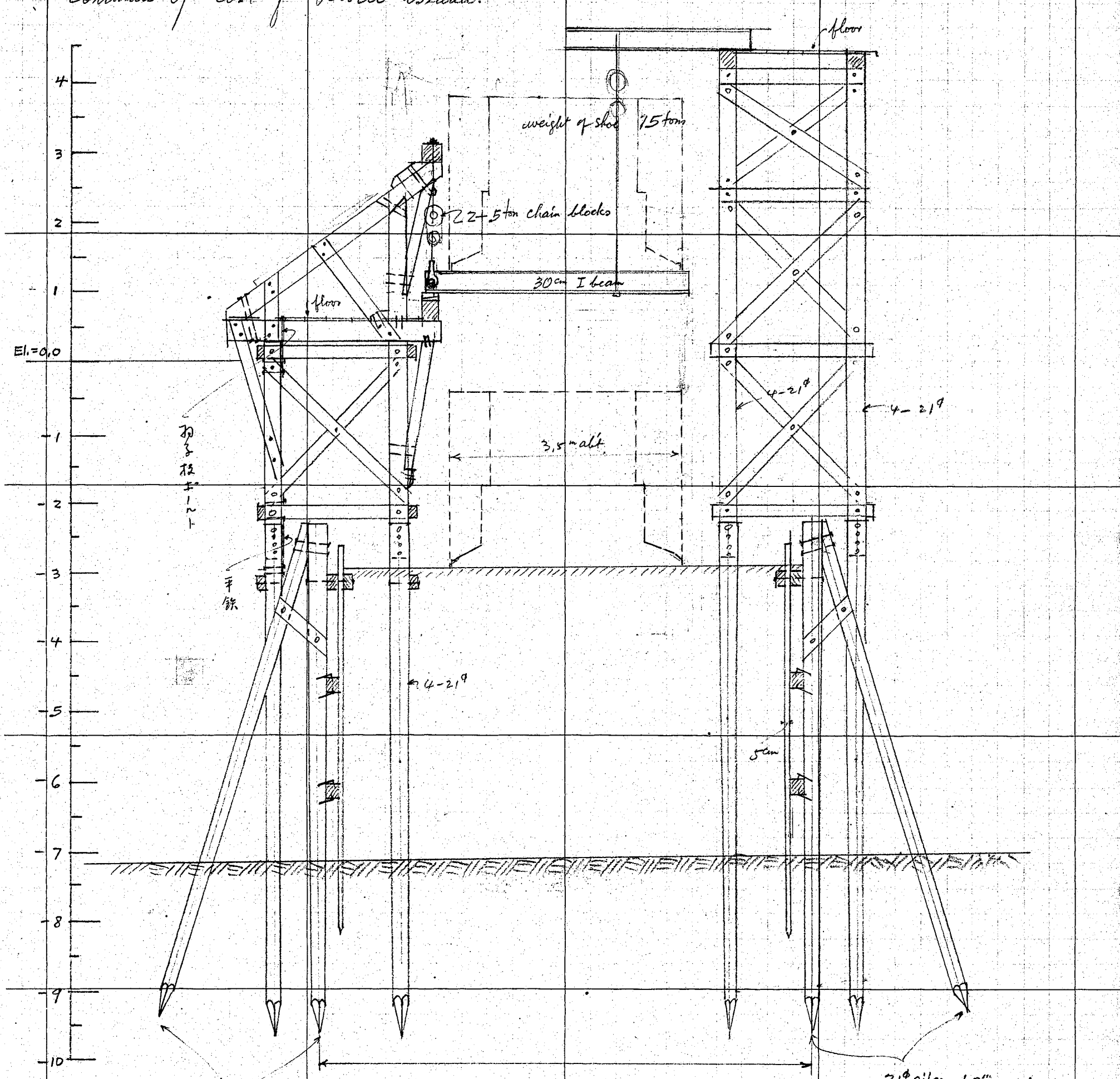
CALCULATIONS FOR

Nagahama Ohashi for Ehime Ken.
Estimate of cost for Well island.



Scale 1:60

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CALCULATIONS FOR

Nagahama Ohashi for Ehime Ken

Estimate of cost for well island continued.

Well island. 7.0m × 13.0m — 4.2m high. Circumference 40m.

materials

piles	80 piles — 21cm/cm × 7.3m	@	9,30	=	744
sheet piles	40m — 6cm × 5.5m	@	12,00	=	480
wales	16 q- — 20 × 20cm × 5.5m	4 @	5.50	=	88
"	16 " — " " × 40	28 @	3.70	=	59
brace	40 " — 5 × 20 × 1.0	28 @	0.25	=	10
misc. bolts, clamps etc.					50
					1431 × 1/3 = 480

labor

piles	80 piles	@	6.0	=	480
sheet piles	40m	@	1,5		60
wales	32 q-	@	0.5		16
brace	40 "	@	0.10		4
divers	5 人	@	12.0		75
misc.					85
					720
					1,200 円
					200
					1,400

filling sand or gravel etc. 6.5 × 9.5 × 4.2 = 260 m³ @ 0.8

Staging for setting curb shoes.

materials

piles	24 piles — 21cm × 7.3	@	9,30	=	223
flooring	3 × 4 = 12m²	@	5.00	=	60
					283 × 1/3 = 95

labor.

piles	24 q-	@	6.0	=	144
flooring	12m²	@	2,0	=	24
I beam & chain block 共3/4 t 4		@	50.0	=	200
					368
misc exp.					37
					405
					500
					250
					2,150 円

足場杭丸 Shoe用 100円 Concrete用 150

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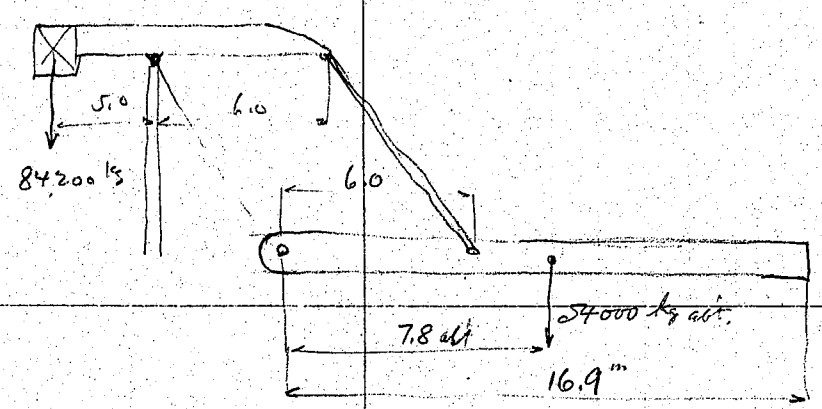
CALCULATIONS FOR

Nagahama Ohashi for Ehime Ken.
Estimate of cost for Bascule span



total wt. of moving leaf
say = $51700 \times \frac{16.9}{16.3} = 54{,}000$ kg.

lever arm $7.5 \times \frac{16.9}{16.3} = 7.8$ m

Cwt. required = $\frac{54000 \times 7.8}{5.0} = 84{,}200$ kg

moment on balance beam
= $84200 \times 5 = 421000$ kgm.
20% impact = $\frac{8400}{505{,}000}$

balance beam
try 2000 × 10 web = 200 cm² $\frac{1}{8}$ web = 25 cm²
eff. depth say 192 cm
flange stress = $\frac{421000 \times 1.2}{1.92} = 219{,}000$ kg × 1.2 = 263000
flange area = $\frac{219000 \times 1.2}{1200} = 182.5 \times 1.2 = 219.00$
$\frac{1}{8}$ web area = 25.0
157.5 cm² net. 194.0 net.

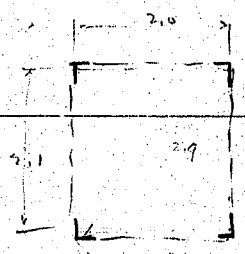
2Ls 150 × 150 × 19 = 106.8 − 19 = 87.8
2 cov pls 340 × 19 = 129.2 − 19 = 110.2
236.0 cm² gr 198.0 cm² net

Cwt. girder.
Cwt. $\frac{84200}{5.9} = 14250$ kg/lin m. max. moment = $\frac{1}{8} \times 14250 \times 5.9^2 = 61800$
15% impact = 9200
71,000 kgm

$\frac{14250}{3200} = 4.45$ m² 2.0 × 2.23
200 kg/cm²

flange stress = $\frac{71000}{2.1} = 33800$ kg. flange stress = $\frac{71000}{2.9} = 24500$
flange area = $\frac{33800}{1200} = 28.2$ cm² net. 2-flg flange area = $\frac{24500}{1200} = 20.4$ net. one flg.

∠ 150 × 150 × 12 = 34.56 − 6 = 28.56 net.



Approx. weight of balance beam.
4Ls 150×150×19 = 167.6 kg.
4 cov pls 340×19 = 202.8
1 web 2000×10 = 157.0
527.4 × 13.5 = 7120
details say 40% = 2880
10,000 kg.

Cwt. girder.
chords. 4Ls 150×150×12 = 108.4 108.4
Diag. 8Ls 125×75×10 = 119.2 × 1.4 = 167.0
verticals 8Ls " 119.2
394.6 × 5.9 = 2330
D-tails say 50% = 1170
3500 kg.

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CALCULATIONS FOR

Nagahama Ohashi for Ekimae Ken.

Link stress

Moment

421,000 × 1.30 = 547000 kgm

547000 ÷ 5.2m (arm) = 105,000 kg ÷ 2 = 52500 kg for one link SR = 43.8 mets

2 [s 250×90 @ 34.6 kg = 88.1 − 22 = 66.1 mets.

weight of link 9.5 × 69.2 = 660

details say 50% 540

1000 kg.

Columns. Max. load. Cent. 84200

link 84200 × 5/6 = 70200

balance beams 2 @ 100m = 20,000

lateral bra. 4000

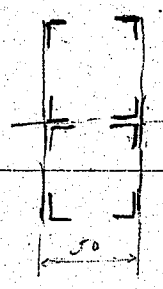
sway + post 10,000

188,400

20% imp 37600

226000 kgs. ÷ 2 = 113,000 kg/col.

SR = 113.0 mm.



8 L's 90×90×10 = 106. kg.

4 pls 500×9 = 140

246 × 7.0 = 1720

500

1110

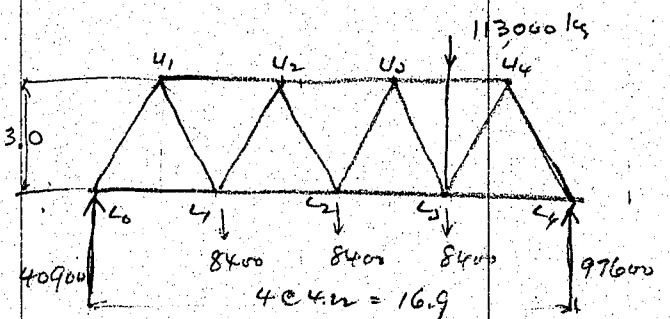
details 50% 1110

3330 kgs.

Sway strut. 7.1 × 325 = 2300 kgs.

Truss. span length 16.9m, 7.3m c to c.

Dead load 2000 kg/m one truss. panel load 4.22 @ 2m = 8,400 kg.



Reaction

8400 × 1.5 = 12600

113000 × 1/4 = 28300

40900

12600

113000 × 3/4 = 85000

97600

U_3–U_4 $\frac{97600 \times 4.2m}{3}$ = 137,000 kg C.

U_2–U_3

40900 × 8.44 = 345000

8400 × 4.2m = − 35400

309600 ÷ 3 = 103200 kg C

L_2–L_3

97600 × 6.33 = 618000

11300 × 2.11 = − 23800

380,000 ÷ 3.0 = 127,000 kg T SR = 106 sets.

Approx. wt.

Top chord. 21.3m @ 160 = 3410

Bottom " 16.9 @ 150 = 2540

Diagonal 6 × 4.3 @ 130 = 3350

9300

= 4200

13500 @ 1.78 = 10600 kgs.

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(3)

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MADE BY K. I DATE 7-10-19 FILE NO
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CALCULATIONS FOR

Nagahama Ohashi for Echizen Ken

Structural steel.
Bascule leaf.

Stringer	7 · 16.1m	@ 42 kg	=	4740	
floor beams	17	@ 900	=	6300	
lateral bracing	16.1	@ 110	=	1770	
main girder	2	@ 8000	=	16000	
Exp jt				1,000	
floor brack				300	
shoes				1000	
sundry				590	
					37,000 kg

Balance Beam

Beams.	2	@ 10,000	=	20000	
Cwt. girder				3500	
Girder	2	@ 1000	=	2000	
lateral bracing	13m	@ 300	=	3900	
					29400

Column with bracing

Columns	2	@ 3500	=	7000	
sway strut				2500	
bracing	4	@ 600	=	2400	
					11900

Cwt. spans.?

Stringer	4 · 17.7	@ 52	=	3680	
floorbeams	4	@ 1200	=	4800	
	1	@ 2500	=	2500	
main truss	2	@ 10600	=	21200	
lateral bracing	16.9	@ 150	=	2500	
Exp. jt				1000	
shoes				2000	
					37700

machinery flooring Say. 9000

Summary = 125000 kg.

Steel 125 @ 180 = 22500 m²

Cwt.-

Flooring & Handrails complete.	2500
operators House.	800
machinery & cabling complete.	12000
Electric Equipment	3500
	41300
	3000
	44300

mortar	19.0 m³	@ 17.3	=	330 m²
Scrap	49.0 tons	@ 55	=	2700
				3030

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CALCULATIONS FOR

Estimate of Cost for Nagahama O-Bashi for Ehime-Ken
4 fixed span Layout (See Drawing Note revised).

Structural Steel in fixed span			364.0 tons	@ 181	=	66000
Deck construction Complete (excluding bascule leaf)						
Concrete	210.0 m³	@	12.32	=	2600	
Forms	1470.0 m²	@	1.20	=	1760	
Reinf. Steel	25.0 tons	@	100.00	=	2500	
Pavement	1155.0 m²	@	3.50	=	4020	
Drains etc					350	
Finish of Coping					1680	
Handrails	31.5 tons	@	238		7500	
Electric wiring and lamp post complete					2000	
Entrance Pedestals cut stone					3000	
					25410	Call this 25000
Bascule span and Counterweight Span						
Structural Steel	125.0 tons	@	180	=	22500	
Timber floor Pavement & Handrails					2500	
Operators House					800	
Machinery & Castings complete					12000	
Electric Equipments					3500	
Mortar in Cwt	19.0 m³	@	17.32		330	
Scrap in Cwt	49.0 tons	@	55		2700	
					44330	Call this 44000
Estimated Cost of Superstructure						135000
Estimate of Cost of One Standard Pier 14.0 meter well						
Concrete 124 below	190 m³	@	13.62	=	2600	
124 next	58 "	@	12.32	=	750	
148	96 "	@	8.12	=	780	
Sand filling	66 "	@	.50	=	330	
Reinforcing Steel	9 tons	@	100	=	900	
Forms	600 m²	@	1.50	=	900	
Curb shoe	14 tons	@	150	=	2100	
Excavation	392	@	6	= say	2400	
Rock Excavation					300	
Cut Stone					630	
Coffer and filling and other Sinking Equipments					2150	
					13840	
Approximate Cost of substructure						
Pier No 1				say	9800	
" 2				"	12500	
3				"	14000	
4				"	13500	
5				"	13500	
both abutments & misc works					12000	
					75300	Call this 75000
Total Cost of structure						
Superstructure complete					135000	
Substructure complete					75000	
Road work for approaches				say	3000	
					213000	

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CALCULATIONS FOR

Estimate of Cost for Nagahama Ohashi for Ehime-Ken
5 fixed span Layout (See Drawing No1 revised)

Structural Steel		330.0 tons @180 =	59400	oo
Deck Construction Complete			25000	oo
Bascule and Cert girder spans			44000	
			128400	oo
Substructure				
Pier no 1	9000			
2	11500			
3	14000			
4	14000			
5	13500			
6	13500			
Abutments	12000			
	87500			
Total Cost of Structure				
Superstructure Complete			128400	
Substructure Complete			87500	
Roadwork for approaches		Sum	3000	
			218900	oo
			204000	

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CALCULATIONS FOR

List of Drawings for Nagahama-Ohashi for Ibaraki-Ken

1.	General Plan and Elevation		
2.	General view of Bascule Span		
3.	Details of Bascule span with floor construction		
4	" " Floor beams, stringers lateral bracings and Erop Joints for bascule.		
5	" " Counter weight span		
6	" " Floor beams, stringers, lateral bracings and Machinery frames for Cwt span.		
7	" " Balance beams, Columns, Cwt and misc bracings.		
8	" " Truss for fixed span	1	
9	" " do	2	
10	" " Floor beams, stringers, lateral bracings etc for fixed span.		
11	" " Floor slab for Bascule and Fixed spans.		
12	" " Handrails and light pedestals		
13	" " Curb shoes for Piers		
14	" " Piers	1	
15	" " "	2	
16	General sketch showing execution & Construction method of piers.		
17	Details of Operating House		
18	" " Rack, pinion, bull wheel, trunnion bearings shafts and bosses.		
19	" " Balance beam bearing, toes and accessories.		
20	" " Gears		
21	" " Shafts	1	
22	" " "	2	
23	" " Bearings for main pinion.		
24	" " Second gears		
25	" " First gears		
26	" " Worm gears and bar		
27	General arrangement of machinery		
28	Details of motor shaft bearings and clutch		
29	" " Hand brake	1	
30	" " do	2	
31	" " do	3	
32	" " Air buffer in front		
33.	General arrangements of front lock and Gate		
34	" " rear gate		
35	" " indicator mechanisms		
36	General layout for mechanisms of operating and machinery rooms.		
37	General arrangement of Operating machinery		
38	Operating diagram		
39.	Electric wiring Diagram		
40.	Other miscellaneous details.		

List of Calculation Papers.

Stress Calculation

Bascule span	25	
Counter weight span	15	
fixed span	20	
Piers	15	
		75 pages about

Material lists.

Bascule span	15	
Counter weight span	8	
fixed span	8	
Piers	9	
	40	
Total		115 pages about

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CALCULATIONS FOR

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List of Drawings for Nagahama Ohashi.

✓	1	General Plan and Elevation
½	2	General view of Bascule span.
½	3	Details of Bascule span with floor construction.
½	4	" " Floor beams, stringers, lateral bracings and expansion joint for Bascule span.
	5	" " Counterweight span.
	6	" " Floor beams, stringers, lateral bracings, and maschinery framings for Cwt. Span.
½	7	" " Balance beams, Columns, Cwt. and misc. bracings.
✓	8	" " Truss for Fixed span I
✓	9	" " " II
✓	10	" " Floor beams, stringers, lateral bracings etc. for fixed span.
	11	" " Floor slab for Bascule and Fixed spans.
½	12	" " Handrail and Light pedestal etc.
	13	" " Curb shoes for piers
	14	" " Piers. I
	15	" " " II
	16	General sketch showing process of execution of piers.
	17	Details of Operating house.
	18	" " Rack, pinion, bull wheel, trunnion bearing, shaft and boss.
	19	" " Balance beam bearing, boss, link and accessories.
	20	" " Gears.
	21	" " Shaft I
	22	" " " II
	23	" " Bearings for main pinion
	24	" " " " Second gear
	25	" " " " first "
	26	" " Worm gear and its gear box.
	27	General arrangement of main maschinery
	28	Details of motor shaft bearing and clutch.
	29	" " Hand brake I
	30	" " " II
	31	" " " III
	32	" " Front air buffer.
	33	General arrangements of front lock and front gate.
	34	" " " rear gate.
	35	" " " indicator mechanisms.
	36	General layout for mechanisms of operating and machinery rooms.
	37	General arrangement of operating maschinery.
	38	Operating diagram.
	39	Electric wiring diagram
	40	Other miscellaneous details.

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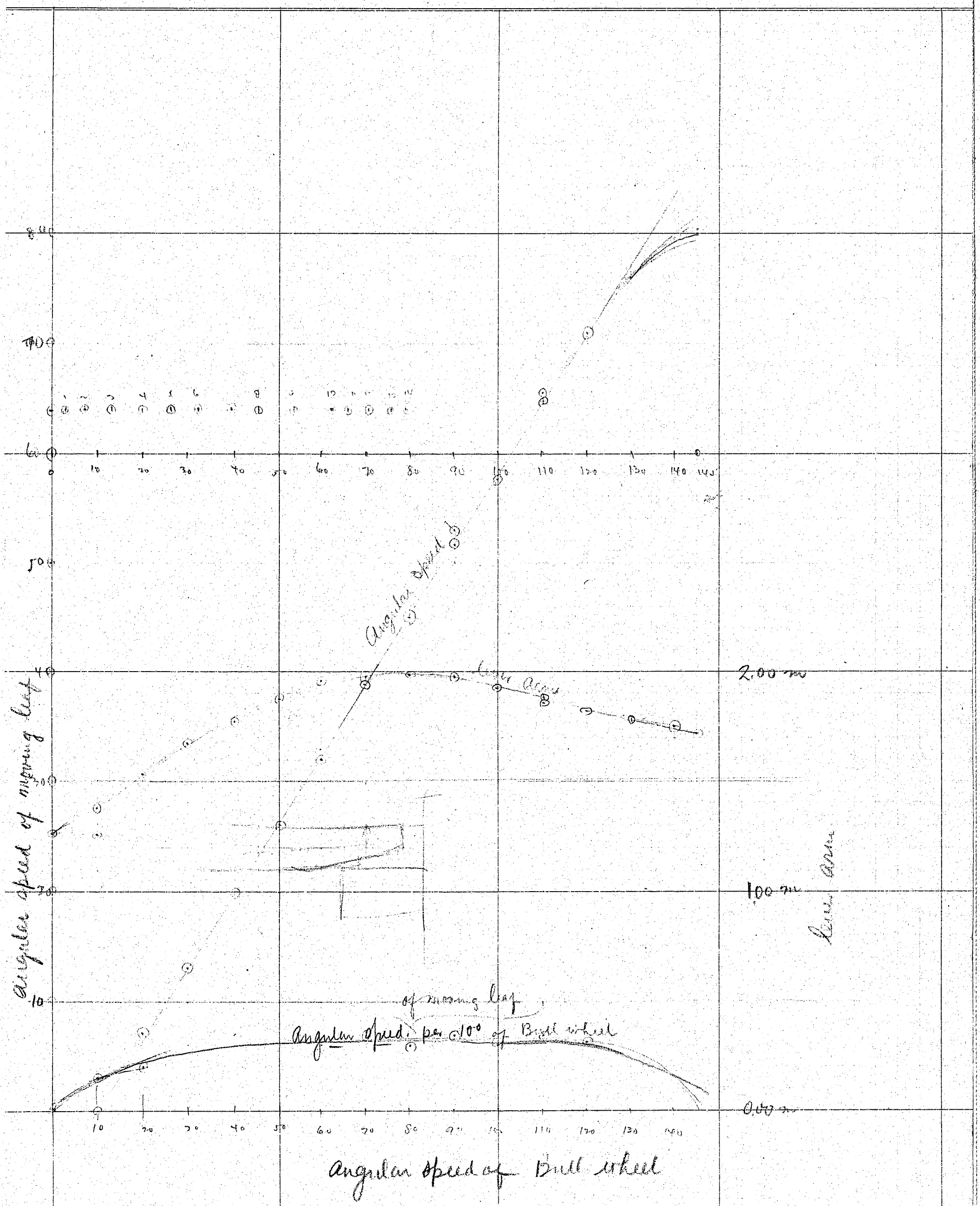
CALCULATIONS FOR



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CALCULATIONS FOR

12 #/0' or $\frac{12}{2.2} \times 3.28^2 = 58.5\ kg/m^2$

60 kg/m²

189 : 30

14.5 moment	$\frac{6.3 \times 60}{2} \times \frac{16.7^2}{2}$	=	279	52,700 kgm
14.0	16.6^2	=	275	52 ow
13	16.3^2	=	265	50.0w
12	15.9^2	=	253	478w
11	15.2	=	231	436w
10	14.2	=	202	382w
9	13.1	=	172	324w
8	11.9	=	142	268w
7	10.6	=	112	212w
6	8.9	=	79	15w
5	7.3	=	53	100w
4	5.6	=	31	59w
3	3.8	=	14	27w
2	2.0	=	4	7.5w
1	0.8	=	.6	100

frictional resistance assumed 15% of carried load.

Carried load. 52700 kg ÷ 1.75 = 30,000 kg link stress.

Friction resistance say 15% 4500

34,500 kg

$34,500 \times \frac{9.5}{1.5} = 12,700$ kg at rack circle. (28 000 lb)

speed at rack = $\pi r \times \frac{145}{180}$ $r = 1.5$ m

$= 3.14 \times 1.5 \times \frac{145}{180} = 3.78$ m

Uniform speed say 180 sec $\frac{3.78}{3} = 1.26$ m per minute 4.13 ft

Theoretical HP = $\frac{1.26 \times 12700}{4560} = 3.50$ HP.

44900 60

$\frac{4.13 \times 28000}{33000} =$ 3.50 HP. $\frac{120,000}{33,000}$

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CALCULATIONS FOR

at (8) 26800 kgm ÷ 1.95 = 13700 kg

rack force 13700 × 1.32 / 1.50 = 12100 kg

18m

13900

15% =

15 13900 × 1.26 / 45m = 3.74 / .18 = 60

90 × 50

27 × 15 × 6m = 2430

15 × 6m = 90 × 27 = 360, 000 kgm

1500 × 2.5

140

60 × 3.14 × 140/180 = 14.7' 4.45 m

92,000 × 445 / 4560 = 91 HP 150 HP / 7.2

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CALCULATIONS FOR

R桁 —

1, truss Span	315 - 24ft	236 t	74,340	8 tm	(28 t) ft tm
1, Bascule	135 -	243 t	32.80 t	340 tm	29 t ft tm
1, Machinery	—	210 tm	21, 000		
1, Electric Equipment			9100		
			137240		

• Panel coats. 65-4ft tm

257295 t
24500 ——
1379 5 ——

24500 t
— 11700
23280 t

about tons.

8700 t
3000
11701

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