増田橋梁建築設計事務所
東京市品川區五反田五ノ一〇八
電話大崎(49)0678番

設計　日付　類別

照査　日付　第　頁

上海高速鐵道

鐵筋混凝土拱橋應力計算書

純徑間一〇、四米
複線軌道

増田橋梁建築設計事務所
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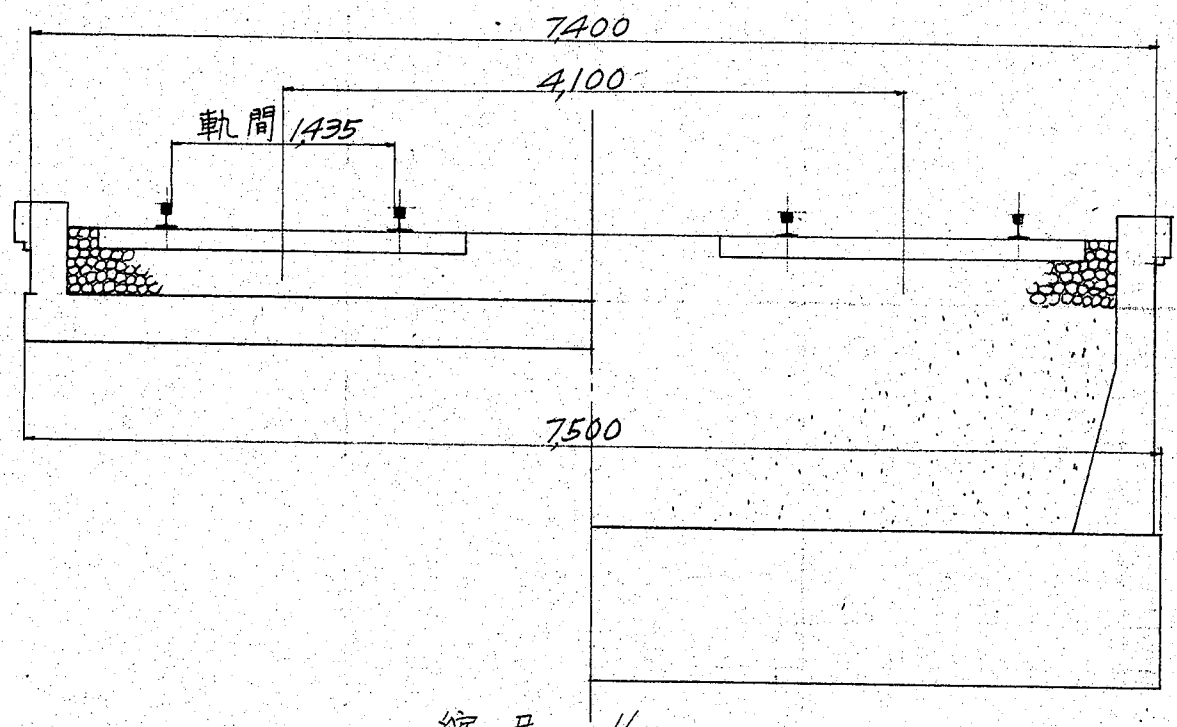
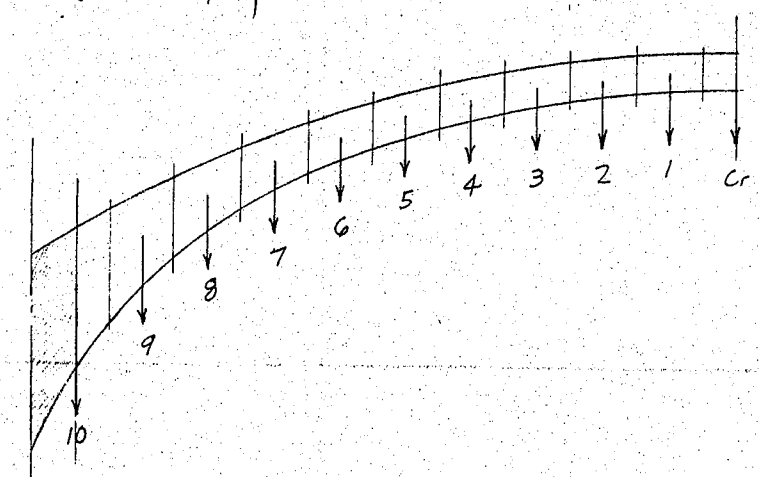
上海地下鐵道鐵筋混凝土拱橋
複線電車軌道(60瓲電車)
純徑間 10.400 米, $l = 11.070^m$, $h = 2.02^m$, $t_0 = 0.3^m$, $t_c = 0.97^m$
橋梁斷面



縮尺 1/50

概算死荷重，計算



W1

軌道,道床及笠石		=	6,560
砂填充	0.035 × 6.90 @ 1,700	=	410
側壁	2@0.635 × 0.25 @ 2,400	=	760
拱環	0.309 × 7.50 @ 2,400	=	5560
			13,290 × 0.52 = 6,920 kg

W2

軌道,道床及笠石		=	6,560
砂填充	0.089 × 6.90 @ 1,700	=	1,045
側壁	2@0.689 × 0.25 @ 2,400	=	830
拱環	0.317 × 7.50 @ 2,400	=	5700
			14,135 × 0.52 = 7,350 kg

W3

軌道,道床及笠石		=	6,560
砂填充	0.171 × 6.90 @ 1,700	=	2,000
側壁	2@0.771 × 0.25 @ 2,400	=	925
拱環	0.327 × 7.50 @ 2,400	=	5880
			15,365 × 0.52 = 7,990 kg

Cr

軌道		=	1,200
道床		=	5,240 } 6,560
笠石		=	120
砂填充	0.015 × 6.90 @ 1,700	=	180
側壁	2 × 0.615 × 0.25 @ 2,400	=	740
拱環	0.305 × 7.50 @ 2,400	=	5,490
			12,970
	12,970 × 0.26 =		3,370 kg

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上海地下鐵道鐵筋混凝土拱橋

W4

軌道道床及笠石		= 6,560
砂填充	0.279 × 6.90 @1,700	= 3,270
側壁	2@0.879 × 0.25 @2,400	= 1,055
拱環	0.342 × 7.50 @2,400	= 6,150
		17,035 × 0.52 = 8,860 kg

W5

軌道道床及笠石		= 6,560
砂填充	0.417 × 6.90 @1,700	= 4,890
側壁	2@1.017 × 0.25 @2,400	= 1,220
拱環	0.362 × 7.50 @2,400	= 6,510
		19,180 × 0.52 = 9,970 kg

W6

軌道道床及笠石		= 6,560
砂填充	0.583 × 6.90 @1,700	= 6,840
側壁	2@1.183 × 0.25 @2,400	= 1,420
拱環	0.394 × 7.50 @2,400	= 7,090
		21,910 × 0.52 = 11,390 kg

W7

軌道道床及笠石		= 6,560
砂填充	0.781 × 6.90 @1,700	= 9,160
側壁	2@1.381 × 0.25 @2,400	= 1,660
拱環	0.460 × 7.50 @2,400	= 8,280
		25,660 × 0.52 = 13,340 kg

W8

軌道道床及笠石		= 6,560
砂填充	1.012 × 6.90 @1,700	= 11,870
側壁	2@1.612 × 0.25 @2,400	= 1,935
拱環	0.588 × 7.50 @2,400	= 10,580
		30,945 × 0.52 = 16,090 kg

W9

軌道道床及笠石		= 6,560
砂填充	1.277 × 6.90 @1,700	= 14,980
側壁	2@1.877 × 0.25 @2,400	= 2,250
拱環	0.814 × 7.50 @2,400	= 14,650
		38,440 × 0.52 = 20,000 kg

W10

軌道道床及笠石		= 6,560
砂填充	1.418 × 6.90 @1,700	= 16,640
側壁	2@2.018 × 0.25 @2,400	= 2,420
拱環	0.958 × 7.50 @2,400	= 17,250
		42,870 × 0.26 = 11,140 kg

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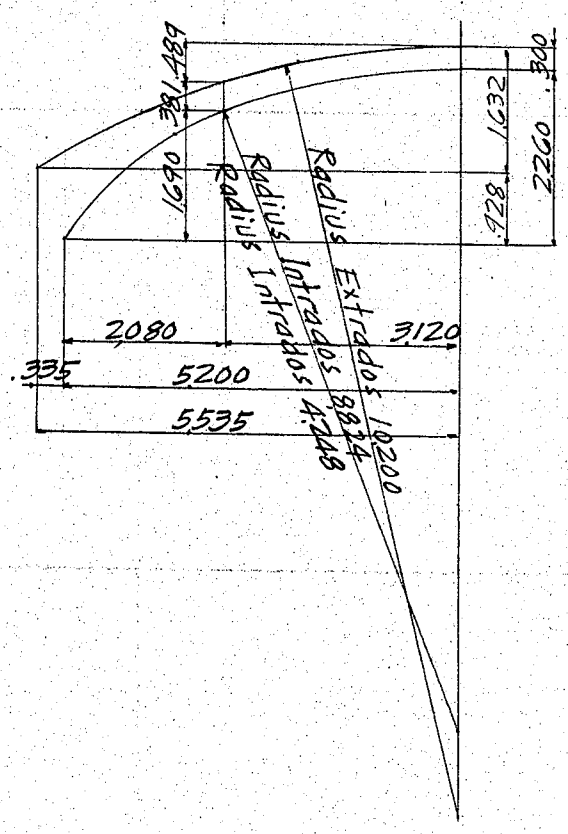
上海地下鐵道鐵筋混凝土拱橋

死荷重反力及拱頂並ニ起拱点ノ曲率ヲ0ト假定シタル場合ノ水平推力ノ概算

	荷重	距離	能率	
Cr	3,370	5.535	18,650	
W1	6,920	5.015	34,700	
W2	7,350	4.495	33,100	
W3	7,990	3.975	31,800	
W4	8,860	3.455	30,600	
W5	9,970	2.935	29250	水平推力 273830 ÷ 2.02 = 135,500 kg
W6	11,390	2.415	27,500	
W7	13,340	1.895	25,300	
W8	16,090	1.375	22,100	
W9	20,000	.855	17,100	
W10	11,140	.335	3730	
	116,420 kg		273,830 kgm	

拱環，寸法



鐵筋

拱頂＝於テハ徑19mm鐵筋(斷面2.84cm²)ヲ上下兩層＝20cm間隔＝使用
起拱点＝於テハ徑22mm鐵筋(斷面3.80cm²)ヲ上下兩層＝20cm間隔＝使用
其ノ他ノ点＝於テハ徑19mm鐵筋ヲ上下兩層＝40cm間隔＝使用

拱頂	2.84 × 37 = 105.1 cm²,	2 @ 1051 = 210.2 cm²
起拱点	3.80 × 37 = 140.6 cm²,	2 @ 140.6 = 281.2 cm²
其ノ他ノ点	2.84 × 19 = 54.0 cm²,	2 @ 54.0 = 108.0 cm²

混凝土ノ物量力率 $\frac{750}{12}d^3 = 0.625\,d^3$

鐵筋ノ物量力率

$\frac{2102\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .3153\left(\frac{d}{2}-0.045\right)^2$ 拱頂

$\frac{2812\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .4218\left(\frac{d}{2}-0.045\right)^2$ 起拱点

$\frac{1080\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .1620\left(\frac{d}{2}-0.045\right)^2$ 其ノ他ノ点

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上海地下鐵道鐵筋混凝土拱橋

格点 拱頂	d	d^3	$I_c=0.625d^3\frac{d}{2}-0.045\left(\frac{d}{2}-0.045\right)^2$			I_s	I_o	混凝土斷面
	.300	0.0270	0.01688	0.105	0.0110 × .3153 =	.00347	0.02035	2250
1	.304	0.0281	0.01756	0.107	0.0114 〃 =	.00359	0.02115	2280
2	.310	0.0298	0.01863	0.110	0.0121 〃 =	.00382	0.02245	2325
3	.317	0.0319	0.01994	0.114	0.0130 × .1620 =	.00211	0.02205	2378
4	.328	0.0353	0.02206	0.119	0.0142 〃 =	.00230	0.02436	2460
5	.342	0.0400	0.02500	0.126	0.0159 〃 =	.00258	0.02758	2565
6	.364	0.0482	0.03013	0.137	0.0188 〃 =	.00305	0.03318	2730
7	.405	0.0664	0.04150	0.158	0.0250 〃 =	.00405	0.04555	3038
8	.485	0.1141	0.07131	0.198	0.0392 × .4218 =	.01653	0.08784	3638
9	.610	0.2270	0.14188	0.260	0.0676 〃 =	.02851	0.17039	4575
10	.795	0.5025	0.31406	0.353	0.1246 〃 =	.05256	0.36662	5963
起拱点	.970	0.9127	0.57044	0.440	0.1936 〃 =	.08166	0.65210	7275

格点 拱頂	x	x^2	y	y^2	d_s	I_o	d_s/I_o	$x\frac{d_s}{I_o}$	$x^2\frac{d_s}{I_o}$	$y\frac{d_s}{I_o}$	$y^2\frac{d_s}{I_o}$
	0.000	0.000	0.000	0.000	.260	0.02035	1278	0	0	0	0
1	0.520	0.270	0.012	0.001	.520	0.02115	2459	1279	665	030	0.03
2	1.040	1.082	0.052	0.003	.523	0.02245	2330	2423	2521	121	0.07
3	1.560	2434	0.123	0.015	.527	0.02205	2390	3728	5817	294	0.36
4	2.080	4326	0.225	0.051	.534	0.02436	2192	4559	9483	493	1.12
5	2.600	6760	0.358	0.128	.543	0.02758	1969	5119	13310	705	252
6	3.120	9734	0.525	0.276	.555	0.03318	1673	5220	16285	878	462
7	3.640	13250	0.733	0.537	.572	0.04555	1256	4572	16642	921	674
8	4.160	17306	0.995	0.990	.596	0.08784	679	2825	11751	676	672
9	4.680	21902	1.330	1.769	.632	0.17039	371	1736	8126	493	656
10	5.200	27040	1.725	2.976	.565	0.36662	154	801	4164	266	458
起拱点	5.535	30636	2.020	4.080	.220	0.65210	.34	188	1042	069	139
							16785	32450	89805	4946	3471

拱頂点

Cr.	x	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
	0	0	0	0	0
1	0.520	0.520	1279	664	015
2	1.040	1.040	2423	2521	126
3	1.560	1.560	3728	5817	459
4	2.080	2.080	4559	9483	1026
5	2.600	2.600	5119	13310	1833
6	3.120	3.120	5220	16285	2741
7	3.640	3.640	4572	16642	3351
8	4.160	4.160	2825	11751	2811
9	4.680	4.680	1736	8126	2309
10	5.200	5.200	801	4164	1382
Sp.	5.535	5.535	188	1042	380
			32450	89805	16433

格点 1

	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
	0	0	0	0
.520	1212	1260	063	
1.040	2486	3878	306	
1.560	3420	7114	770	
2.080	4096	10650	1466	
2.600	4350	13572	2284	
3.120	3919	14265	2873	
3.640	2472	10284	2460	
4.160	1543	7221	2052	
4.680	721	3749	1244	
5.015	171	946	345	
	24390	72939	13863	

格点 2

	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
	0	0	0	0
.520	1243	1939	153	
1.040	2280	4742	513	
1.560	3072	7987	1100	
2.080	3480	10858	1827	
2.600	3266	11888	2394	
3.120	2118	8811	2107	
3.640	1350	6318	1796	
4.160	641	3333	1106	
4.495	153	847	309	
	17603	56723	11305	

格点 3

	x	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
4	2.080	0.520	1140	2371	257
5	2.600	1.040	2048	5325	733
6	3.120	1.560	2610	8143	1370
7	3.640	2.080	2612	9508	1915
8	4.160	2.600	1765	7342	1756
9	4.680	3.120	1158	5419	1540
10	5.200	3.640	561	2917	968
Sp.	5.535	3.975	135	747	273
			12029	41772	8812

格点 4

	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
	0	0	0	0
.520	1024	2662	367	
1.040	1740	5429	914	
1.560	1959	7131	1436	
2.080	1412	5874	1405	
2.600	965	4516	1283	
3.120	480	2496	828	
3.455	117	648	236	
	7697	28756	6469	

格点 5

	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
	0	0	0	0
.520	870	2714	457	
1.040	1306	4754	957	
1.560	1059	4405	1054	
2.080	772	3613	1027	
2.600	400	2080	690	
2.935	100	554	202	
	4507	18120	4387	

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上海地下鐵道鐵筋混凝土拱橋

	x	m	格 6 $m\frac{ds}{I_0}$	表 6 $mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格 7 $m\frac{ds}{I_0}$	表 7 $mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格 8 $m\frac{ds}{I_0}$	表 8 $mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
7	3.640	0.520	6.53	23.77	4.79								
8	4.160	1.040	7.06	29.37	7.02	.520	3.53	14.68	3.51				
9	4.680	1.560	5.79	27.10	7.70	1.040	3.86	18.06	5.13	.520	1.93	9.03	2.57
10	5.200	2.080	3.20	16.64	5.52	1.560	2.40	12.48	4.14	1.040	1.60	8.32	2.76
Sp.	5.535	2.415	.82	4.54	1.66	1.895	.64	3.54	1.29	1.375	.47	2.60	.95
			23.40	101.42	26.69		10.43	48.76	14.07		4.00	19.95	6.28

	x	m	格 9 $m\frac{ds}{I_0}$	表 9 $mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格 10 $m\frac{ds}{I_0}$	表 10 $mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
10	5.200	0.520	.80	4.16	1.38				
Sp.	5.535	0.855	.29	1.61	.59	.335	.11	.61	.22
			1.09	5.77	1.97		.11	.61	.22

拱頂表推力 $H_0=\frac{\int\frac{ds}{I_0}\int my\frac{ds}{I_0}-\int m\frac{ds}{I_0}\int y\frac{ds}{I_0}}{2\left[\int\frac{ds}{I_0}\int y^2\frac{ds}{I_0}-\left(\int y\frac{ds}{I_0}\right)^2\right]}=\frac{A}{B}$　$B=2e337978=675956$

荷重表

								A		B		H_0
Cr.	167.85	×	164.33	=	27582.79	− 324.50 ×	49.46	= 160497.7	1153302	÷ 675956	=	1.706
1	〃	×	138.63	=	23269.05	− 243.90 ×	〃	= 120632.9	1120576	〃	=	1.658
2	〃	×	113.05	=	18975.44	− 176.03 ×	〃	= 87044.4	1026900	〃	=	1.519
3	〃	×	88.12	=	14790.94	− 120.29 ×	〃	= 59495.4	884140	〃	=	1.308
4	〃	×	64.69	=	10858.22	− 76.97 ×	〃	= 38069.4	705128	〃	=	1.043
5	〃	×	43.87	=	7363.58	− 45.07 ×	〃	= 22291.6	513442	〃	=	.760
6	〃	×	26.69	=	4479.92	− 23.40 ×	〃	= 11573.6	332256	〃	=	.492
7	〃	×	14.07	=	2361.65	− 10.43 ×	〃	= 5158.7	184578	〃	=	.273
8	〃	×	6.28	=	1054.10	− 4.00 ×	〃	= 1978.4	85626	〃	=	.127
9	〃	×	1.97	=	330.66	− 1.09 ×	〃	= 539.1	27675	〃	=	.041
10	〃	×	.22	=	36.93	− .11 ×	〃	= 54.4	3149	〃	=	.005

拱頂表彎曲率 $M_0=\frac{-H_0 2\int y\frac{ds}{I_0}+\int m\frac{ds}{I_0}}{2\int\frac{ds}{I_0}}=\frac{C}{D}$　$D=2e16785=33570$

荷重表

									C		D		M_0
Cr	2	×	1.706	×	49.46	=	− 168.76	+ 324.50	= 155.74	÷	33570	=	0.4639
1	〃		1.658	〃		=	− 164.01	+ 243.90	= 79.89		〃	=	0.2380
2	〃		1.519	〃		=	− 150.26	+ 176.03	= 25.77		〃	=	0.0768
3	〃		1.308	〃		=	− 129.39	+ 120.29	= − 9.10		〃	=	−0.0271
4	〃		1.043	〃		=	− 103.17	+ 76.97	= − 26.20		〃	=	−0.0780
5	〃		.760	〃		=	− 75.18	+ 45.07	= − 30.11		〃	=	−0.0897
6	〃		.492	〃		=	− 48.67	+ 23.40	= − 25.27		〃	=	−0.0753
7	〃		.273	〃		=	− 27.01	+ 10.43	= − 16.58		〃	=	−0.0494
8	〃		.127	〃		=	− 12.56	+ 4.00	= − 8.56		〃	=	−0.0255
9	〃		.041	〃		=	− 4.06	+ 1.09	= − 2.97		〃	=	−0.0088
10	〃		.005	〃		=	− .49	+ .11	= − .38		〃	=	−0.0011

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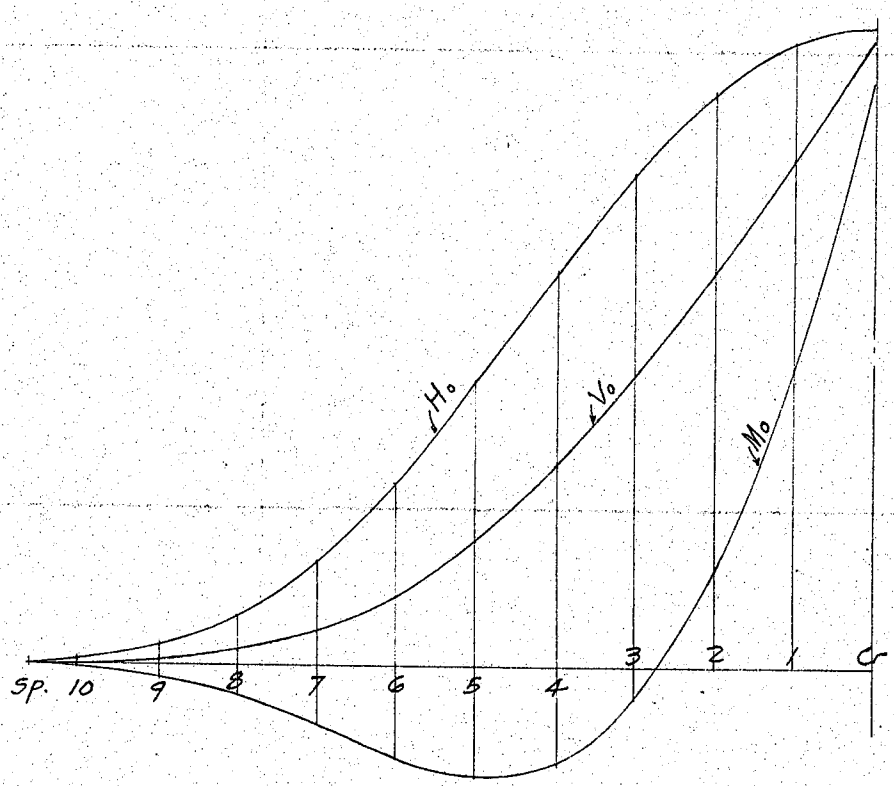
上海地下鐵道鐵筋混凝土拱橋

拱頂点剪力 $V_0 = \dfrac{\int mx\frac{ds}{I_0}}{2\int x^2\frac{ds}{I_0}} = \dfrac{E}{F}$

荷重点	E		F		V_0	$1-V_0$
Cr	898.05	÷	1796.10	=	0.5000	0.5060
1	729.39		〃	=	0.4061	0.5939
2	567.23		〃	=	0.3158	0.6842
3	417.72		〃	=	0.2326	0.7674
4	287.56		〃	=	0.1601	0.8399
5	181.20		〃	=	0.1009	0.8991
6	101.42		〃	=	0.0565	0.9435
7	48.76		〃	=	0.0271	0.9729
8	19.95		〃	=	0.0111	0.9889
9	5.77		〃	=	0.0032	0.9968
10	.61		〃	=	0.0003	0.9997
Sp.	0		〃	=	0.0000	1.0000

拱頂点ニ於ケル水平推力，彎曲率及剪力，影響線



格点，單位荷重ニヨル彎曲率

左半分，彎曲率 $M_L = M_0 + H_0 y + V_0 x - d'$

右半分，彎曲率 $M_R = M_0 + H_0 y - V_0 x$

起拱点 $x = 5.535,\ y = 2.020$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	0.4639	3.4461	2.7675	5.535	1.1425	1.1425
1	0.2380	3.3492	2.2478	5.015	.8200	1.3394
2	0.0768	3.0684	1.7480	4.495	.3982	1.3972
3	-0.0271	2.6422	1.2874	3.975	-.0725	1.3277
4	-0.0780	2.1069	.8862	3.455	-.5399	1.1427
5	-0.0897	1.5352	.5585	2.935	-.9310	.8870
6	-0.0753	.9938	.3127	2.415	-1.1838	.6058
7	-0.0494	.5515	.1500	1.895	-1.2429	.3521
8	-0.0255	.2565	.0614	1.375	-1.0826	.1696
9	-0.0088	.0828	.0177	.855	-.7633	.0563
10	-0.0011	.0101	.0017	.335	-.3243	.0073
Sp	0	0	0	0	0	0

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設計	日付	類別	A
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上海地下鐵道鐵筋混凝土拱橋

格点 10　$x = 5.200$, $y = 1.725$

格点	M_o	$H_o y$	$V_o x$	d'	M_L	M_R
Cr.	0.4639	2.9429	2.6000	5.200	.8068	.8068
1	0.2380	2.8601	2.1117	4.680	.5298	.9864
2	0.0768	2.6203	1.6422	4.160	.1793	1.0549
3	-0.0271	2.2563	1.2095	3.640	-.2013	1.0197
4	-0.0780	1.7992	.8325	3.120	-.5663	.8887
5	-0.0897	1.3110	.5247	2.600	-.8540	.6966
6	-0.0753	.8487	.2938	2.080	-1.0128	.4796
7	-0.0494	.4709	.1409	1.560	-.9976	.2806
8	-0.0255	.2191	.0577	1.040	-.7887	.1359
9	-0.0088	.0707	.0166	.520	-.4415	.0453
10	-0.0011	.0086	.0016		.0091	.0059
Sp.	0	0	0		0	0

格点 8　$x = 4.160$, $y = 0.995$

格点	M_o	$H_o y$	$V_o x$	d'	M_L	M_R
Cr.	0.4639	1.6975	2.0800	4.160	.0814	.0814
1	0.2380	1.6497	1.6894	3.640	-.0629	.1983
2	0.0768	1.5114	1.3137	3.120	-.2181	.2745
3	-0.0271	1.3015	.9676	2.600	-.3580	.3068
4	-0.0780	1.0378	.6660	2.080	-.4542	.2938
5	-0.0897	.7562	.4197	1.560	-.4738	.2468
6	-0.0753	.4895	.2350	1.040	-.3908	.1792
7	-0.0494	.2716	.1127	.520	-.1851	.1095
8	-0.0255	-.1264	.0462		.1471	.0547
9	-0.0088	.0408	.0133		.0453	.0187
10	-0.0011	.0050	.0012		.0051	.0027
Sp.	0	0	0		0	0

格点 6　$x = 3.120$, $y = 0.525$

格点	M_o	$H_o y$	$V_o x$	d'	M_L	M_R
Cr.	0.4639	.8957	1.5600	3.120	-.2004	-.2004
1	0.2380	.8705	1.2670	2.600	-.2245	-.1585
2	0.0768	.7975	.9853	2.080	-.2204	-.1110
3	-0.0271	.6867	.7257	1.560	-.1747	-.0661
4	-0.0780	.5476	.4995	1.040	-.0709	-.0299
5	-0.0897	.3990	.3148	.520	.1041	-.0055
6	-0.0753	.2583	.1763		.3593	.0067
7	-0.0494	.1433	.0846		.1785	.0093
8	-0.0255	.0667	.0346		.0758	.0066
9	-0.0088	.0215	.0100		.0227	.0027
10	-0.0011	.0026	.0009		.0024	.0006
Sp.	0	0	0		0	0

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上海地下鐵道鐵筋混凝土拱橋

格点 4　　x = 2.080,　y = 0.225

格点	M_0	H_0y	V_0x	d'	M_L	M_R
Cr.	0.4639	.3839	1.0400	2.080	-.1922	-.1922
1	0.2380	.3731	.8447	1.560	-.1042	-.2336
2	0.0768	.3418	.6569	1.040	.0355	-.2383
3	-0.0271	.2943	.4838	.520	.2310	-.2166
4	-0.0780	.2347	.3330		.4897	-.1763
5	-0.0897	.1710	.2099		.2912	-.1286
6	-0.0753	.1107	.1175		.1529	-.0821
7	-0.0494	.0614	.0564		.0684	-.0444
8	-0.0255	.0286	.0231		.0262	-.0200
9	-0.0088	.0092	.0067		.0071	-.0063
10	-0.0011	.0011	.0006		.0006	-.0006
Sp.	0	0	0		0	0

格点 2　　x = 1.040,　y = 0.052

格点	M_0	H_0y	V_0x	d'	M_L	M_R
Cr	0.4639	.0887	.5200	1.040	.0326	.0326
1	0.2380	.0862	.4223	.520	.2265	-.0981
2	0.0768	.0790	.3284		.4842	-.1726
3	-0.0271	.0680	.2419		.2828	-.2010
4	-0.0780	.0542	.1665		.1427	-.1903
5	-0.0897	.0395	.1049		.0547	-.1551
6	-0.0753	.0256	.0588		.0091	-.1085
7	-0.0494	.0142	.0282		-.0070	-.0634
8	-0.0255	.0066	.0115		-.0074	-.0304
9	-0.0088	.0021	.0033		-.0034	-.0100
10	-0.0011	.0003	.0003		-.0011	-.0011
Sp	0	0	0		0	0

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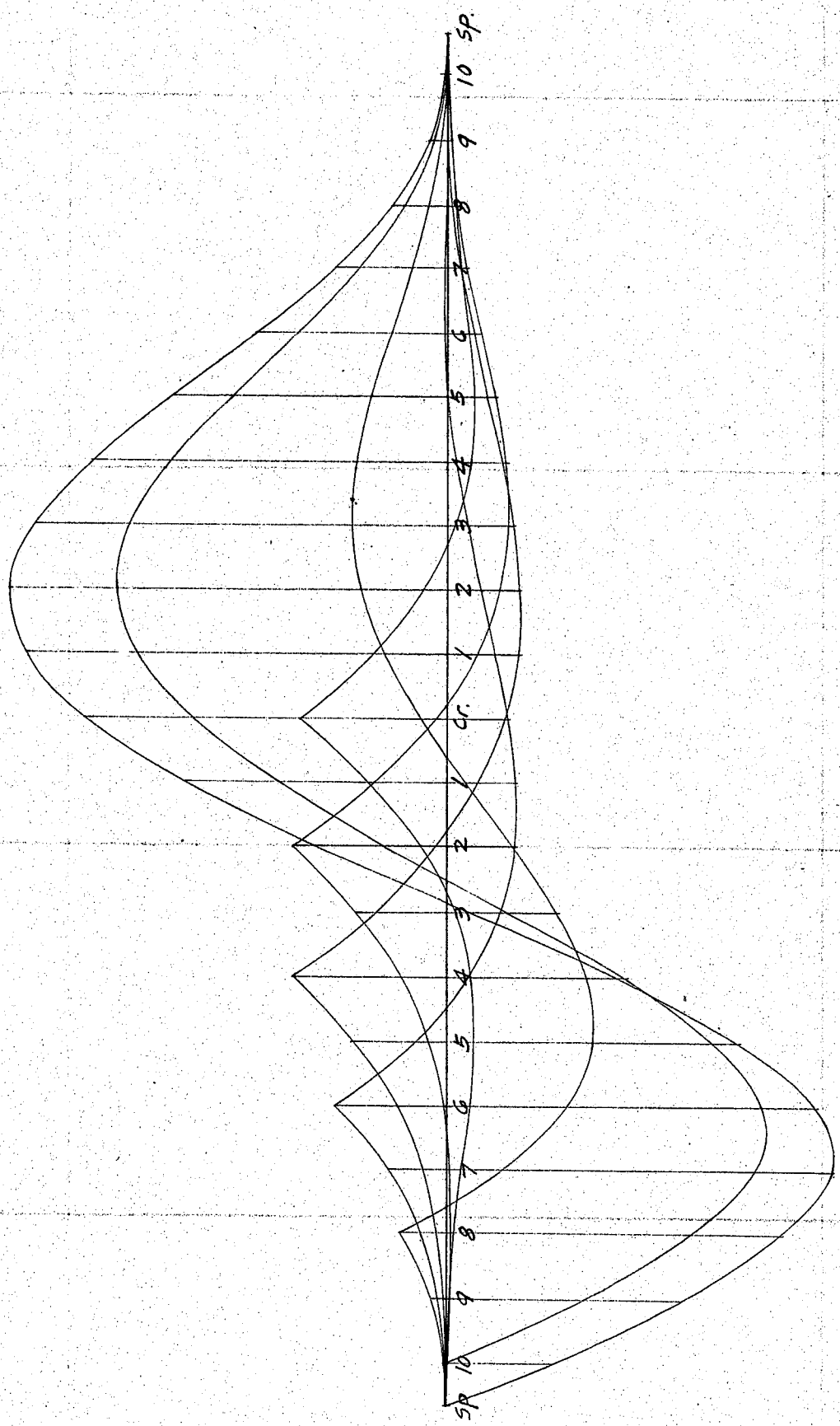
設計	日付	類別	A
照査	日付	第	9 頁

上海地下鐵道鐵筋混凝土拱橋
格点弯曲率，影響線



縮尺　距離　1/50
弯曲率　1cm = 0.20

増田橋梁建築設計事務所
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設計	日付	類別	A
照査	日付	第	10 頁

上海地下鐵道鐵筋混凝土拱橋

格点，死荷重彎曲率

拱頂

格点	荷重	M_0	M
Cr	3370	0.4639	1,563
1	6,920	0.2380	1,645
2	7,350	0.0768	564
3	7,990	-0.0271	-217
4	8,860	-0.0780	-691
5	9,970	-0.0897	-894
6	11,390	-0.0753	-858
7	13,340	-0.0494	-659
8	16,090	-0.0255	-410
9	20,000	-0.0088	-176
10	11,140	-0.0011	-12
			3,772
			-3,917

-145 × 2 = -290 Kgm

格点2			格点4		格点6		格点8		格点10	
格点	荷重		M		M		M		M	
10L	11,140	-.0011	-12	.0006	7	.0024	27	.0051	57	.0091	101
9	20,000	-.0034	-68	.0071	142	.0227	454	.0453	906	-.4415	-8,825
8	16,090	-.0074	-119	.0262	422	.0758	1,220	.1471	2,367	-.7887	-12,680
7	13,340	-.0070	-93	.0684	913	.1785	2,382	-.1851	-2,468	-.9976	-13,310
6	11,340	.0091	104	.1529	1,742	.3593	4,093	-.3908	-4,450	-1.0128	-11,530
5	9,970	.0547	545	.2912	2,903	.1041	1,038	-.4738	-4,723	-.8540	-8,510
4	8,860	.1427	1,264	.4897	4,340	-.0709	-628	-.4542	-4,025	-.5663	-5,020
3	7,990	.2828	2,260	.2310	1,847	-.1747	-1,395	-.3580	-2,860	-.2013	-1,608
2	7,350	.4842	3,560	.0355	261	-.2204	-1,620	-.2181	-1,603	.1793	1,318
1	6,920	.2265	1,566	-.1042	-720	-.2245	-1,552	-.0629	-435	.5298	3,662
Cr	6,740	.0326	220	-.1922	-1,295	-.2004	-1,352	.0814	549	.8068	5,440
1	6,920	-.0981	-678	-.2336	-1,615	-.1585	-1,096	.1983	1,372	.9864	6,820
2	7,350	-.1726	-1,268	-.2383	-1,752	-.1110	-816	.2745	2,018	1.0549	7,750
3	7,990	-.2010	-1,606	-.2166	-1,730	-.0661	-528	.3068	2,450	1.0197	8,140
4	8,860	-.1903	-1,677	-.1763	-1,562	-.0299	-265	.2938	2,603	.8887	7,878
5	9,970	-.1551	-1,545	-.1286	-1,282	-.0055	-55	.2468	2,460	.6966	6,945
6	11,390	-.1085	-1,235	-.0821	-936	.0067	76	.1792	2,040	.4796	5,460
7	13,340	-.0634	-846	-.0444	-592	.0093	124	.1095	1,462	.2806	3,742
8	16,090	-.0304	-489	-.0200	-322	.0066	106	.0547	880	.1359	2,187
9	20,000	-.0100	-200	-.0063	-126	.0027	54	.0187	374	.0453	906
10R	11,140	-.0011	-12	-.0006	-7	.0006	7	.0027	30	.0059	66
			-9,848		12,577		9,581		19,568		60,314
			9,519		-11,939		-9,307		-20,564		-61,483
			-329 Kgm		638 Kgm		274 Kgm		-996 Kgm		-1,169 Kgm

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設計	日付	類別	A
照査	日付	第	11頁

上海地下鐵道鐵筋混凝土拱橋

起拱点

格点	荷重		M
10L	11,140	-.3243	-3,612
9	20,000	-.7633	-15,260
8	16,090	-1.0826	-17,420
7	13,340	-1.2429	-16,580
6	11,390	-1.1838	-13,480
5	9,970	-.9310	-9,278
4	8,860	-.5399	-4,785
3	7,990	-.0725	-579
2	7,350	.3982	2,927
1	6,920	.8200	5,670
Cr	6,740	1.1425	7,700
1	6,920	1.3394	9,260
2	7,350	1.3972	10,270
3	7,990	1.3277	10,620
4	8,860	1.1427	10,120
5	9,970	.8870	8,840
6	11,390	.6058	6,900
7	13,340	.3521	4,695
8	16,090	.1696	2,728
9	20,000	.0563	1,126
10R	11,140	.0073	81
			-80,994
			80,937
			-57 kgm

死荷重推力

格点	荷重	H。	H				水平推力=ヨル 軸推力	垂直剪力			垂直剪力=ヨル 軸推力
Cr.	3,370	1.706	5,750	135,638	×	1.000 =	135,638	0	×	0.000 =	0
1	6,920	1.658	11,470					6,830			
2	7,350	1.519	11,170	〃	×	.995 =	135,000	13,965	×	0.100 =	1,396
3	7,990	1.308	10,450					21,635			
4	8,860	1.043	9,250	〃	×	.980 =	132,800	30,060	×	0.210 =	6,310
5	9,970	.760	7,570					39,475			
6	11,390	.492	5,600	〃	×	.945 =	128,200	50,155	×	0.325 =	16,280
7	13,340	.273	3,640					62,520			
8	16,090	.127	2,043	〃	×	.875 =	118,700	77,235	×	0.495 =	38,230
9	20,000	.041	820					95,280			
10	11,140	.005	56	〃	×	.750 =	101,700	110,850	×	0.660 =	73,200
Sp	116,420		67,819	〃	×	.705 =	95,600	116,420	×	0.715 =	83,200
			× 2								
			135,638 kg								

死荷重軸推力ノ總計

	Cr	2	4	6	8	10	Sp
垂直剪力=ヨル	—	1,396	6,310	16,280	38,230	73,200	83,200
水平推力=ヨル	135,638	135,000	132,800	128,200	118,700	101,700	95,600
	135,638	136,396	139,110	144,480	156,930	174,900	178,800

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設計　日付　類別　A
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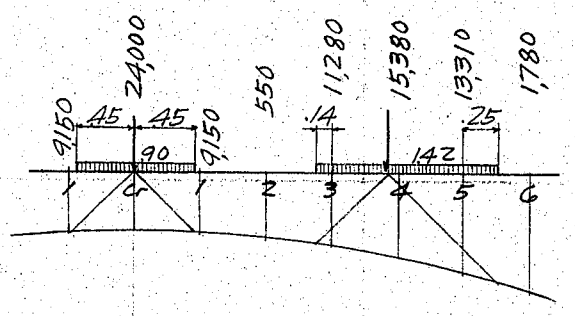
上海地下鐵道鐵筋混凝土拱橋

活荷重應力

電車輪荷重
衝撃荷重　$i = \frac{25}{50+1107} = .409$

30,000 kg　特殊荷重　33,000 kg
12,300
42,300 kg

拱頂　正彎曲率



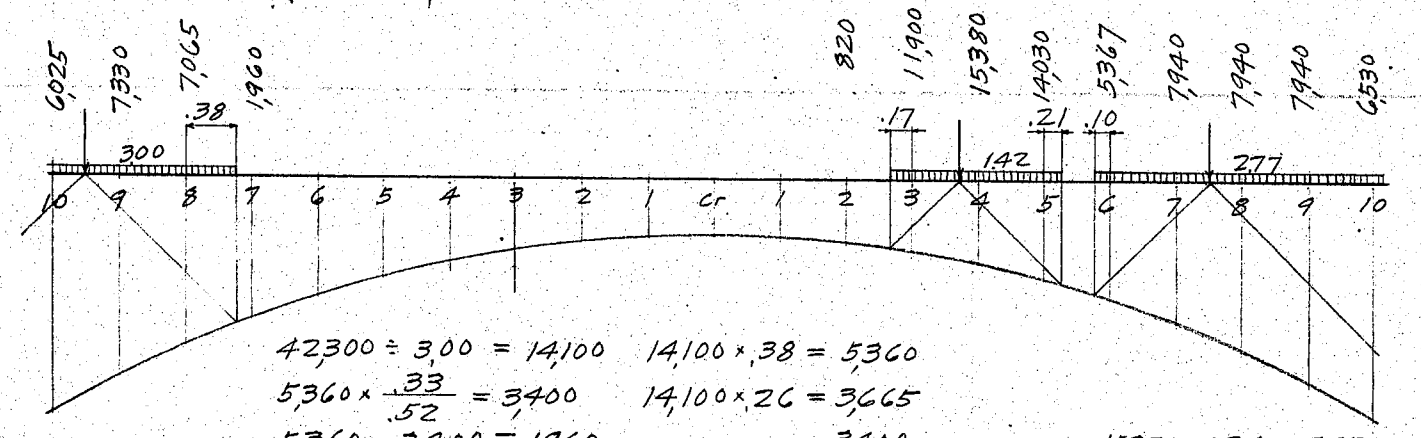
$21,150 \times \frac{.225}{.52} = 9,150$　　$2e\,(21,150 - 9,150) = 24,000$

$42,300 \div 1.43 = 29,600$ kg/m　　$29,600 \times .14 \times \frac{.45}{.52} = 3,590$
$29,600 \times .14 = 4,140$,　$4,140 - 3,590 = 550$
$29,600 \times .26 = 7,690$　　$7,690 + 3,590 = 11,280$
$2 @ 7,690 = 15,380$　　$29,600 \times .25 = 7,400$
$7,400 \times \frac{.395}{.52} = 5,620$　　$7,400 - 5,620 = 1,780$
$7,690$
$13,310$

格点		Mu	M	Ho	H
1	9,150	0.2380	2,178	1.658	15,170
0	24,000	0.4639	11,130	1.706	40,940
1	9,150	0.2380	2,178	1.658	15,170
2	550	0.0768	42	1.519	835
3	11,280	-0.0271	- 306	1.308	14,770
4	15,380	- 0.0780	- 1,200	1.043	16,050
5	13,310	- 0.0897	- 1,194	.760	10,120
6	1,780	- 0.0753	- 134	.492	875
			12,694 kgm		113,930 kg

特殊荷重
$M = 12,694 \times 1.1 = 13,970$ kgm
$H = 113,930 \times 1.1 = 125,300$ kg

拱頂　負彎曲率



$42,300 \div 3.00 = 14,100$　　$14,100 \times .38 = 5,360$
$5,360 \times \frac{.33}{.52} = 3,400$　　$14,100 \times .26 = 3,665$
$5,360 - 3,400 = 1,960$　　$3,400$
$2e\,3,665 = 7,330$　　$7,065$
$14,100 \times .1675 = 2,360 + 3,665 = 6,025$

$29,600 \times .17 = 5,030$
$5,030 \times \frac{.435}{.52} = 4,210$
$7,690$
$11,900$
$5,030 - 4,210 = 820$
$29,600 \times .21 = 6,210$
$6,210 \times \frac{.415}{.52} = 4,960$
$42,300 \div 2.77 = 15,270$
$15,270 \times 0.1 = 1,527$
$1,527 \times \frac{.47}{.52} = 1,380$
$4,960$
$7,690$
$14,030$
$15,270 \times .1675 = 2,560$
$3,970$
$6,530$

$15,270 \times 0.26 = 3,970$
$6,210 - 4,960 = 1,250$
$1,527 - 1,380 = 147$
$5,367$
$2 @ 3,970 = 7,940$

格点		Mu	M	Ho	H
10	6,025	- 0.0011	- 7	0.005	30
9	7,330	- 0.0088	- 65	0.041	301
8	7,065	- 0.0255	- 180	0.127	897
7	1,960	- 0.0494	- 97	0.273	535
2	820	0.0678	56	1.519	1,245
3	11,900	- 0.0271	- 322	1.308	15,570
4	15,380	- 0.0780	- 1,200	1.043	16,050
5	14,030	- 0.0897	- 1,260	.760	10,670
6	5,367	- 0.0753	- 404	.492	2,640
7	7,940	- 0.0494	- 392	.273	2,168
8	7,940	- 0.0255	- 205	.127	1,008
9	7,940	- 0.0088	- 70	.041	326
10	6,530	- 0.0011	- 7	.005	33
			- 4,153 kgm		51,473 kg

特殊荷重
$M = -3,804 \times 1.1 = -4,185$ kgm
$H = 49,710 \times 1.1 = 54,700$ kg

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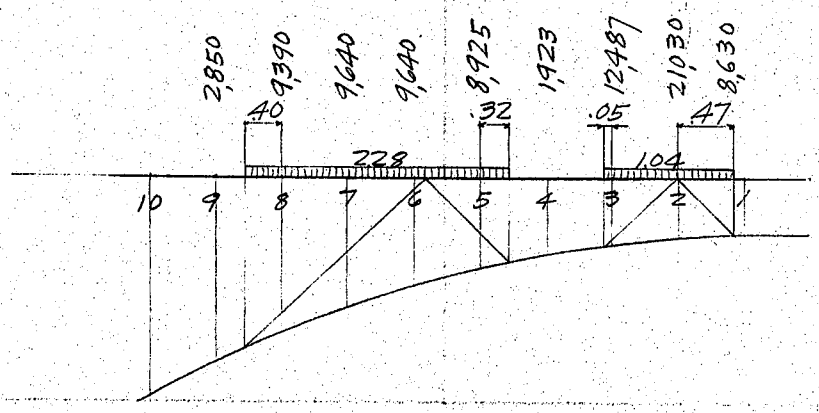
設計　日付　類別　A
照査　日付　第　13頁

上海地下鐵道鐵筋混凝土拱橋

格点2　正弯曲率



42,300 ÷ 2.28 = 18,550
7,420 × .20/.52 = 2,850
18,550 × .26 = 4,820
2 @ 4,820 = 9,640
18,550 × .32 = 5,930
5,930 − 1,825 = 4,105
4,820
8,925
42,300 ÷ 1.04 = 40,650
2,035 − 98 = 1,927

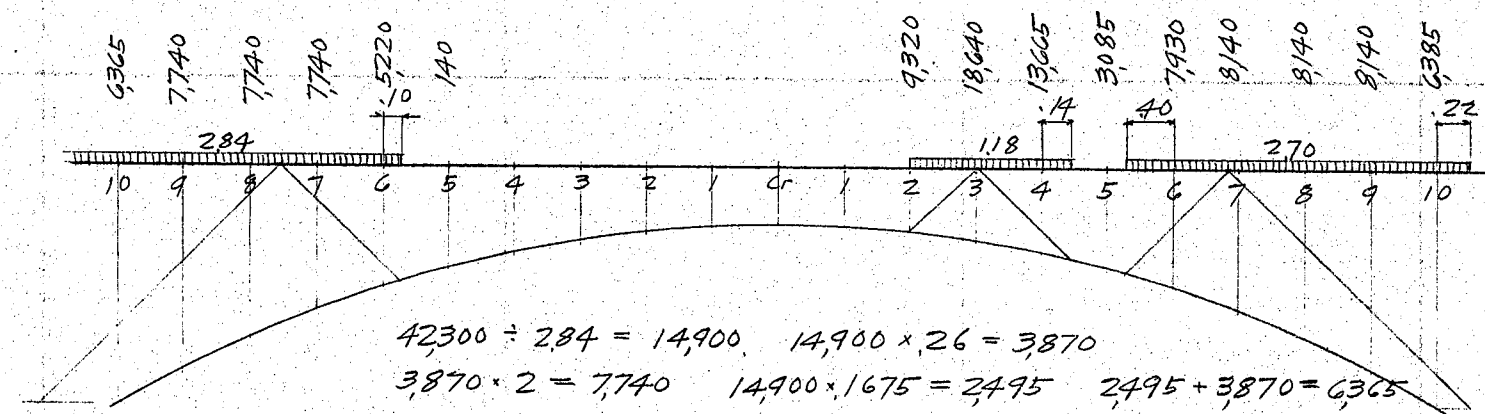
18,550 × .40 = 7,420
7,420 − 2,850 = 4,570
4,820
9,390
5,930 × .16/.52 = 1,825
40,650 × .05 = 2,035
2,035 × .025/.52 = 98
1,825
1,923
40,650 × .26 = 10,560
1,927
12,487
40,650 × .47 = 19,100
19,100 × .235/.52 = 8,630
19,100 − 8,630 = 10,470
10,560
21,030

格点		Mu	M	Ho	H	Vo	V
9	2,850	−0.0034	−10	.041	117	−.0032	−9
8	9,390	−.0074	−70	.127	1,193	−.0111	−104
7	9,640	−.0070	−67	.273	2,630	−.0271	−261
6	9,640	.0091	88	.492	4,743	−.0565	−545
5	8,925	.0547	488	.760	6,780	−.1009	−900
4	1,923	.1427	274	1.043	2,008	−.1601	−308
3	12,487	.2828	3,530	1.308	16,340	−.2326	−2,900
2	21,030	.4842	10,180	1.519	31,970	.6842	14,400
1	8,630	.2265	1,955	1.658	14,300	.5939	5,120
			16,368 kgm		80,081 kg		14,493 kg

特殊荷重
M = 16,368 × 1.1 = 18,000 kgm
H = 80,081 × 1.1 = 88,100 kg
V = 14,493 × 1.1 = 15,950 kg
軸推力 = 81,150 × 1.1 = 89,200 kg

軸推力
80,081 × .995 = 79,700
14,493 × .100 = 1,450
81,150 kg

格点2　負弯曲率



42,300 ÷ 2.84 = 14,900　14,900 × .26 = 3,870
3,870 × 2 = 7,740　14,900 × .1675 = 2,495　2,495 + 3,870 = 6,365
14,900 × .10 = 1,490　1,490 × .05 ÷ .52 = 140　1,490 − 140 = 1,350

格点		Mu	M	Ho	H
10	6,365	−.0011	−7	.005	32
9	7,740	−.0034	−26	.041	317
8	7,740	−.0074	−57	.127	982
7	7,740	−.0070	−54	.273	2,112
6	5,220	.0091	48	.492	2,570
5	140	.0547	8	.760	106
2	9,320	−.1726	−1,608	1.519	14,160
3	18,640	−.2010	−3,745	1.308	24,400
4	13,665	−.1903	−2,600	1.043	14,250
5	3,085	−.1551	−479	.760	2,345
6	7,930	−.1085	−860	.492	3,900
7	8,140	−.0634	−516	.273	2,220
8	8,140	−.0304	−247	.127	1,034
9	8,140	−.0100	−81	.041	334
10	6,385	−.0011	−7	.005	32
			−10,231 kgm		68,794 kg

特殊荷重
M = −10,143 × 1.1 = −11,150 kgm
H = 62,675 × 1.1 = 68,900 kg

42,300 ÷ 1.18 = 35,850
35,850 × .26 = 9,320
35,850 × .14 = 5,020
5,020 × .45/.52 = 4,345
9,320
13,665
5,020 − 4,345 = 675
42,300 ÷ 2.70 = 15,670
15,670 × .26 = 4,070
15,670 × .04 = 6,270
6,270 × .2/.52 = 2,410
675
3,085
6,270 − 2,410 = 3,860
4,070
7,930
15,670 × .22 × .225/.335 = 2,315
4,070
6,385

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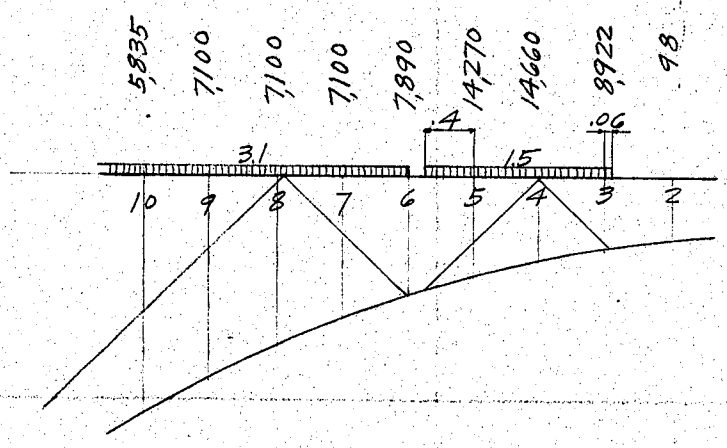
設計	日付	類別	A
照査	日付	第	14頁

上海地下鐵道鐵筋混凝土拱橋

格点4　正彎曲率



格点		Mu	M	Ho	H	Vo	V
10	5,835	.0006	4	.005	29	-.0003	-2
9	7,100	.0071	50	.041	291	-.0032	-23
8	7,100	.0262	186	.127	902	-.0111	-79
7	7,100	.0684	486	.273	1,938	-.0271	-192
6	7,880	.1529	1,205	.492	3,876	-.0565	-445
5	14,270	.2912	4,155	.760	10,850	-.1009	-1,440
4	14,660	.4897	7,180	1.043	15,300	.8399	12,300
3	8,922	.2310	2,060	1.308	11,670	.7674	6,840
2	98	.0355	3	1.519	149	.6842	67
			15,329 kgm		45,005		17,026

42,300 ÷ 3.1 = 13,650　　13,650 × .26 = 3,550
13,650 × .1675 = 2,285
3,550
5,835

42,300 ÷ 1.5 = 28,200　　28,200 × .26 = 7,330
28,200 × 0.4 = 11,280　　11,280 × .20/.52 = 4,340
11,280 − 4,340 = 6,940　　3,550
7,330　　7,890
14,270

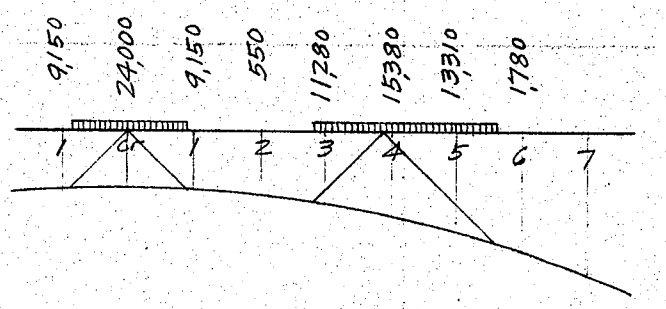
28,200 × .06 = 1,690　　1,690 × .03 ÷ .52 = 98
1,690 − 98 = 1,592
7,330
8,922

特殊荷重
M = 15,329 × 1.1 = 16,860 kgm
H = 45,005 × 1.1 = 49,500 kg
V = 17,026 × 1.1 = 18,730 〃
軸推力 = 47,675 × 1.1 = 52,400 〃

軸推力

45,005 × .980 = 44,100
17,026 × .210 = 3,575
47,675 kg

格点4　負彎曲率



格点		Mu	M	Ho	H
1	9,150	-.1042	-953	1.658	15,170
Cr	24,000	-.1922	-4,610	1.706	40,900
1	9,150	-.2336	-2,137	1.658	15,170
2	550	-.2383	-131	1.519	835
3	11,280	-.2166	-2,442	1.308	14,760
4	15,380	-.1763	-2,712	1.043	16,050
5	13,310	-.1286	-1,712	.760	10,120
6	1,780	-.0821	-146	.492	876
			-14,843 kgm		113,881 kg

特殊荷重
M = −14,843 × 1.1 = −16,330 kgm
H = 113,881 × 1.1 = 125,300 kg

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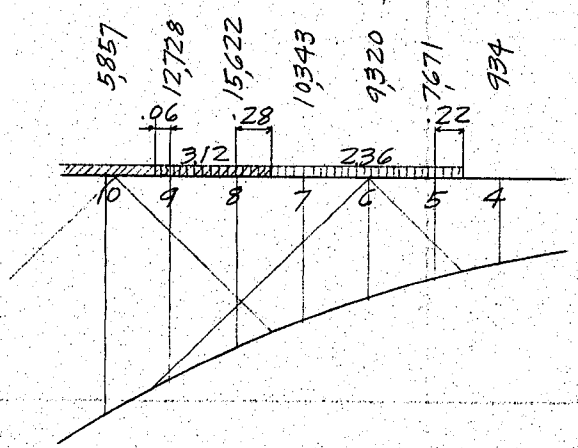
照査 日付 第 15 頁

上海地下鐵道鐵筋混凝土拱橋

格点6 正彎曲率



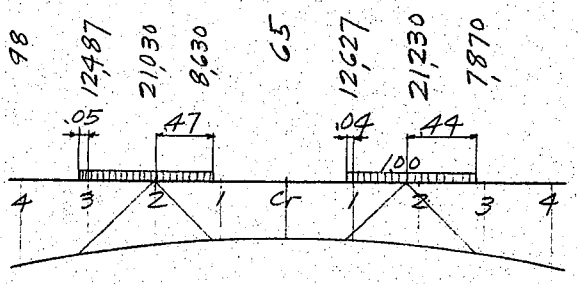
42,300÷3.12 = 13,560　13,560×.26 = 3525　13,560×.1675 = 2,270
13,560×.28 = 3,800　3,800×14/52 = 1,023　3,800−1,023 = 2,777
42,300÷2.36 = 17,930　17,930×.26 = 4,660　17,930×.06 = 1,080
1,080×.03/.52 = 62　1,080−62 = 1,018　17,930×.22 = 3,945

3,525	7,050	3,525	1,023	3,945×11/52 = 934
2,270	4,660	2,777	9320	3,945−934 = 3,011
62	1,018	9,320	10,343	4,660
5,857	12,728	15,622		7,671

格点		Mu	M	Ho	H
10	5,857	.0024	14	.005	29
9	12,728	.0227	289	.041	522
8	15,622	.0758	1,185	.127	1,985
7	10,343	.1785	1,845	.273	2,823
6	9,320	.3593	3,350	.492	4,585
5	7,671	.1041	798	.760	5,830
4	934	−.0709	−66	1.043	975
			7,415 kgm		16,749 kg

特殊荷重
M = 7,415 × 1.1 = 8,150 kgm
H = 16,749 × 1.1 = 18,420 kg

格点6 負彎曲率



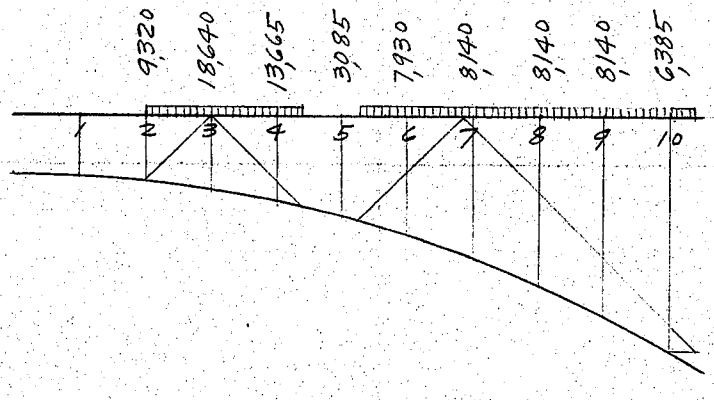
42,300×.26 = 11,000　1,692×50/52 = 1,627
42,300×.04 = 1,692　1,692−1,627 = 65
1,627　42,300×.44 = 18,600
11,000　18,600×22/52 = 7,870　18,600−7,870 = 10,230
12,627　11,000
21,230

格点		Mu	M	Ho	H	Vo	V
4	98	−.0709	−7	1.043	102	.8399	82
3	12,487	−.1747	−2,180	1.308	16,330	.7674	9,580
2	21,030	−.2204	−4,635	1.519	31,950	.6842	14,400
1	8,630	−.2245	−1,937	1.658	14,320	.5939	5,120
Cr	65	−.2004	−13	1.706	111	.5000	33
1	12,627	−.1585	−2,000	1.658	20,940	.4061	5,130
2	21,230	−.1110	−2,358	1.519	32,260	.3158	6,710
3	7,870	−.0661	−520	1.308	10,300	.2326	1,830
			−13,650 kgm		126,313 kg		42,885 kg

特殊荷重
M = −13,650 × 1.1 = −15,020 kgm
H = 126,313 × 1.1 = 139,000 kg
V = 42,885 × 1.1 = 47,150 ,
軸推力 = 133,330 × 1.1 = 146,700 ,

軸推力
126,313 × .945 = 119,400
42,885 × .325 = 13,930
133,330 kg

格点8 正彎曲率



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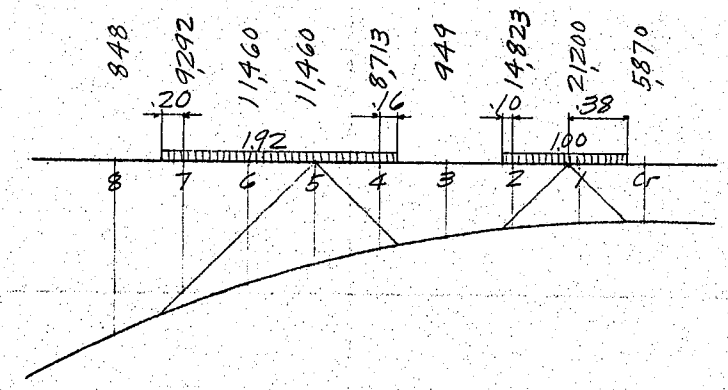
上海地下鐵道鐵筋混凝土拱橋

格点		Mu	M	Ho	H
2	9,320	.2745	2,560	1.519	14,160
3	18,640	.3068	5,720	1.308	24,400
4	13,665	.2938	4,015	1.043	14,270
5	3,085	.2468	761	.760	2,345
6	7,930	.1792	1,420	.492	3,900
7	8,140	.1095	891	.273	2,220
8	8,140	.0547	445	.127	1,034
9	8,140	.0187	152	.041	334
10	6,385	.0027	17	.005	32
			15,981 kgm		62,695 kg

特殊荷重
M = 15,981 × 1.1 = 17,580 kgm
H = 62,695 × 1.1 = 69,000 kg

格点8　負彎曲率



42,300 ÷ 1.92 = 22,050
22,050 × .20 = 4,410
4,410 − 848 = 3,562
5,730
9,292

22,050 × .26 = 5,730
4,410 × .10/.52 = 848
22,050 × .16 = 3,525
3,525 × .08/.52 = 542
3,525 − 542 = 2,983
5,730
8,713

42,300 × .26 = 11,000
42,300 × 0.1 × .05/.52 = 407
542
949

42,300 − 407 = 3,823
11,000
14,823

42,300 × .38 = 16,070
16,070 × .19/.52 = 5,870
16,070 − 5,870 = 10,200
11,000
21,200

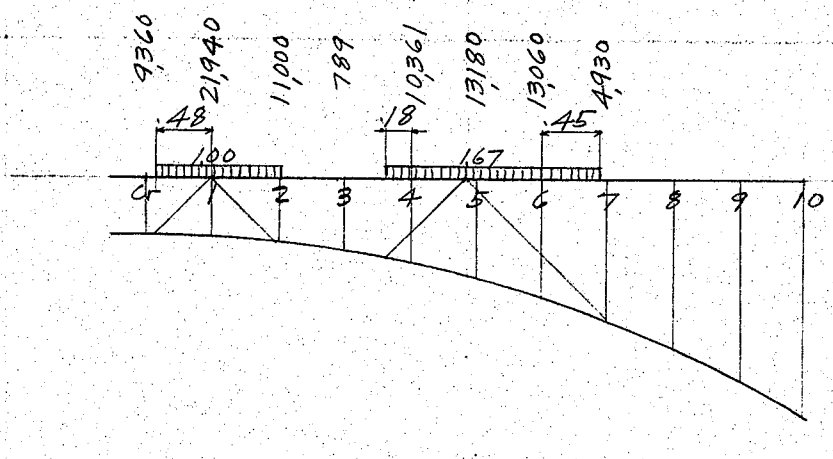
格点		Mu	M	Ho	H	Vo	V
8	848	.1471	125	.127	108	0.9889	839
7	9,292	-.1851	-1,720	.273	2,536	0.9729	9,040
6	11,460	-.3908	-4,480	.492	5,640	0.9435	10,820
5	11,460	-.4738	-5,430	.760	8,710	0.8991	10,300
4	8,713	-.4542	-3,955	1.043	9,090	0.8399	7,315
3	949	-.3580	-340	1.308	1,242	0.7674	7,280
2	14,823	-.2181	-3,235	1.519	22,500	0.6842	10,150
1	21,200	-.0629	-1,333	1.658	35,150	0.5939	12,580
Cr.	5,870	.0814	478	1.706	10,020	0.5000	2,935
			-19,890 kgm		94,996 kg		71,259 kg

軸推力

94,996 × .875 = 83,100
71,259 × .495 = 35,300
118,400 kg

特殊荷重
M = −19,890 × 1.1 = −21,870 kgm
H = 94,996 × 1.1 = 104,500 kg
V = 71,259 × 1.1 = 78,400 〃
軸推力 = 118,400 × 1.1 = 130,300 〃

格点10　正彎曲率



42,300 × .26 = 11,000
20,300 × .24/.52 = 9,360
42,300 × .48 = 20,300
20,300 − 9,360 = 10,940
11,000
21,940

42,300 ÷ 1.67 = 25,340
25,340 × .18 = 4,560
4,560 − 789 = 3,771
6,590
10,361

25,340 × .26 = 6,590
4,560 × .09/.52 = 789
25,340 × .45 = 11,400
11,400 × .225/.52 = 4,930
11,400 − 4,930 = 6,470
6,590
13,060

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照査　日付　第　17頁

上海地下鐵道鐵筋混凝土拱橋

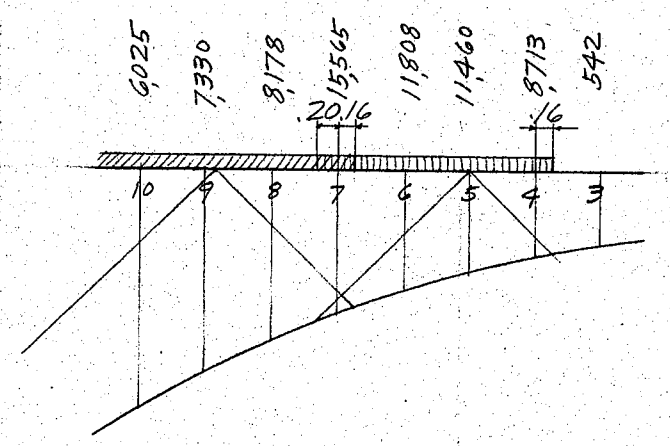
格点		Mu	M	Ho	H	Vo	V
Cr	9360	.8068	755	1706	15,970	.5000	4,680
1	21,940	.9864	21,650	1658	36,400	.4061	8,910
2	11,000	1.0549	11,600	1519	16,710	.3158	3,470
3	789	1.0197	805	1308	1,032	.2326	184
4	10,361	.8887	9,210	1043	10,820	.1601	1,657
5	13,180	.6966	9,180	.760	10,020	.1009	1,330
6	13,060	.4796	6,260	.492	6,430	.0565	738
7	4,930	.2806	1,380	.273	1,345	.0271	134
			60,840 kgm		98,727 kg		21,103 kg

特殊荷重
M = 60,840 × 1.1 = 66,900 kgm
H = 98,727 × 1.1 = 108,500 kg
V = 21,103 × 1.1 = 23,200 〃
軸推力 = 87,920 × 1.1 = 96,700 〃

軸推力

98,727 × .750 = 74,000
21,103 × .660 = 13,920
87,920 kg

格点10　負彎曲率



42,300 ÷ 3.00 = 14,100　14,100 × .26 = 3,665　14,100 × .16 = 2,260
2260 × .08/.52 = 348　2,260 − 348 = 2,608
14,100 × .1675 = 2,360　7,330　3,665　348
3,665　848　2,608　11,460
6,025　8,178　5,730　11,808
3,562
15,565

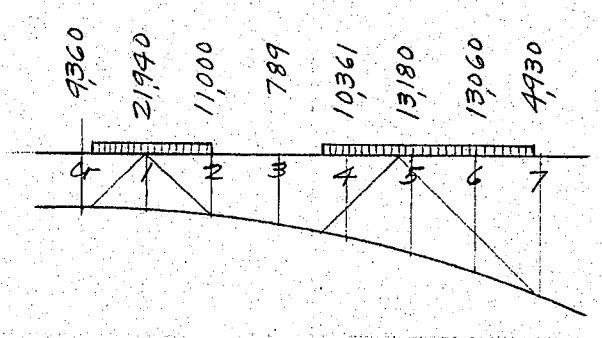
格点		Mu	M	Ho	H	Vo	V
10	6,025	.0091	55	.005	30	0.9997	6,020
9	7,330	-.4415	-3,235	.041	301	0.9968	7,310
8	8,178	-.7887	-6,450	.127	1,038	0.9889	8,090
7	15,565	-.9976	-15,520	.273	4,250	0.9729	15,150
6	11,808	-1.0128	-11,950	.492	5,810	0.9435	11,150
5	11,460	-.8540	-9,790	.760	8,710	0.8991	10,300
4	8,713	-.5663	-4,935	1.043	9,090	0.8399	7,310
3	542	-.2013	-109	1.308	709	0.7674	416
			-51,934 kgm		29,938 kg		65,746 kg

特殊荷重
M = −51,934 × 1.1 = −57,100 kgm
H = 29,938 × 1.1 = 32,900 kg
V = 65,746 × 1.1 = 72,300 〃
軸推力 = 65,850 × 1.1 = 72,500 〃

軸推力

29,938 × .750 = 22,450
65,746 × .660 = 43,400
65,850 kg

起拱点　正彎曲率



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設計　日付　類別　A

照査　日付　第　18頁

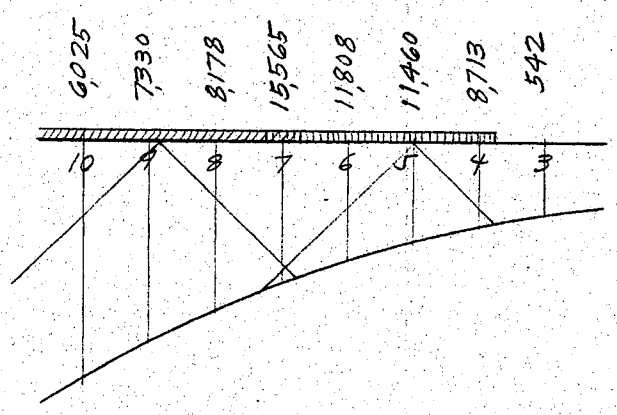
上海地下鐵道鐵筋混凝土拱橋

格矣		Mu	M	Ho	H	Vo	V	
Cr	9360	1.1425	10,700	1.706	15,970	0.5000	4,680	
1	21,940	1.3394	29,400	1.658	36,380	0.4061	8,910	
2	11,000	1.3972	15,370	1.519	16,700	0.3158	3,470	
3	789	1.3277	1,047	1.308	1,032	0.2326	184	特殊荷重
4	10,361	1.1427	11,840	1.043	10,820	0.1601	1,656	M = 89,703 × 1.1 = 98,600 kgm
5	13,180	.8870	11,700	.760	10,030	0.1009	1,330	H = 98,707 × 1.1 = 108,500 kg
6	13,060	.6058	7,910	.492	6,430	0.0565	738	V = 21,102 × 1.1 = 23,200 〃
7	4,930	.3521	1,736	.273	1,345	0.0271	134	軸推力 = 84,680 × 1.1 = 93,100 〃
			89,703 kgm		98,707 kg		21,102 kg	

軸推力

98,707 × .705 = 69,600
21,102 × .715 = 15,080
84,680 kg

起拱矣　負彎曲率



格矣		Mu	M	Ho	H	Vo	V	
10	6,025	-.3243	-1,955	.005	30	0.9997	6,020	
9	7,330	-.7633	-5,595	.041	301	0.9968	7,310	
8	8,178	-1.0826	-8,850	.127	1,038	0.9889	8,090	
7	15,565	-1.2429	-19,330	.273	4,250	0.9729	15,150	特殊荷重
6	11,808	-1.1838	-13,980	.492	5,810	0.9435	11,130	M = -65,119 × 1.1 = -71,600 kgm
5	11,460	-.9310	-10,670	.760	8,710	0.8991	10,300	H = 29,938 × 1.1 = 32,950 kg
4	8,713	-.5399	-4,700	1.043	9,090	0.8399	7,320	V = 65,736 × 1.1 = 72,300 〃
3	542	-.0725	-39	1.308	709	0.7674	416	軸推力 = 68,100 × 1.1 = 75,000 〃
			-65,119 kgm		29,938 kg		65,736 kg	

軸推力

29,938 × .705 = 21,100
65,736 × .715 = 47,000
68,100 kg

温度應力

拱頂 = 於ケル水平推力　$H_0 = \dfrac{Ewtl\int \frac{ds}{I_0}}{2\left[\int \frac{ds}{I_0}\int y^2\frac{ds}{I} - \left(\int y\frac{ds}{I_0}\right)^2\right]} = \dfrac{G}{B}$

茲 = E = 1,400,000,000 kg/m²
w = 0.000012 (1°C = 対ス心膨張係数)
t = 温度ノ変化
l = 径間長 = 11.07 m

Ewt = 252,000 kg

温度 15°C ノ降下 = 対シテ

$$H_0 = \frac{-252{,}000 \times 11.07 \times 16785}{6759.56} = -69{,}200 \text{ kg}$$

$$M_0 = -\frac{H_0\int y\frac{ds}{I_0}}{\int \frac{ds}{I_0}} = 69{,}200 \times \frac{4946}{16785} = 20{,}400 \text{ kgm}$$

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電話大崎(49)0678番

設計 日付 類別 A
照査 日付 第 19 頁

上海地下鐵道鐵筋混凝土拱橋

格点，溫度應力

格点			彎曲率		軸推力		
2	20,400 − 69,200 ×	.052 =	16,800 kgm	−69,200 ×	.995 =	−68,850 kg
4	20,400 − 69,200 ×	.225 =	4,830	−69,200 ×	.980 =	−67,800 〃
6	20,400 − 69,200 ×	.525 =	−15,950	−69,200 ×	.945 =	−65,400 〃
8	20,400 − 69,200 ×	.995 =	−48,450	−69,200 ×	.875 =	−60,600 〃
10	20,400 − 69,200 ×	1.725 =	−99,000	−69,200 ×	.750 =	−51,900 〃
Sp.	20,400 − 69,200 ×	2.020 =	−119,400	−69,200 ×	.705 =	−48,800 〃

拱環，平均應力

拱頂，斷面積 22500
鐵筋，換算面積 3153
25653 m²

拱環，厚，比 = 起拱点，厚 / 拱頂，厚 = 970/300 = 3.23

ライズ，比 = 2.02/11.07 = 0.183

拱頂=於ケルH

死荷重應力 135,638 ÷ 25653 = 52,900 @ 0.84 = 44450 kg/m²

活荷重應力

拱頂	+M	125,300	÷ 25653 =	48850	@ 0.81 =	39,580	kg/m²
	−M	54,700	〃 =	21,330	@ 0.85 =	18,140	〃
格点2	+M	88,100	〃 =	34350	@ 0.81 =	27,820	〃
	−M	68,900	〃 =	26,860	@ 0.85 =	22,820	〃
格点4	+M	49,500	〃 =	19,300	@ 0.81 =	15,640	〃
	−M	125,300	〃 =	48,850	@ 0.85 =	41,500	〃
格点6	+M	18,420	〃 =	7,180	@ 0.81 =	5,820	〃
	−M	139,000	〃 =	54,200	@ 0.85 =	46,100	〃
格点8	+M	69,000	〃 =	26,900	@ 0.81 =	21,800	〃
	−M	104,500	〃 =	40,750	@ 0.85 =	34,630	〃
格点10	+M	108,500	〃 =	42,300	@ 0.81 =	34,270	〃
	−M	32,900	〃 =	12,830	@ 0.85 =	10,920	〃
起拱点	+M	108,500	〃 =	42,300	@ 0.82 =	34,700	〃
	−M	32,950	〃 =	12,850	@ 0.85 =	10,930	〃

溫度應力 −69,200 〃 = −26,980 @ 0.73 = −19,700 〃

拱環，纖維應力

拱頂 正彎曲率

	軸推力	彎曲率	平均應力
死荷重	135,638	−290	44450
活荷重	125,300	13,970	39,580
溫度，變化	−69,200	20,400	−19,700
助縮	−16,400	4840	−4660
	175,338 kg	38,920 kgm	59,670 kg/m²

$R = \frac{19,700}{252,000+19,700} C = 0.0725\,C$

59,670 ÷ 252,000 = 0.237, $d'/h = 4.5/30 = 0.15$

$A_s = 105.1$, $p = \frac{105.1}{750\times30} = 0.00467$

$e = 38,920 \div 175,338 = 0.222$

$e/h = 22.2/30 = 0.74$ $K = 0.39$ $C = 0.155$

$f_c = \frac{N}{bhc} = \frac{175,338}{750\times30\times0.155} = 50.3$ kg/cm²

若シ 22mmφ 鐵筋ヲ 20cm c.to c 37 @ 3.80 = 140.6 $p = \frac{140.6}{750\times30} = 0.00625$

$K = 0.422$, $C = 0.177$

$f_c = \frac{175338}{750\times30\times0.177} = 44.0$ kg/cm²

$f_s = 15\times44.0\times\frac{.578}{.422} = 903$ kg/cm²

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設計	日付	類別	A
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上海地下鐵道鐵筋混凝土拱橋

格点2　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	136,396	-329	44,450
活荷重	89,200	18,000	27,820
温度變化	-68,850	16,800	-19,700
肋縮	-13,360	3,260	-3,810
	143,386 kg	37,731 kgm	48,760 kg/m²

48,760 ÷ 252,000 = 0.194　h = 31 cm
d'/h = 4.5/31 = 0.145　As = 140.6 cm²
p = 140.6/(750×31) = 0.00605
e = 37,731 ÷ 143,386 = 0.263
e/h = 26.3/31 = 0.848　K = 0.40　C = 0.153

$$f_c = \frac{143386}{750 \times 31 \times 0.153} = 40.3\ kg/cm^2$$

$$f_s = 15 \times 40.3 \times \frac{0.6}{0.4} = 907\ kg/cm^2$$

格点4　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	139,110	638	44,450
活荷重	52,400	16,860	15,640
温度變化	-67,800	4,830	-19,700
肋縮	-10,100	720	-2,930
	113,610 kg	23,048 kgm	37,460 kg/m²

37,460 ÷ 252,000 = 0.149　h = 32.8 cm
d'/h = 4.5/32.8 = 0.137　As = 54.0 cm²
p = 54.0/(750×32.8) = 0.0022
e = 23,048 ÷ 113,610 = 0.203
e/h = 20.3/32.8 = 0.619
K = 0.37　C = 0.162

$$f_c = \frac{113610}{750 \times 32.8 \times 0.162} = 28.5\ kg/cm^2$$

$$f_s = 15 \times 28.5 \times \frac{0.63}{0.37} = 727\ kg/cm^2$$

格点6　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	144,480	274	44,450
活荷重	146,700	-15,020	46,100
温度變化	-65,400	-15,950	-19,700
肋縮	-17,070	-4,160	-5,140
	208,710 kg	-34,856 kgm	65,710 kg/m²

65710 ÷ 252,000 = 0.261　h = 36.4 cm
d'/h = 4.5/36.4 = 0.124　As = 54.0 cm²
p = 54.0/(750×36.4) = 0.00198
e = 34856 ÷ 208,710 = 0.167
e/h = 16.7/36.4 = 0.459　K = 0.43　C = 0.205

$$f_c = \frac{208710}{750 \times 36.4 \times 0.205} = 37.3\ kg/cm^2$$

$$f_s = 15 \times 37.3 \times \frac{0.57}{0.43} = 742\ kg/cm^2$$

格点8　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	156,930	-996	44,450
活荷重	130,300	-21,870	34,630
温度變化	-60,600	-48,450	-19,700
肋縮	-13,270	-10,610	-4,310
	213,360 kg	-81,926 kgm	55,070 kg/m²

55,070 ÷ 252,000 = 0.219　h = 48.5 cm
d'/h = 4.5/48.5 = 0.093　As = 140.6 cm²
p = 140.6/(750×48.5) = 0.00387
e = 81,926 ÷ 213,360 = 0.384
e/h = 38.4/48.5 = 0.792
K = 0.38　C = 0.153

$$f_c = \frac{213360}{750 \times 48.5 \times 0.153} = 38.3\ kg/cm^2$$

$$f_s = 15 \times 38.3 \times \frac{0.62}{0.38} = 937\ kg/cm^2$$

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上海地下鐵道鐵筋混凝土拱橋

格点 10　正弯曲率

	軸推力	弯曲率	平均應力
死荷重	174,900	-1,169	44,450
活荷重	96,700	66,900	34,270
温度変化	51,900	99,000	19,700
肋縮	-18,780	-35,830	-7,140
	304,720 kg	128,901 kgm	91,280 kg/m²

91,280 ÷ 252,000 = 0.362　h = 79.5 cm
e = 128,901 ÷ 304,720 = 0.424

格点 10　負弯曲率

	軸推力	弯曲率	平均應力
死荷重	174,900	-1,169	44,450
活荷重	72,500	-57,100	10,920
温度変化	-51,900	-99,000	-19,700
肋縮	-6,800	-12,970	-2590
	188,700 kg	-170,239 kgm	33,080 kg/m²

33,080 ÷ 252,000 = 0.131
d'/h = 4.5/79.5 = 0.0566　As = 140.6 cm²
$p = \frac{140.6}{750 \times 79.5} = 0.00236$
e = 170,239 ÷ 188,700 = 0.903
e/h = 90.3/79.5 = 1.137
k = 0.29　c = 0.095

$f_c = \frac{188,700}{750 \times 79.5 \times 0.095} = 33.3 \text{ kg/cm}^2$

$f_s = 15 \times 33.3 \times \frac{0.71}{0.29} = 1,220 \text{ kg/cm}^2$

起拱点　正弯曲率

	軸推力	弯曲率	平均應力
死荷重	178,800	-57	44,450
活荷重	93,100	98,600	34,700
温度変化	48,800	119,400	19,700
肋縮	-17,760	-43,450	-7,170
	302,940 kg	174,493 kgm	91,680 kg/m²

91,680 ÷ 252,000 = 0.364　h = 97.0 cm
d'/h = 4.5/97.0 = 0.0464　As = 140.6 cm²
$p = \frac{140.6}{750 \times 97.0} = 0.00193$
e = 174,493 ÷ 302,940 = 0.576
e/h = 57.6/97.0 = 0.594
k = 0.38　c = 0.171

$f_c = \frac{302,940}{750 \times 97.0 \times 0.171} = 24.4 \text{ kg/cm}^2$

$f_s = 15 \times 24.4 \times \frac{0.62}{0.38} = 597 \text{ kg/cm}^2$

起拱点　負弯曲率

	軸推力	弯曲率	平均應力
死荷重	178,800	-57	44,450
活荷重	75,000	-71,600	10,930
温度変化	-48,800	-119,400	-19,700
肋縮	-6,390	-15,640	-2590
	198,610 kg	-206,697 kgm	33,090 kg/m²

33,090 ÷ 252,000 = 0.131
e = 206,697 ÷ 198,610 = 1.04
e/h = 104/97 = 1.072
k = 0.275　c = 0.092

$f_c = \frac{198,610}{750 \times 97.0 \times 0.092} = 29.7 \text{ kg/cm}^2$

$f_s = 15 \times 29.7 \times \frac{0.725}{0.275} = 1,175 \text{ kg/cm}^2$

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設計 日付 類別 A
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上海地下鐵道鐵筋混凝土拱橋

橋脚ノ設計

死荷重反力 $Rd = 116,420$ kg
死荷重水平推力 $Hd = 135,638$ kg
死荷重彎曲率 $Md = -57$ kgm

活荷重

起拱点＝最大正彎曲率ノ起ル場合

反力 $Rl = 23,200 \div 1.409 = 16,470$ kg
水平推力 $Hl = 108,500$ 〃 $= 77,000$ kg
彎曲率 $Ml = 98,600$ 〃 $= 70,000$ kgm

起拱点＝最大水平推力ノ起ル場合

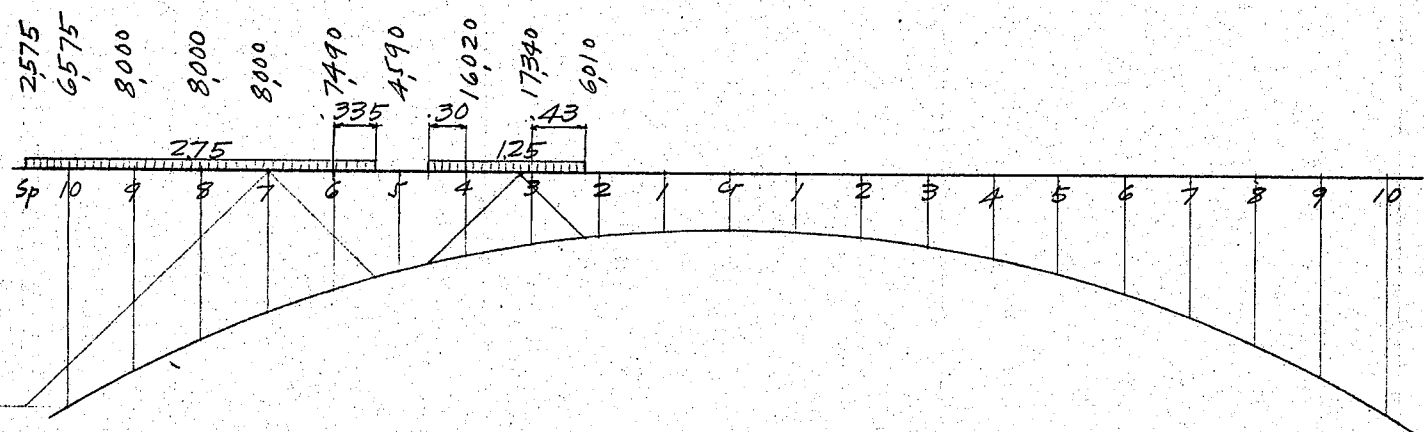
反力 $Rl = 47,150 \div 1.409 = 33,500$ kg
水平推力 $Hl = 139,000$ 〃 $= 98,700$ kg

彎曲率

格点		Mu	M
4	98	-.5399	-53
3	12,487	-.0725	-905
2	21,030	.3982	8,380
1	8,630	.8200	7,120
0	65	1.1425	74
1	12,627	1.3394	16,920
2	21,230	1.3972	29,680
3	7,870	1.3277	10,450

71,666 kgm × 1.1 = 78,900 ÷ 1.409 = 56,000 kgm

起拱点＝最大反力ノ起ル場合



格点		Vo	V	Mu	M	Ho	H
Sp.	2,575	1.0000	2,575	—	—	—	—
10	6,575	.9997	6,570	-.3243	-2,130	0.005	33
9	8,000	.9968	7,980	-.7633	-6,100	.041	328
8	8,000	.9889	7,910	-1.0826	-8,660	.127	1,017
7	8,000	.9729	7,780	-1.2429	-9,940	.273	2,182
6	7,490	.9435	7,065	-1.1838	-8,865	.492	3,685
5	4,590	.8991	4,125	-.9310	-4,270	.760	3,488
4	16,020	.8399	13,450	-.5399	-8,645	1.043	16,700
3	17,340	.7674	13,300	-.0725	-1,260	1.308	22,700
2	6,010	.6842	4,110	.3982	2,390	1.519	9,130
			74,865 kg		-47,480 kgm		59,263 kg

42,300 ÷ 2.75 = 15,380
15,380 × .335 = 5,150
15,380 × .26 = 4,000
5,150 × .1675/.52 = 1,660
5,150 − 1,660 = 3,490
42,300 ÷ 1.25 = 33,850
33,850 × .30 = 10,150
10,150 × .15/.52 = 2,930
1,660
4,590
33,850 × .26 = 8,800
10,150 − 2,930 = 7,220
16,020
33,850 × .43 = 14,550
14,550 × .215/.52 = 6,010
14,550 − 6,010 = 8,540
8,800
17,340

特殊荷重

反力 $Rl = 74,865 \times 1.1 = 82,350 \div 1.409 = 58,600$ kg
水平推力 $Hl = 59,263 \times 1.1 = 65,200$ 〃 $= 46,300$ kg
彎曲率 $Ml = -47,480 \times 1.1 = -52,200$ 〃 $= -37,000$ kgm

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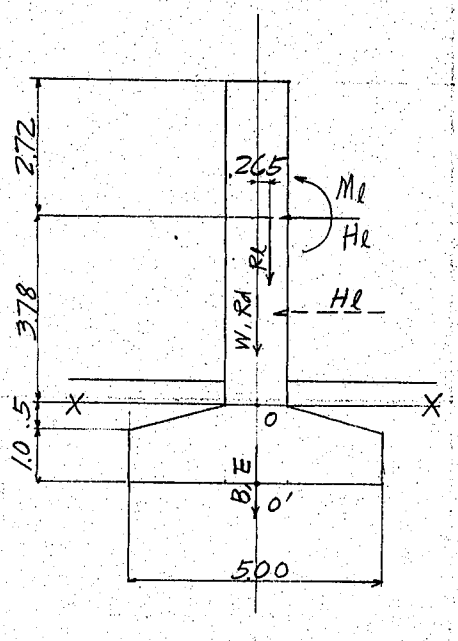
上海地下鐵道鐵筋混凝土拱橋



橋脚上部ノ重量

軌道	2 × 600 × 120	=	1,440
道床	40 × 690 × 120 @ 1,900	=	6,300
填充砂	155 × 690 × 120 @ 1,700	=	21,820
側壁	2 @ 80 × 120 × 210 @ 2,400	=	9,670
橋脚体	120 × 390 × 850 @ 2,400	=	95,400
		W =	134,630 kg

最大正彎曲率ノ起心場合

死荷重反力　Rd = 2 @ 116,420 = 232,840 kg

衝撃係数　$i = \dfrac{0.5 \times 16,470}{16,470 + 232,840 + 134,630} = 0.021$

活荷重

反力	Rl = 16,470 × 1.021	=	16,800 kg
水平推力	Hl = 77,000 〃	=	78,600 〃
彎曲率	Ml = 70,000 〃	=	71,400 kgm

O 点ニ於ケル彎曲率

	V	H		M
W	134,630	× 0	=	0
Rd	232,840	× 0	=	0
Rl	16,800	×		
Hl		78,600 × 1.89	=	148,500
	384,270 kg	78,600 kg		148,500 kgm

e = 148,500 ÷ 384,270 = 0.387 m

基礎上ノ土ノ重量

2 @ 0.75 × 2.00 × 9.00 = 27.00
0.50 × 0.50 × 1.00 = 0.25
27.25 @ 1,600 = 43,600 kg = E

基礎ノ重量

0.50 × 3.00 × 9.00 = 13.50
1.00 × 5.00 × 9.00 = 45.00
58.50 @ 2,400 = 140,400 kg = B

134,630
275,030 kg

衝撃係数　$i = \dfrac{0.5 \times 16,470}{16,470 + 232,840 + 275,030} = 0.0157$

活荷重

反力	Rl = 16,470 × 1.0157	=	16,720 kg
水平推力	Hl = 77,000 × 〃	=	78,200 kg
彎曲率	Ml = 70,000 × 〃	=	71,100 kgm

O' 点ニ於ケル能率

	V	H		M
W + B	275,030	× 0	=	0
Rd	232,840	× 0	=	0
Rl	16,720	× 0	=	0
Hl		78,200 × 3.39	=	265,000
E	43,600	× 0	=	0
	568,190 kg	78,200 kg		265,000 kgm

e = 265,000 ÷ 568,190 = 0.466 m

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上海地下鐵道鐵筋混凝土拱橋

滑動係数　78,200 ÷ 568,190 = 0.14

$$\text{支圧力} = \frac{568,190}{5.00 \times 9.00} \times \left(1 \pm \frac{6 \times .466}{5.0}\right) = \begin{matrix} 19,700 \text{ kg/m}^2 \\ 5,570 \text{ 〃} \end{matrix}$$

1,519
,401

最大水平推力ノ起心場合

衝撃係数　$i = \frac{0.5 \times 33,500}{33,500 + 232,840 + 134,630} = 0.0418$

活荷重

反力	Rl =	33,500 × 1.0418	= 34,870 kg
水平推力	Hl =	98,700 〃	= 102,800 kg
弯曲率	Ml =	56,000 〃	= 58,300 kgm

0点ヨリ下ケル弯曲率

	V	H		M
W	134,630	×	0	= 0
Rd	232,840	×	0	= 0
Rl	34,870	×		= 0
Hl		102,800 ×	1.89	= 194,300
	402,340 kg	102,800 kg		194,300 kgm

$e = 194,300 \div 402,340 = 0.483$ m

衝撃係数　$i = \frac{0.5 \times 33,500}{33,500 + 232,840 + 275,030} = 0.031$

活荷重

反力	Rl =	33,500 × 1.031	= 34,500 kg
水平推力	Hl =	98,700 〃	= 101,700 kg
弯曲率	Ml =	56,000 〃	= 57,700 kgm

0′点ヨリ下ケル能率

	V	H		M
W+B	275,030	×	0	= 0
Rd	232,840	×	0	= 0
Rl	34,500	×		= 0
Hl		101,700 ×	3.39	= 345,000
E	43,600	×	0	= 0
				= 0
	585,970 kg	101,700 kg		345,000 kgm

$e = 345,000 \div 585,970 = 0.589$ m

滑動係数　101,700 ÷ 585,970 = 0.174

$$\text{支圧力} = \frac{585,970}{5.00 \times 9.00} \times \left(1 \pm \frac{6 \times 0.589}{5.0}\right) = \begin{matrix} 22,200 \text{ kg/m}^2 \\ 3,810 \text{ 〃} \end{matrix}$$

1,717
29

最大反力ノ起心場合

衝撃係数　$i = \frac{0.5 \times 58,600}{58,600 + 232,840 + 134,630} = 0.0688$

活荷重

反力	Rl =	58,600 × 1.0688	= 62,700 kg
水平推力	Hl =	46,300 × 〃	= 49,500 kg
弯曲率	Ml =	−37,000 × 〃	= −39,600 kgm

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上海地下鐵道鐵筋混凝土拱橋

0点＝於ケル弯曲率

	V	H			M
W	134,630		×	0 =	0
Rd	232,840		×	0 =	0
Rl	62,700		×	0 =	0
Hl		49,500	×	1.89 =	93,500
	430,170 kg	49,500 kg			93,500 kgm

$e = 93{,}500 \div 430{,}170 = 0.218\ m$

衝撃係数　$i = \frac{0.5 \times 58{,}600}{58{,}600 + 232{,}840 + 275{,}030} = 0.0517$

活荷重

反力	Rl = 58,600 × 1.0517	=	61,600 kg
水平推力	Hl = 46,300	=	48,650 kg
弯曲率	Ml = −37,000	=	−38,900 kgm

0'点＝於ケル弯率

	V	H			M
W+B	275,030		×	0 =	0
Rd	232,840		×	0 =	0
Rl	61,600		×	=	0
Hl		48,650	×	3.39 =	165,000
E	43,600		×	0 =	0
	613,070 kg	48,650 kg			165,000 kgm

$e = 165{,}000 \div 613{,}070 = 0.269\ m$

滑動係数　$48{,}650 \div 109{,}780 = 0.444$

支圧力　$= \frac{613{,}070}{500 \times 900} \times \left(1 \pm \frac{6 \times 269}{500}\right) = 18{,}030\ kg/m^2$　1.323
$9{,}220\ kg/m^2$　.677

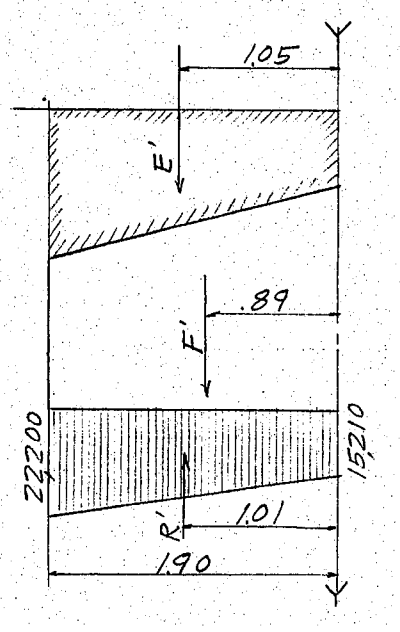
断面，設計

橋脚体，断面

$M = 194{,}300$ kgm, $N = 402{,}340$ kg, $S = 102{,}800$ kg, $e = 0.483$ m
$h = 120$ cm, $d'/h = 4.5/120 = 0.0375$, $e/h = 48.3/120 = 0.403$
$A_s = 19^{mm\phi}$ 20 cm c. to c. $= 43 \times 2.835 = 121.8\ cm^2$
$p = \frac{121.8}{850 \times 120} = 0.0012$　$K = 0.48$　$C = 0.238$

$f_c = \frac{402{,}340}{850 \times 120 \times .238} = 16.6\ kg/cm^2$

$f_s = 15 \times 16.6 \times \frac{0.52}{0.48} = 270\ kg/cm^2$



基礎

$E' = 0.75 \times 1.00 \times 1.90 \text{ @ } 1{,}600 = 2{,}280$ kg
$F' = 1.25 \times 1.00 \times 1.90 \text{ @ } 2{,}400 = 5{,}700$ kg
$R' = 18{,}700 \times 1.90 = 35{,}500$ kg

Y-Y＝於ケル弯曲率

R'	35,500 × 1.01	=	35,800
E'	−2,280 × 1.05	=	−2,400
F'	−5,700 × .89	=	−5,070

S = 27,520 kg　M = 28,330 kgm

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設計 日付 類別 A
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上海地下鐵道鐵筋混凝土拱橋

所要有効厚 $d=\sqrt{\frac{28330\times100}{100\times7.13}}=63.0\,cm$

使用有効厚 140cm 被覆 10cm 總厚 150 cm

所要鐵筋量 $\frac{28330\times100}{1200\times7/8\times140}=19.3\,cm^2$

鐵筋 22mmφ 15cm c. to c. $=6.67\times3.801=25.4\,cm^2$

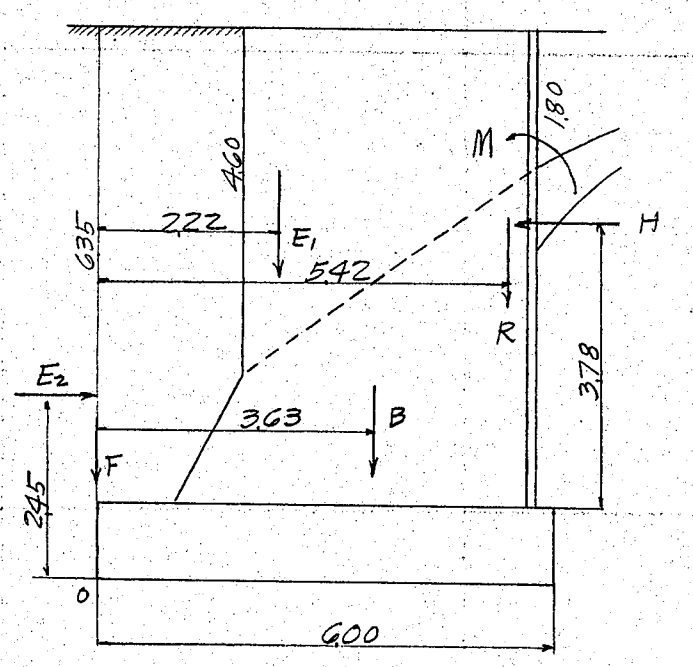
$P=\frac{25.4}{100\times140}=0.0018$ $j=0.931$ $K=0.208$

$f_s=\frac{28330\times100}{25.4\times0.931\times140}=856\,kg/cm^2$

$f_c=\frac{2\times28330\times100}{0.931\times0.208\times100\times140^2}=14.9\,kg/cm^2$

$s=\frac{27520}{100\times0.931\times140}=2.1\,kg/cm^2$

橋臺，設計



死荷重

反力	Rd =	116,420 kg
水平推力	Hd =	135,038 kg
彎曲率	Md =	−57 kgm

躯体重量

$335\times385\times110=142\times356=50.55$
$088\times090\times800=634\times160=1014$
$315\times385\times800=9700\times411=39870$
$100\times600\times900=5400\times300=16200$

171.54 363 62139

B = 171,54 @ 2,400 = 411,500 kg

上部荷重及び重量

$635\times100\times900=572$ @1,600 $=91,500\times050=45,750$
$548\times090\times900=444$ @ 〃 $=71,000\times143=101,500$
$320\times385\times690=850$ @ 〃 $=136,000\times356=484,000$
2 @ $600\times575=$ $=6,900\times288=19,870$
$690\times40\times575=159$ @1,900 $=30,200\times288=86,900$
$100\times50\times500=25$ @1,600 $=4,000\times350=14,000$

E_1 = 339,600 kg 222 752,020

土圧 $\frac{1}{3}\times wh=\frac{1}{3}\times1,600\times7.35=3,920$ kg

$E_2=\frac{1}{2}\times3,920\times7.35\times9.00=129,700$ kg

土，摩擦

$\tan\theta=\tan20^\circ=0.364$

$F=129,700\times0.364=47,200$ kg

最大正彎曲率，起ル場合

衝撃係数 $i=\frac{05\times16,470}{16,470+116,420+411,500}=0.015$

活荷重

反力	Rl =	16,470 × 1,015 =	16,720 kg
水平推力	Hl =	77,000 × 〃 =	78,200 kg
彎曲率	Ml =	70,000 × 〃 =	71,000 kgm

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上海地下鐵道鐵筋混凝土拱橋

$R = 116,420 + 16,720 = 133,140$ kg
$H = 135,638 + 78,200 = 213,838$ kg
$M = -57 + 71,000 = +70,943$ kgm

0点=於ケル能率

	V	H		M
R	133,140		× 5.42 =	721,000
E_1	339,600		× 2.22 =	753,500
B	411,500		× 3.63 =	1,494,000
F	47,200		× 0 =	0
H		−213,838	× 4.78 =	−1,022,000
E_2		129,700	× 2.45 =	317,500
M			=	− 70,943
	931,440 kg	84,138 kg		2,193,057 kgm

$2,193,057 \div 931,440 = 2.36$ m
$e = 3.00 - 2.36 = .64$ m
滑動係数 $84,138 \div 931,440 = 0.09$

支圧力 $= \frac{931,440}{6.00 \times 9.00} \times \left(1 \pm \frac{6 \times .64}{6.0}\right) = 28,300$ kg/m²
$6,200$ 〃

最大水平推力ノ起心場合

衝撃係数 $i = \frac{.05 \times 33,500}{33,500 + 116,420 + 411,500} = 0.03$

活荷重

反力	R_l =	33,500 × 1.03 = 34,500 kg
水平推力	H_l =	98,700 〃 = 101,700 kg
弯曲率	M_l =	56,000 〃 = 57,700 kgm

$R = 116,420 + 34,500 = 150,920$ kg
$H = 135,638 + 101,700 = 237,338$ kg
$M = -57 + 57,700 = 57,643$ kgm

0点=於ケル能率

	V	H		M
R	150,920		× 5.42 =	818,000
E_1	339,600		× 2.22 =	753,500
B	411,500		× 3.63 =	1,494,000
F	47,200		× 0 =	0
H		−237,338	× 4.78 =	−1,135,000
E_2		129,700	× 2.45 =	317,500
M			=	− 57,643
	949,220 kg	−107,638 kg		2,190,357 kg

$2,190,357 \div 949,220 = 2.19$ m
$e = 3.00 - 2.19 = 0.81$ m
滑動係数 $107,638 \div 949,220 = 0.113$

支圧力 $= \frac{949,220}{6.00 \times 9.00} \times \left(1 \pm \frac{6 \times 0.81}{6.0}\right) = 31,800$ kg/m²
$3,340$ 〃

最大反力ノ起心場合

衝撃係数 $i = \frac{.05 \times 58,600}{58,600 + 116,420 + 411,500} = 0.05$

活荷重

反力	R_l =	58,600 × 1.05 = 61,500 kg
水平推力	H_l =	46,300 〃 = 48,600 〃
弯曲率	M_l =	−37,000 〃 = −38,800 kgm

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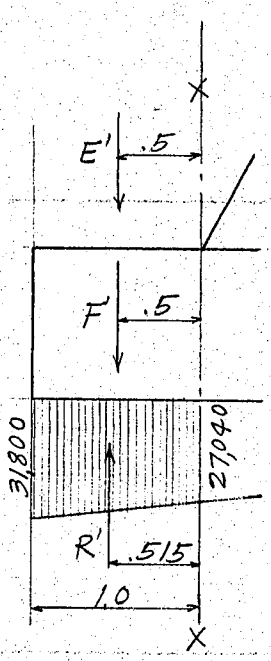
上海地下鐵道鐵筋混凝土拱橋

$R = 116,420 + 61,500 = 177,920$ kg
$H = 135,638 + 48,600 = 184,238$ 〃
$M = -57 - 38,800 = -38,857$ kgm

前記ノ場合ヨリ安全ナル事明ナリ



$E' = 1.00 \times 1.00 \times 6.35 \times 1,600 = 10,160$ kg
$F' = 1.00 \times 1.00 \times 1.00 \times 2,400 = 2,400$ kg
$R' = 1.00 \times 1.00 \times 29,420 = 29,420$ kg

X－X ニ於ケル能率

R'	29,420	× .515 =	15,150
E'	−10,160	× .50 =	−5,080
F'	−2,400	× .50 =	−1,200
	$S = 16,860$ kg		$M = 8,870$ kgm

所要有効厚 $d = \sqrt{\frac{8870 \times 100}{100 \times 7.13}} = 35.3$ cm

使用有効厚 90 cm 被覆 10 cm 總厚 100 cm

所要鐵筋量 $= \frac{8870 \times 100}{1,200 \times 7/8 \times 90} = 9.4$ cm²

鐵筋 19mmϕ 25 cm c. to c. $= 4 @ 2.84 = 11.4$ cm²

$p = \frac{11.4}{100 \times 90} = 0.00127$　$j = 0.94$　$k = 0.18$

$f_s = \frac{8,870 \times 100}{11.4 \times 0.94 \times 90} = 920$ kg/cm²

$f_c = \frac{2 \times 8870 \times 100}{0.94 \times 0.18 \times 100 \times 90^2} = 12.9$ kg/cm²

$s = \frac{16,860}{100 \times 0.94 \times 90} = 2.0$ kg/cm²

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設計	日付	類別
照査	日付	第　頁

上海高速鉄道

鉄筋混凝土拱橋應力計算書

純徑間一四・〇米
複線軌道

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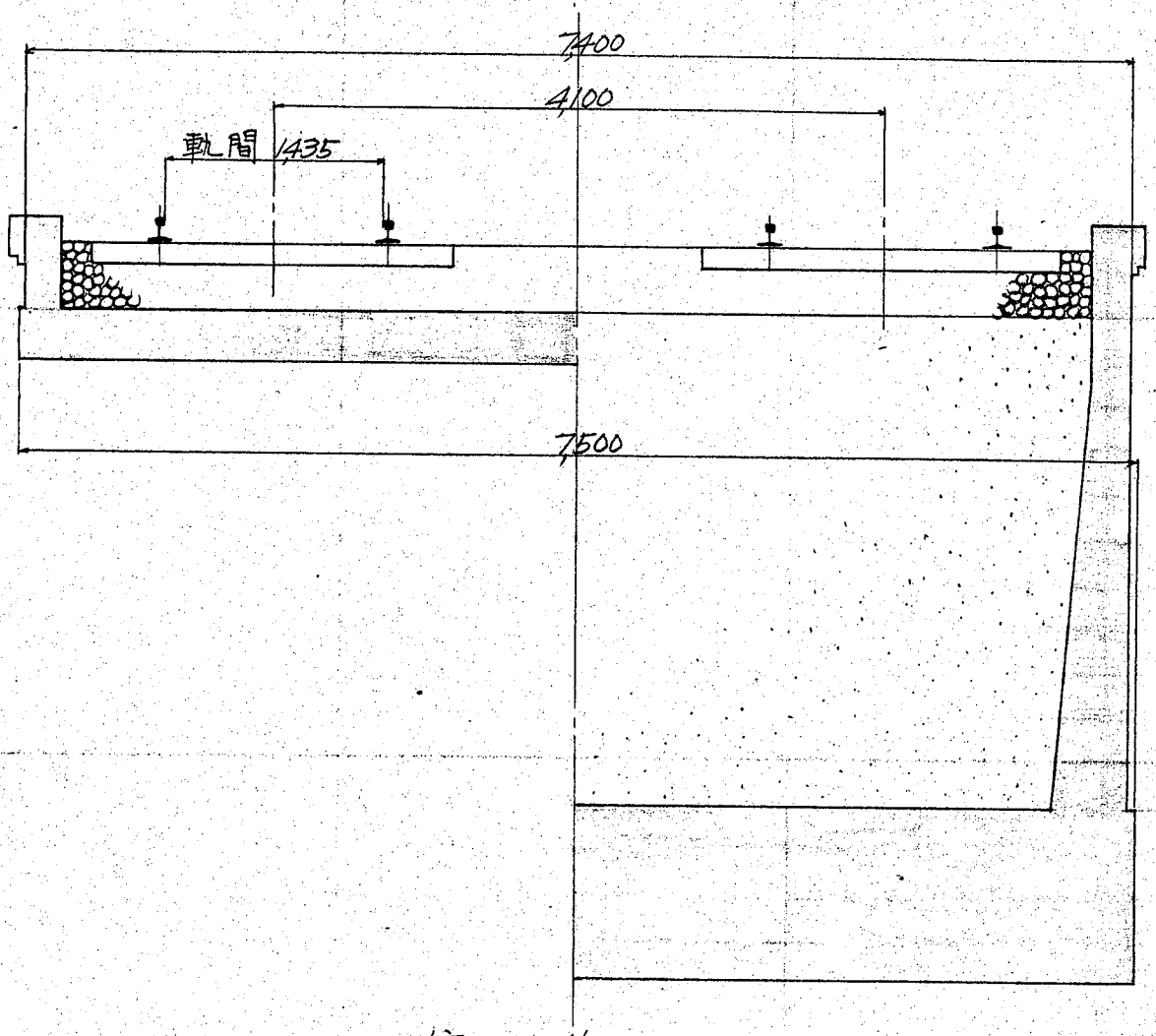
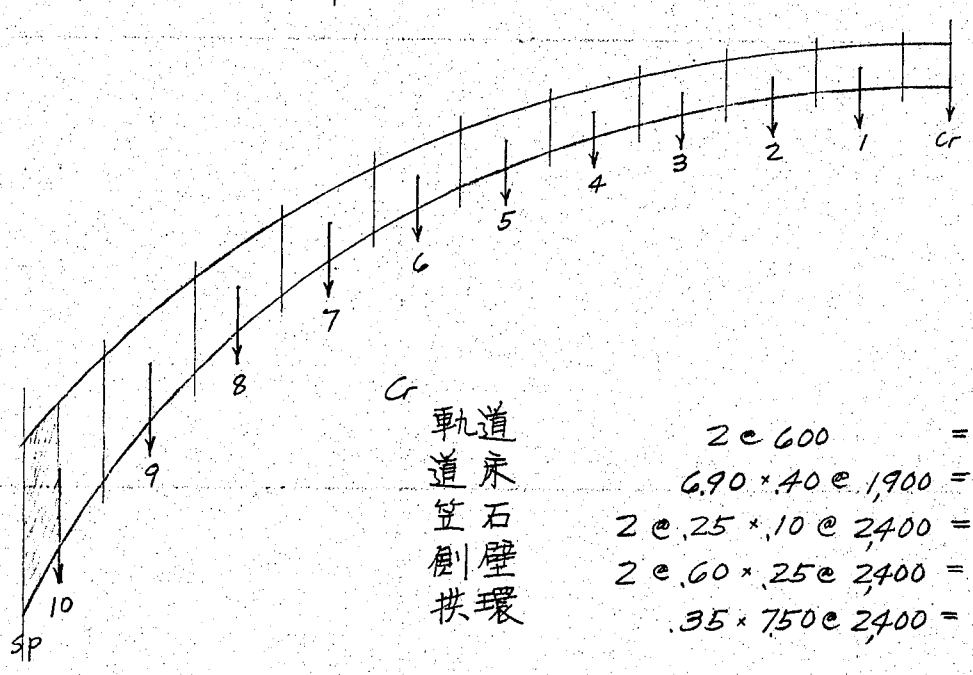
設計	日付	類別	B
照査	日付	第	1頁

上海地下鐵道鐵筋混凝土拱橋
複線電車軌道 (60 瓲電車)
純經間 14.000 米, $l = 14.540\,m$, $h = 3.730\,m$, $t_0 = 0.35\,m$, $t_e = 0.70\,m$
橋梁斷面



縮尺 1/50

概算死荷重，計算



Cr

軌道	2 @ 600	= 1,200	
道床	6.90 × .40 @ 1,900	= 5,240	6,560
笠石	2 @ .25 × .10 @ 2,400	= 120	
側壁	2 @ .60 × .25 @ 2,400	= 720	
拱環	.35 × 7.50 @ 2,400	= 6,300	
		13,580 × .35 = 4,750 kg	

W1

軌道,道床及笠石		= 6,560	
砂填充	.03 × 6.90 @ 1,700	= 350	
側壁	2 @ .63 × .25 @ 2,400	= 760	
拱環	.353 × 7.50 @ 2,400	= 6,360	
		14,030 × .70 = 9,820 kg	

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上海地下鐵道鐵筋混凝土拱橋

W2
軌道道床及笠石 = 6,560
砂填充 .108 × 6.90 @ 1,700 = 1,270
側壁 2@.708 × .25 @ 2,400 = 850
拱環 .360 × 7.50 @ 2,400 = 6480
15,160 kg × .70 = 10,620 kg

W3
軌道道床及笠石 = 6,560
砂填充 .230 × 6.90 @ 1,700 = 2,700
側壁 2@.830 × .25 @ 2400 = 1,000
拱環 .373 × 7.50 @ 2,400 = 6710
16,970 × .70 = 11,880 kg

W4
軌道道床及笠石 = 6,560
砂填充 .403 × 6.90 @ 1,700 = 4,730
側壁 2@1,003 × .25 @ 2,400 = 1,205
拱環 .394 × 7.50 @ 2,400 = 7090
19,585 × .70 = 13,700 kg

W5
軌道道床及笠石 = 6,560
砂填充 .625 × 6.90 @ 1,700 = 7,330
側壁 2@1225 × .25 @ 2,400 = 1,470
拱環 .428 × 7.50 @ 2,400 = 7,700
23,060 × .70 = 16,140 kg

W6
軌道道床及笠石 = 6,560
砂填充 .910 × 6.90 @ 1,700 = 10,680
側壁 2@1.51 × .25 @ 2,400 = 1,810
拱環 .477 × 7.50 @ 2,400 = 8,590
27,640 × .70 = 19,350 kg

W7
軌道道床及笠石 = 6,560
砂填充 1.275 × 6.90 @ 1,700 = 14,950
側壁 2@1.875 × .25 @ 2,400 = 2,250
拱環 .548 × 7.50 @ 2,400 = 9,860
33,620 × .70 = 23,530 kg

W8
軌道道床及笠石 = 6,560
砂填充 1.69 × 6.90 @ 1,700 = 19,820
側壁 2@2.29 × .25 @ 2,400 = 2,750
拱環 .655 × 7.50 @ 2,400 = 11,790
40,920 × .70 = 28,650 kg

W9
軌道道床及笠石 = 6,560
砂填充 2.17 × 6.90 @ 1,700 = 25,450
側壁 2@2.77 × .25 @ 2,400 = 3,330
拱環 .833 × 7.50 @ 2,400 = 15,000
50,340 × .70 = 35,250 kg

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上海地下鐵道鐵筋混凝土拱橋

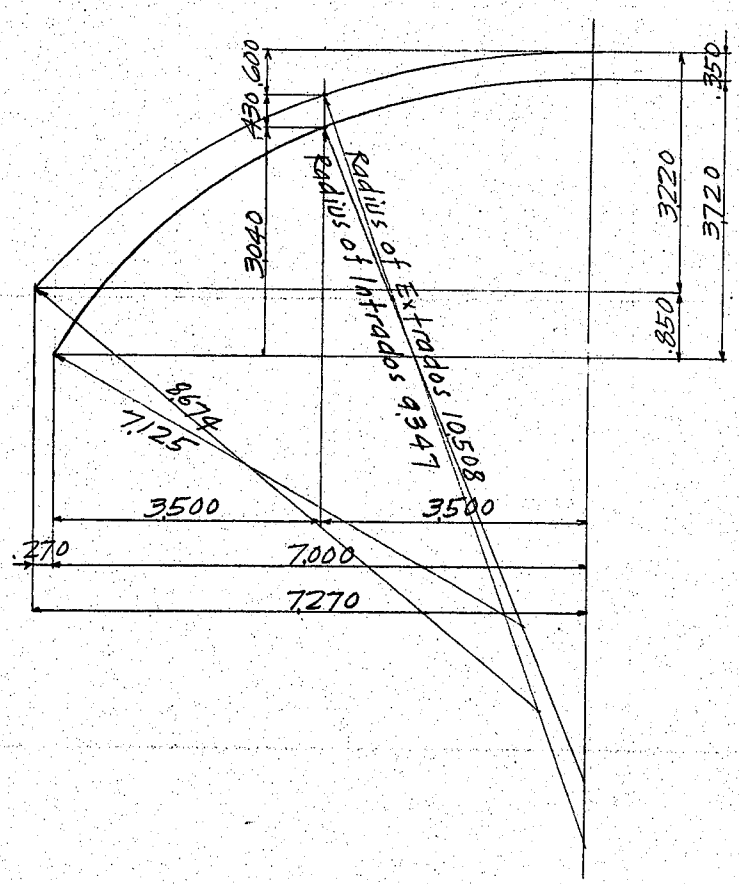
W10
軌道道床及笠石 = 6,560
砂填充 2.44 × 6.90 @ 1,700 = 28,600
側壁 2 @ 3.04 × .25 @ 2,400 = 3,645
拱環 9.45 × 7.50 @ 2,400 = 17,000
55,805 × .35 = 19,550 kg

死荷重反力及拱頂並=起拱点ノ彎曲率ヲ0ト假定シタル場合ノ水平推力ノ概算

	荷重	距離	能率
Cr	4,750	7.270	34,530
W1	9,820	6.570	64,500
W2	10,620	5.870	62,300
W3	11,880	5.170	61,400
W4	13,700	4.470	61,200
W5	16,140	3.770	60,850
W6	19,350	3.070	54,400
W7	23,530	2.370	55,800
W8	28,650	1.670	47,830
W9	35,250	.970	34,200
W10	19,550	.270	5,280
	193,240 kg		547,290 kgm

水平推力 547,290 ÷ 3.730 = 146,700 kg

拱環，寸法



鐵筋
拱頂 = 於テハ徑 19mm 鐵筋(斷面 2.84 cm²)ヲ上下兩層 = 20 cm 間隔 = 便用
起拱点 = 於テハ徑 19mm 鐵筋ヲ上下兩層 = 20 cm 間隔 = 便用
其ノ他ノ点 = 於テハ徑 19mm 鐵筋ヲ上下兩層 = 40 cm 間隔 = 便用

拱頂	2.84 × 37 = 105.1 cm²	2 @ 105.1 = 210.2 cm²
起拱点	2.84 × 37 = 105.1 cm²	2 @ 105.1 = 210.2 cm²
其ノ他ノ点	2.84 × 19 = 54.0 cm²	2 @ 54.0 = 108.0 cm²

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上海地下鐵道鐵筋混凝土拱橋

混凝土，物量力率　$\frac{750}{12}d^3 = 0.625\,d^3$

鐵筋，物量力率　$\frac{2102\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .3153\left(\frac{d}{2}-0.045\right)^2$　拱頂及起拱矣

$\frac{1080\times15}{10000}\times\left(\frac{d}{2}-0.045\right)^2 = .1620\left(\frac{d}{2}-0.045\right)^2$　其，他，矣

格矣	d	d^3	$I_c=0.625d^3$	$\frac{d}{2}-0.045$	$\left(\frac{d}{2}-0.045\right)^2$			I_s	I_o	混凝土斷面
Cr	.350	0.0429	0.02681	0.130	0.0169	× .3153	=	0.00533	0.03214	2.625
1	.353	0.0440	0.02750	0.132	0.0174	〃	=	0.00549	0.03299	2.648
2	.360	0.0467	0.02919	0.135	0.0182	〃	=	0.00574	0.03493	2.700
3	.370	0.0507	0.03169	0.140	0.0196	× .1620	=	0.00318	0.03487	2.775
4	.385	0.0571	0.03569	0.148	0.0219	〃	=	0.00355	0.03924	2.888
5	.405	0.0664	0.04150	0.158	0.0250	〃	=	0.00405	0.04555	3.038
6	.425	0.0768	0.04800	0.168	0.0282	〃	=	0.00457	0.05257	3.188
7	.460	0.0973	0.06081	0.185	0.0342	〃	=	0.00554	0.06635	3.450
8	.510	0.1327	0.08294	0.210	0.0441	× .3153	=	0.01390	0.09684	3.825
9	.570	0.1852	0.11575	0.240	0.0576	〃	=	0.01816	0.13391	4.275
10	.650	0.2746	0.17163	0.280	0.0784	〃	=	0.02472	0.19635	4.875
Sp.	.700	0.3430	0.21438	0.305	0.0930	〃	=	0.02932	0.24370	5.250

格矣	x	x^2	y	y^2	d_s	I_o	d_s/I_o	$x\frac{d_s}{I_o}$	$x^2\frac{d_s}{I_o}$	$y\frac{d_s}{I_o}$	$y^2\frac{d_s}{I_o}$
Cr	0	0	0	0	.350	.03214	10.89	0	0	0	0
1	0.700	0.490	0.025	0.0006	.703	.03299	21.31	14.92	10.44	.53	.01
2	1.400	1.960	0.100	0.0100	.708	.03493	20.27	28.38	39.73	2.03	.20
3	2.100	4.410	0.230	0.0529	.718	.03487	20.59	43.24	90.80	4.74	1.09
4	2.800	7.840	0.420	0.1764	.731	.03924	18.63	52.16	146.06	7.82	3.29
5	3.500	12.250	0.670	0.4489	.750	.04555	16.47	57.65	201.76	11.03	7.39
6	4.200	17.640	0.960	0.9216	.780	.05257	14.84	62.33	261.78	14.25	13.68
7	4.900	24.010	1.350	1.8225	.825	.06635	12.43	60.91	298.44	16.78	22.65
8	5.600	31.360	1.840	3.3856	.890	.09684	9.19	51.46	288.20	16.91	31.16
9	6.300	39.690	2.470	6.1009	1.003	.13391	7.49	47.19	297.28	18.50	45.70
10	7.000	49.000	3.320	11.0224	.800	.19635	4.07	28.49	199.43	13.51	44.86
Sp.	7.270	52.853	3.730	13.9129	.250	.24370	1.03	7.49	54.44	3.84	14.33
							157.21	454.22	1888.36	109.94	184.36

格矣	x	m	拱頂矣 $m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$	m	格矣1 $m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$	m	格矣2 $m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
Cr.	0	0	0	0	0								
1	0.700	0.700	14.92	10.44	.37	0	0	0	0				
2	1.400	1.400	28.38	39.73	2.84	0.700	14.19	19.87	1.42	0	0	0	0
3	2.100	2.100	43.24	90.80	9.95	1.400	28.83	60.54	6.64	0.700	14.41	30.27	3.32
4	2.800	2.800	52.16	146.06	21.90	2.100	39.12	109.54	16.42	1.400	26.08	73.02	10.95
5	3.500	3.500	57.65	201.76	38.61	2.800	46.12	161.42	30.88	2.100	34.59	121.07	23.16
6	4.200	4.200	62.33	261.78	59.85	3.500	51.94	218.16	49.88	2.800	41.55	174.52	39.90
7	4.900	4.900	60.91	298.44	82.22	4.200	52.21	255.82	70.48	3.500	43.51	213.19	58.73
8	5.600	5.600	51.46	288.20	94.70	4.900	45.03	252.15	82.86	4.200	38.60	216.13	71.02
9	6.300	6.300	47.19	297.28	116.55	5.600	41.94	264.26	103.60	4.900	36.70	231.23	90.65
10	7.000	7.000	28.49	199.43	94.59	6.300	25.64	179.49	85.13	5.600	22.79	159.54	75.67
Sp.	7.270	7.270	7.49	54.44	27.93	6.570	6.77	49.20	25.24	5.870	6.05	43.96	22.55
			454.22	1888.36	549.51		351.79	1570.45	472.55		264.28	1262.93	395.95

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設計　日付　類別 B
照査　日付　第 5 頁

上海地下鐵道鐵筋混凝土拱橋

格点	x	m	格点3 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格点4 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格点5 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
3	2,100	0	0	0	0								
4	2800	0.700	13.04	36.51	5.47	0	0	0	0				
5	3500	1.400	23.06	80.71	15.44	0.700	11.53	40.36	7.72	0	0	0	0
6	4.200	2.100	31.16	130.89	29.93	1.400	20.78	87.26	19.95	0.700	10.39	43.63	9.98
7	4.900	2.800	34.80	170.55	46.98	2.100	26.10	127.91	35.24	1.400	17.40	85.27	23.49
8	5.600	3.500	32.17	180.11	59.19	2.800	25.73	144.09	47.35	2.100	19.30	108.07	35.51
9	6.300	4.200	31.46	198.20	77.70	3.500	26.22	165.17	64.75	2.800	20.97	132.13	51.80
10	7.060	4.900	19.94	139.60	66.21	4.200	17.09	119.66	56.75	3.500	14.25	99.72	47.29
Sp.	7.270	5.170	5.33	38.71	19.86	4.470	4.60	33.47	17.17	3.770	3.88	28.23	14.48
			190.96	975.28	320.78		132.05	717.92	248.93		86.19	497.05	182.55

格点	x	m	格点6 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格点7 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格点8 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
6	4.200	0	0	0	0								
7	4.900	0.700	8.70	42.64	11.75	0	0	0					
8	5.600	1.400	12.87	72.04	23.67	0.700	6.43	36.02	11.84	0	0	0	0
9	6.300	2.100	15.73	99.10	38.85	1.400	10.49	66.07	25.90	0.700	5.24	33.03	12.95
10	7.000	2.800	11.40	79.77	37.83	2.100	8.55	59.83	28.38	1.400	5.70	39.89	18.92
Sp.	7.270	3.070	3.16	22.99	11.79	2.370	2.44	17.75	9.11	1.670	1.72	12.51	6.42
			51.86	316.54	123.89		27.91	179.67	75.23		12.66	85.43	38.29

格点	x	m	格点9 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	格点10 $m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
9	6.300	0	0	0	0				
10	7.000	0.700	2.85	19.94	9.46	0	0		
Sp.	7.270	0.970	1.00	7.26	3.73	0.270	0.28	2.02	1.04
			3.85	27.20	13.19		0.28	2.02	1.04

拱頂点推力 $H_0 = \dfrac{\int\frac{ds}{I_0}\int my\frac{ds}{I_0} - \int m\frac{ds}{I_0}\int y\frac{ds}{I_0}}{2\left[\int\frac{ds}{I_0}\int y^2\frac{ds}{I_0} - \left(\int y\frac{ds}{I_0}\right)^2\right]} = \dfrac{A}{B}$　　$B = 2 \times 1689644 = 3379288$

荷重点

										A			H_0
Cr	157.21	×	549.51	=	86,388.47	−	454.22	×	109.94	=	49,936.95	36,451.52	÷ 3,379,288	=	1.079
1	〃	×	472.55	=	74,289.59	−	351.79	×	〃	=	38,675.79	35,613.80	〃	=	1.054
2	〃	×	395.95	=	62,247.30	−	264.28	×	〃	=	29,054.94	33,192.36	〃	=	0.982
3	〃	×	320.78	=	50,429.82	−	190.96	×	〃	=	20,994.14	29,435.68	〃	=	0.871
4	〃	×	248.93	=	39,134.29	−	132.05	×	〃	=	14,517.58	24,616.71	〃	=	0.728
5	〃	×	182.55	=	28,698.69	−	86.19	×	〃	=	9,475.73	19,222.96	〃	=	0.569
6	〃	×	123.89	=	19,476.75	−	51.86	×	〃	=	5,701.49	13,775.26	〃	=	0.408
7	〃	×	75.23	=	11,826.91	−	27.91	×	〃	=	3,068.43	8,758.48	〃	=	0.259
8	〃	×	38.29	=	6,019.57	−	12.66	×	〃	=	1,391.84	4,627.73	〃	=	0.137
9	〃	×	13.19	=	2,073.60	−	3.85	×	〃	=	423.27	1,650.33	〃	=	0.049
10	〃	×	1.04	=	163.50	−	0.28	×	〃	=	30.78	132.72	〃	=	0.004

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設計	日付	類別	B
照査	日付	第	6頁

上海地下鐵道鐵筋混凝土拱橋

拱頂点弯曲率 $M_0 = \dfrac{-H_0 2\int y\frac{ds}{I_0} + \int m\frac{ds}{I_0}}{2\int\frac{ds}{I_0}} = \dfrac{C}{D}$ $D = 2 \times 15721 = 31442$

荷重点

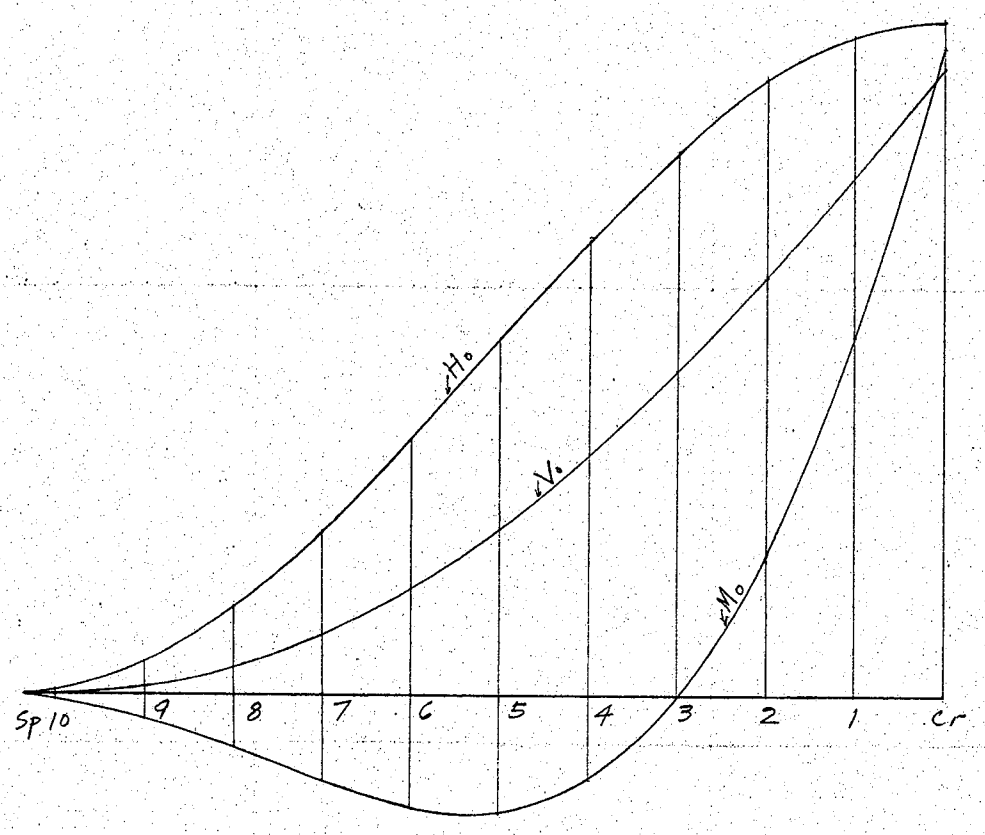
					C		D		M_0
Cr	−2 ×	1.079	× 109.94	=	−237.25	+ 454.22	= 216.97	÷ 31442	= 0.6901
1	〃 ×	1.054	〃	=	−231.75	+ 351.79	= 120.04	〃	= 0.3818
2	〃 ×	0.982	〃	=	−215.92	+ 264.28	= 48.36	〃	= 0.1538
3	〃 ×	0.871	〃	=	−191.52	+ 190.96	= −0.56	〃	= −0.0018
4	〃 ×	0.728	〃	=	−160.07	+ 132.05	= −28.02	〃	= −0.0891
5	〃 ×	0.569	〃	=	−125.11	+ 86.19	= −38.92	〃	= −0.1238
6	〃 ×	0.408	〃	=	−89.71	+ 51.86	= −37.85	〃	= −0.1204
7	〃 ×	0.259	〃	=	−56.95	+ 27.91	= −29.04	〃	= −0.0924
8	〃 ×	0.137	〃	=	−30.12	+ 12.66	= −17.46	〃	= −0.0555
9	〃 ×	0.049	〃	=	−10.77	+ 3.85	= −6.92	〃	= −0.0220
10	〃 ×	0.004	〃	=	−.88	+ 0.28	= −0.60	〃	= −0.0019

拱頂点剪力 $V_0 = \dfrac{\int mx\frac{ds}{I_0}}{2\int x^2\frac{ds}{I_0}} = \dfrac{E}{F}$

荷重点

				V_0	$1-V_0$
Cr	1,88836	÷ 3,77672	=	.5000	.5000
1	1,570.45	〃	=	.4158	.5842
2	1,262.93	〃	=	.3344	.6656
3	975.28	〃	=	.2582	.7418
4	717.92	〃	=	.1901	.8099
5	497.05	〃	=	.1316	.8684
6	316.54	〃	=	.0838	.9162
7	179.67	〃	=	.0476	.9524
8	85.43	〃	=	.0226	.9774
9	27.20	〃	=	.0072	.9928
10	2.02	〃	=	.0005	.9995

拱頂ニ於ケル水平推力，弯曲率及剪力ノ影響線



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設計	日付	類別	B
照査	日付	第	7頁

上海地下鐵道鐵筋混凝土拱橋
格点，單位荷重ニヨル弯曲率
左半分，弯曲率 $M_L = M_0 + H_0 y + V_0 x - d'$
右半分，弯曲率 $M_R = M_0 + H_0 y - V_0 x$

起拱点 $x = 7.270,\ y = 3.730$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	0.6901	4.0247	3.6350	7.270	1.0798	1.0798
1	0.3818	3.9314	3.0229	6.570	.7661	1.2903
2	0.1538	3.6629	2.4311	5.870	.3778	1.3856
3	-0.0018	3.2488	1.8771	5.170	-.0459	1.3699
4	-0.0891	2.7154	1.3820	4.470	-.4617	1.2443
5	-0.1238	2.1224	.9567	3.770	-.8147	1.0419
6	-0.1204	1.5218	.6092	3.070	-1.0594	.7922
7	-0.0924	0.9661	.3461	2.370	-1.1502	.5276
8	-0.0555	0.5110	.1643	1.670	-1.0502	.2912
9	-0.0220	0.1828	.0523	.970	-.7569	.1085
10	-0.0019	0.0149	.0036	.270	-.2534	.0094
Sp	0	0	0	0	0	0

格点10 $x = 7.000,\ y = 3.320$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	0.6901	3.5823	3.5000	7.000	.7724	.7724
1	0.3818	3.4993	2.9106	6.300	.4417	.9705
2	0.1538	3.2602	2.3408	5.600	.1548	1.0732
3	-0.0018	2.8917	1.8074	4.900	-.2027	1.0825
4	-0.0891	2.4170	1.3307	4.200	-.5414	.9972
5	-0.1238	1.8891	.9212	3.500	-.8135	.8441
6	-0.1204	1.3546	.5866	2.800	-.9792	.6476
7	-0.0924	.8549	.3332	2.100	-.9993	.4343
8	-0.0555	.4548	.1582	1.400	-.8425	.2411
9	-0.0220	.1627	.0504	.700	-.5089	.0903
10	-0.0019	.0133	.0035		.0149	.0079
Sp	0	0	0		0	0

格点8 $x = 5.600,\ y = 1.840$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	0.6901	1.9854	2.8000	5.600	-.1245	-.1245
1	0.3818	1.9394	2.3285	4.900	-.2503	.0073
2	0.1538	1.8069	1.8726	4.200	-.3667	.0881
3	-0.0018	1.6026	1.4459	3.500	-.4533	.1549
4	-0.0891	1.3395	1.0646	2.800	-.4850	.1858
5	-0.1238	1.0470	.7370	2.100	-.4398	.1862
6	-0.1204	.7507	.4693	1.400	-.3004	.1610
7	-0.0924	.4766	.2666	.700	-.0492	.1176
8	-0.0555	.2521	.1266		.3232	.0700
9	-0.0220	.0902	.0403		.1085	.0279
10	-0.0019	.0074	.0028		.0083	.0027
Sp	0	0	0		0	0

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設計	日付	類別	B
照査	日付	第	8 頁

上海地下鐵道鐵筋混凝土拱橋

格矣 6　　x = 4200 , y = 0.960

格矣	Mo	Hoy	Vox	d'	ML	MR
Cr	0.6901	1.0358	2.1000	4.200	-.3741	-.3741
1	0.3818	1.0118	1.7464	3.500	-.3600	-.3528
2	0.1538	.9427	1.4045	2.800	-.2990	-.3080
3	-0.0018	.8362	1.0844	2.100	-.1812	-.2500
4	-0.0891	.6989	.7984	1.400	.0082	-.1886
5	-0.1238	.5462	.5527	.700	.2751	-.1303
6	-0.1204	.3917	.3520		.6233	-.0807
7	-0.0924	.2486	.1999		.3561	-.0437
8	-0.0555	.1315	.0949		.1709	-.0189
9	-0.0220	.0470	.0302		.0552	-.0052
10	-0.0019	.0038	.0021		.0040	-.0002
Sp	0	0	0		0	0

格矣 4　　x = 2.800 , y = 0.420

格矣	Mo	Hoy	Vox	d'	ML	MR
Cr	0.6901	.4532	1.4000	2.800	-.2567	-.2567
1	0.3818	.4427	1.1642	2.100	-.1113	-.3397
2	0.1538	.4124	.9363	1.400	.1025	-.3701
3	-0.0018	.3658	.7230	.700	.3870	-.3590
4	-0.0891	.3058	.5323		.7490	-.3156
5	-0.1238	.2390	.3685		.4837	-.2533
6	-0.1204	.1714	.2346		.2856	-.1836
7	-0.0924	.1088	.1333		.1497	-.1169
8	-0.0555	.0575	.0633		.0653	-.0613
9	-0.0220	.0206	.0202		.0188	-.0216
10	-0.0019	.0017	.0014		.0012	-.0016
Sp	0	0	0		0	0

格矣 2　　x = 1.400 , y = 0.100

格矣	Mo	Hoy	Vox	d'	ML	MR
Cr	0.6901	.1079	.7000	1.400	.0980	.0980
1	0.3818	.1054	.5821	.700	.3693	-.0949
2	0.1538	.0982	.4682		.7202	-.2162
3	-0.0018	.0871	.3615		.4468	-.2762
4	-0.0891	.0728	.2661		.2498	-.2824
5	-0.1238	.0569	.1842		.1173	-.2511
6	-0.1204	.0408	.1173		.0377	-.1969
7	-0.0924	.0259	.0666		.0001	-.1331
8	-0.0555	.0137	.0316		-.0102	-.0734
9	-0.0220	.0049	.0101		-.0070	-.0272
10	-0.0019	.0004	.0007		-.0008	-.0022
Sp	0	0			0	0

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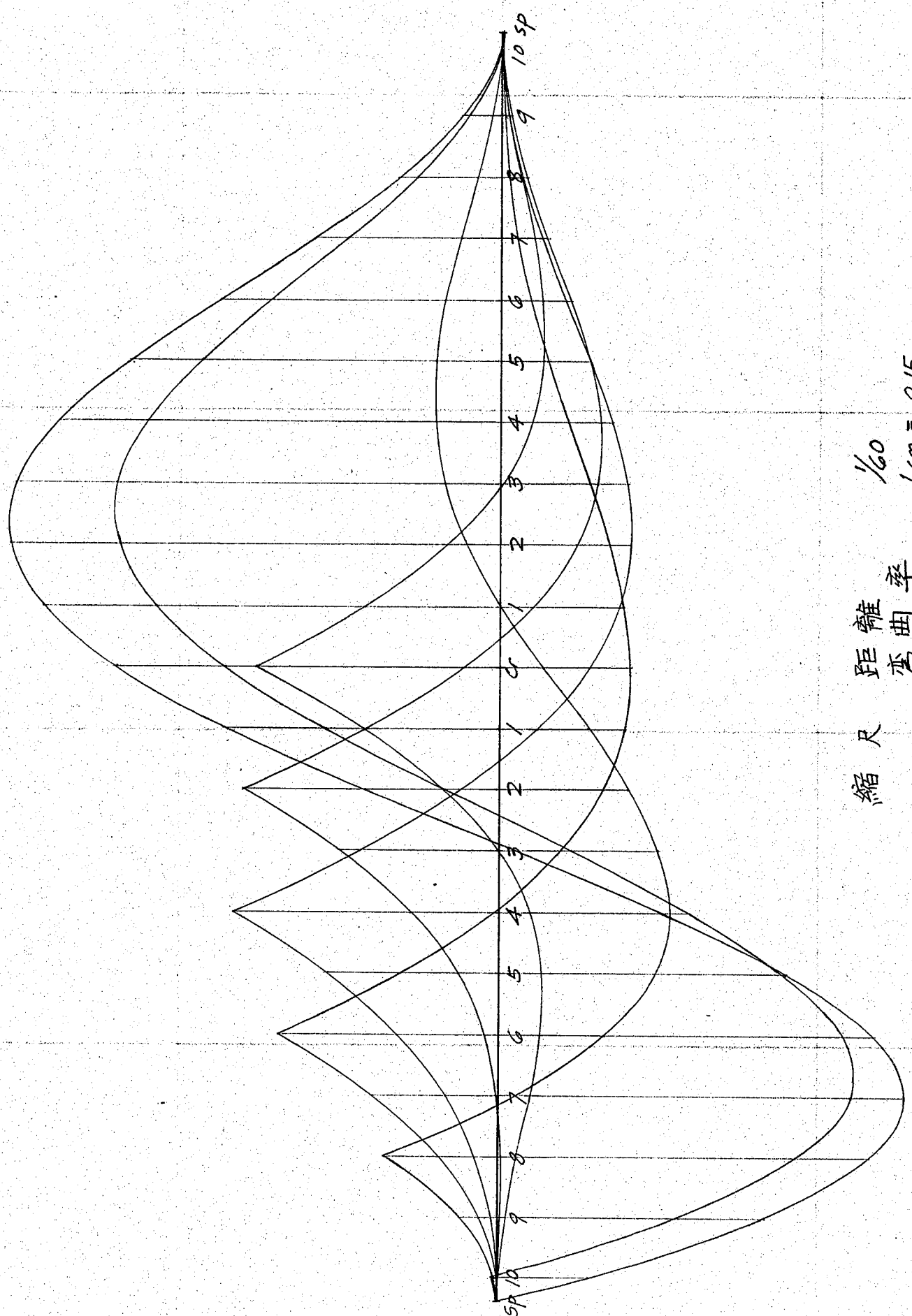
設計	日付	類別	B
照査	日付	第	9 頁

上海地下鐵道鐵筋混凝土拱橋
格奚弯曲率ノ影響線 。



縮尺　距離　1/60
弯曲率　1cm = 0.15

増田橋梁建築設計事務所
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設計	日付	類別	B
照査	日付	第	10頁

上海地下鐵道鐵筋混凝土拱橋

格点ノ死荷重彎曲率

拱頂

格点	荷重	M_0	M
Cr	4,750	0.6901	3,278
1	9,820	0.3818	3,750
2	10,620	0.1538	1,633
3	11,880	-0.0018	- 21
4	13,700	-0.0891	-1,221
5	16,140	-0.1238	-2,000
6	19,350	-0.1204	-2,330
7	23,530	-0.0924	-2,177
8	28,650	-0.0555	-1,590
9	35,250	-0.0220	- 775
10	19,550	-0.0019	- 37
			8,661
			-10,151

-1,490 × 2 = -2,980 kgm

	格点2		格点4		格点6		格点8		格点10	
格点	荷重		M		M		M		M	
10c	19,550	-.0008	-16	.0012	23	.0040	78	.0083	162	.0149	291
9	35,250	-.0070	-247	.0188	663	.0552	1,945	.1085	3,823	-.5089	-17,940
8	28,650	-.0102	-292	.0653	1,870	.1709	4,895	.3232	9,250	-.8425	-24,130
7	23,530	.0001	2	.1497	3,520	.3561	8,380	-.0492	-1,158	-.9993	-23,530
6	19,350	.0377	729	.2856	5,522	.6233	12,070	-.3004	-5,815	-.9792	-18,950
5	16,140	.1173	1,895	.4837	7,810	.2751	4,440	-.4398	-7,095	-.8135	-13,130
4	13,700	.2498	3,420	.7490	10,270	.0082	112	-.4850	-6,645	-.5414	-7,415
3	11,880	.4468	5,310	.3870	4,600	-.1812	-2,153	-.4533	-4,385	-.2027	-2,408
2	10,620	.7202	7,650	.1025	1,088	-.2990	-3,175	-.3667	-3,892	.1548	1,645
1	9,820	.3693	3,628	-.1113	-1,093	-.3600	-3,535	-.2503	-2,460	.4917	4,828
Cr	9,500	.0980	931	-.2567	-2,438	-.3741	-3,555	-.1245	-1,183	.7724	7,340
1	9,820	-.0949	-932	-.3397	-3,335	-.3528	-3,465	.0073	72	.9705	9,530
2	10,620	-.2162	-2,295	-.3701	-3,930	-.3080	-3,270	.0881	935	1.0732	11,400
3	11,880	-.2762	-3,282	-.3590	-4,268	-.2500	-2,970	.1549	1,840	1.0825	12,870
4	13,700	-.2824	-3,870	-.3156	-4,323	-.1886	-2,583	.1858	2,546	.9972	13,660
5	16,140	-.2511	-4,050	-.2533	-4,087	-.1303	-2,105	.1862	3,005	.8441	13,620
6	19,350	-.1969	-3,810	-.1836	-3,552	-.0807	-1,562	.1610	3,115	.6476	12,520
7	23,530	-.1381	-3,133	-.1169	-2,750	-.0437	-1,028	.1176	2,770	.4343	10,230
8	28,650	-.0734	-2,103	-.0613	-1,757	-.0189	- 542	.0700	2,005	.2411	6,910
9	35,250	-.0272	- 958	-.0216	- 761	-.0052	- 183	.0279	983	.0903	3,183
10R	19,550	-.0022	- 43	-.0016	- 31	-.0002	- 4	.0027	53	.0079	155
			-25,031		35,366		31,920		30,559		108,182
			23,565		-32,325		-30,130		-32,633		-107,503
			-1,466 kgm		3,041 kgm		1,790 kgm		-2,074 kgm		679 kgm

増田橋梁建築設計事務所
東京市品川區五反田五ノ一〇八
電話大崎(48)0678番

設計	日付	類別	B
照査	日付	第	11頁

上海地下鐵道鐵筋混凝土拱橋

起拱点

格点	荷重		M
10^L	19,550	-.2534	-4,955
9	35,250	-.7569	-26,680
8	28,650	-1.0502	-30,100
7	23,530	-1.1502	-27,070
6	19,350	-1.0594	-20,500
5	16,140	-.8147	-13,150
4	13,700	-.4617	-6,320
3	11,880	-.0459	-546
2	10,620	.3778	4,010
1	9,820	.7661	7,520
Cr	9,500	1.0798	10,260
1	9,820	1.2903	12,670
2	10,620	1.3856	14,720
3	11,880	1.3699	16,280
4	13,700	1.2443	17,050
5	16,140	1.0419	16,800
6	19,350	.7922	15,330
7	23,530	.5276	12,420
8	28,650	.2912	8,340
9	35,250	.1085	3,825
10^R	19,550	.0094	184
			-129,321
			139,409
			10,088 Kgm

死荷重推力

格点	荷重	H_0	H		水平推力ニヨル軸推力	垂直剪力	垂直剪力ニヨル軸推力
Cr	4,750	1.079	5,125	150,280 × 1.000 =	150,280	0 × 0.000 =	0
1	9,820	1.054	10,350				
2	10,620	.982	10,430	〃 × 0.988 =	148,500	19,880 × 0.145 =	2,885
3	11,880	.871	10,350				
4	13,700	.728	9,980	〃 × 0.957 =	143,800	43,920 × 0.286 =	12,560
5	16,140	.569	9,185				
6	19,350	.408	7,890	〃 × 0.897 =	134,800	76,585 × 0.437 =	33,470
7	23,530	.259	6,100				
8	28,650	.137	3,925	〃 × 0.777 =	116,800	124,115 × 0.625 =	77,600
9	35,250	.049	1,727				
10	19,550	.004	78	〃 × 0.600 =	90,200	183,465 × 0.823 =	150,900
Sp				〃 × 0.540 =	81,100	193,240 × 0.845 =	163,300
	193,240		75,140				
			× 2				
			150,280 Kg				

死荷重軸推力，總計

	Cr	2	4	6	8	10	Sp
垂直剪力ニヨル	—	2,885	12,560	33,470	77,600	150,900	163,300
水平推力ニヨル	150,280	148,500	143,800	134,800	116,800	90,200	81,100
	150,280	151,385	156,360	168,270	194,400	241,100	244,400

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東京市品川區五反田五ノ一〇八
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設計 日付 類別 B
照査 日付 第 12頁

上海地下鐵道鐵筋混凝土拱橋

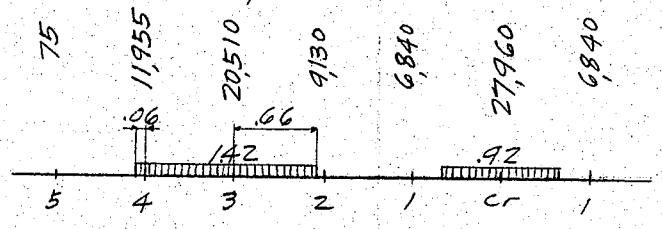
活荷重應力

電車輪荷重
衝撃荷重 $i = \frac{25}{50+14.54} = .388$

30,000
11,640
41,640 kg

特殊荷重 33,000 kg

拱頂 正彎曲率



41,640÷142 = 29,330
29,330×.06 = 1,760
1,760−75 = 1,685
10,270
11,955

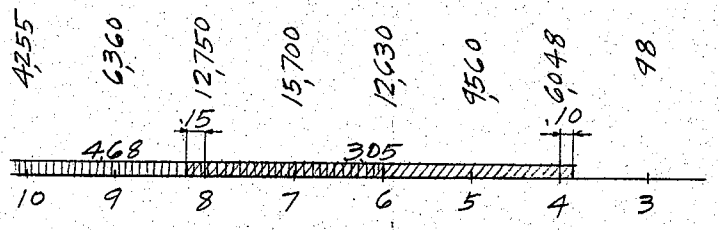
29,330×.35 = 10,270
1,760×.03/.70 = 75
29,330×.66 = 19,370
19,370×.33/.70 = 9,130
19,370−9,130 = 10,240
10,270
20,510

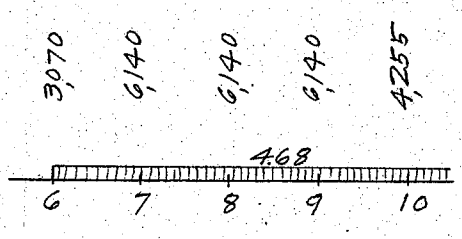
20,820×.23/.70 = 6,840

格点		Mu	M	Ho	H
5	75	-0.1238	− 9	.569	43
4	11,955	-0.0891	− 1,066	.728	8,700
3	20,510	-0.0018	− 37	.871	17,860
2	9,130	0.1538	1,405	.982	8,970
1	6,840	0.3818	2,612	1.054	7,210
cr	27,960	0.6901	19,300	1.079	30,160
1	6,840	0.3818	2,612	1.054	7,210
			24,817 kgm		80,153 kg

特殊荷重
M = 24,817×1.1 = 27,300 kgm
H = 80,153×1.1 = 88,100 kg

拱頂 負彎曲率





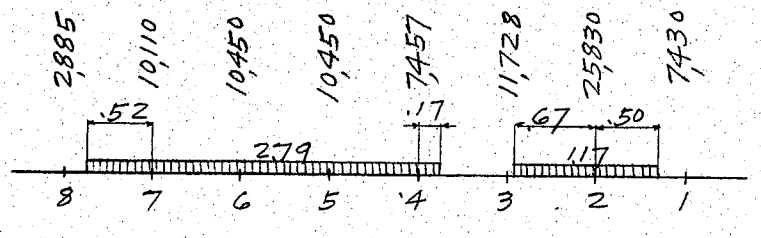
41,640÷4.68 = 8,770
8,770×.35 = 3,070
8,770×.135 = 1,185
4,255

41,640÷3.05 = 13,660 13,660×.35 = 4,780
13,660×.15 = 2,050 2,050×.075/.70 = 220
2,050−220 = 1,830
4,780
6,140
12,750
6,140
6,360

13,66×.05/.70 = 98 1,366−98 = 1,268

格点		Mu	M	Ho	H
10	4,255	-0.0019	− 8	.004	17
9	6,360	-0.0220	-140	.049	312
8	12,750	-0.0555	-708	.137	1,747
7	15,700	-0.0924	-1,450	.259	4,065
6	12,630	-0.1204	-1,522	.408	5,155
5	9,560	-0.1238	-1,184	.569	5,440
4	6,048	-0.0891	− 539	.728	4,405
3	98	-0.0018	−	.871	85
6	3,070	-0.1204	− 368	.408	1,252
7	6,140	-0.0924	− 567	.259	1,590
8	6,140	-0.0555	− 341	.137	841
9	6,140	-0.0220	− 135	.049	301
10	4,255	-0.0019	− 8	.004	17
			-6,970 kgm		25,227 kg

格点乙 正彎曲率



41,640×.50 = 20,820
20,820×.25/.70 = 7,430
20,820−7,430 = 13,390

41,640÷2.79 = 14,930 14,930×.35 = 5,225
14,930×.52 = 7,770 7,770×.26/.70 = 2,885
7,770−2,885 = 4,885 14,930×.17 = 2,540
2,540×.085/.70 = 308 2,540−308 = 2,232

41,640÷1.17 = 35,600 35,600×.67 = 23,860
23,860×.335/.70 = 11,420 23,860−11,420 = 12,440
308 13,390
11,728 25,830

増田橋梁建築設計事務所
東京市品川區五反田五ノ一〇八
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設計	日付	類別	B
照査	日付	第	13頁

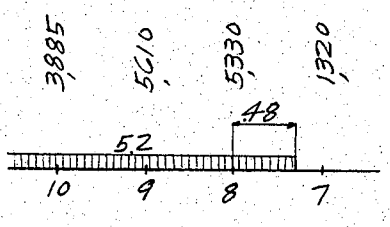
上海地下鐵道鐵筋混凝土拱橋

格点		Mu	M	Ho	H	Vo	V
8	2,885	-0.0102	-29	0.137	395	-0.0226	-65
7	10,110	0.0001	1	0.259	2,618	-0.0476	-481
6	10,450	0.0377	394	0.408	4,265	-0.0838	-876
5	10,450	0.1173	1,227	0.569	5950	-0.1316	-1,375
4	7,457	0.2498	1,862	0.728	5,420	-0.1901	-1,416
3	11,728	0.4468	8240	0.871	10,220	-0.2582	-3,027
2	25,830	0.7202	18,600	0.982	25,370	0.6656	17,200
1	7,430	0.3693	2,745	1.054	7,830	0.5842	4,345
			33,040 kgm		62,068 kg		14,305 kg

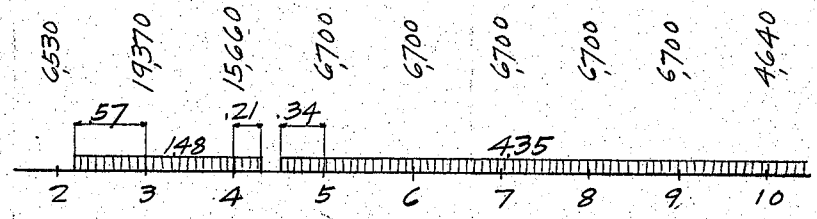
軸推力
62,068 × .988 = 61,300
14,305 × .145 = 2,070
63,370 kg

特殊荷重
M = 33,040 × 1.1 = 36,350 kgm
H = 62,068 × 1.1 = 68,250 kg
V = 14,305 × 1.1 = 15,730 〃
軸推力 = 63,370 × 1.1 = 69,650 〃

格点2　負曲率



41,640 ÷ .52 = 8,010
8,010 × .48 = 3,845
3,845 − 1,320 = 2,525
2,805
5,330



8,010 × .35 = 2,805
3,845 × 24/70 = 1,320
8,010 × .135 = 1,080
2,805
3,885

28,150 × .21 = 5,910
5,910 × 105/70 = 890
5,910 − 890 = 5,020
3,250 × 17/70 = 790
9,850
15,660

41,640 ÷ 148 = 28,150
28,150 × .35 = 9,850
28,150 × .57 = 16,050
16,050 × 285/70 = 6,530
16,050 − 6,530 = 9,520
41,640 ÷ 435 = 9,570
9,570 × .35 = 3,350
9,570 × .34 = 3,250
3,250 − 790 = 2,460
3,350
890
6,700
9,570 × .135 = 1,290
3,350
4,640

格点		Mu	M	Ho	H	Vo	V
10	3,885	-.0008	-3	0.004	16	-.0005	-2
9	5,610	-.0070	-39	0.049	275	-.0072	-40
8	5330	-.0102	-54	0.137	730	-.0226	-121
7	1,320	.0001	-	0.259	342	-.0476	-63
2	6,530	-.2162	-1,412	0.982	6,410	.3344	2,183
3	19,370	-.2762	-5,350	0.871	16,880	.2582	5,000
4	15,660	-.2824	-4420	0.728	11,400	.1901	2,975
5	6,700	-.2511	-1,683	0.569	3,812	.1316	882
6	6,700	-.1969	-1,320	0.408	2,735	.0838	562
7	6,700	-.1331	-891	0.259	1,735	.0476	319
8	6,700	-.0734	-492	0.137	918	.0226	151
9	6,700	-.0272	-182	0.049	328	.0072	48
10	4,640	-.0022	-15	0.004	27	.0005	2
			-15,861 kgm		45,608 kg		11,896 kg

特殊荷重
M = -15,765 × 1.1 = -17,340 kgm
H = 44,245 × 1.1 = 48,650 kg
V = 12,122 × 1.1 = 13,330 〃

軸推力
45,608 × .988 = 45,050
11,896 × .145 = 1,725
46,775 kg

特殊荷重軸推力
48,650 × .988 = 48,100
13,330 × .145 = 1,930
50,030 kg

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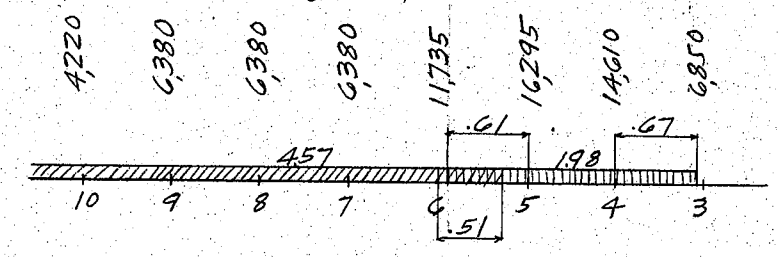
東京市品川區五反田五ノ一〇八
電話大崎(49)0678番

設計　日付　類別　B
照査　日付　第　14頁

上海地下鐵道鐵筋混凝土拱橋

格点4　正弯曲率



格点		Mu	M	Ho	H	V。11,735	V
10	4,220	.0012	5	.004	17	-.0005	- 2
9	6,380	.0188	120	.044	313	-.0072	-46
8	6,380	.0653	417	.137	874	-.0226	-144
7	6,380	.1497	955	.259	1,653	-.0476	-304
6	11,735	.2856	3,350	.408	4,790	-.0838	-983
5	16,295	.4837	7,880	.569	9,270	-.1316	-2,145
4	14,610	.7490	10,950	.728	10,640	.8099	11,830
3	6,850	.3870	2,650	.871	5,965	.7418	5,080
			26,326 kgm		33,522 kg		13,286 kg

41,640 ÷ 4.57 = 9,110
9,110 × .51 = 4,650
4,650 − 1,695 = 2,955
41,640 ÷ 1.98 = 21,030
12,830 × 305/70 = 5,590
3,190
2955

9,110 × .35 = 3,190
4,650 × 255/70 = 1,695
21,030 × .61 = 12,830
12,830 − 5,590 = 7,240
21,030 × .35 = 7,360
1,695
16,295

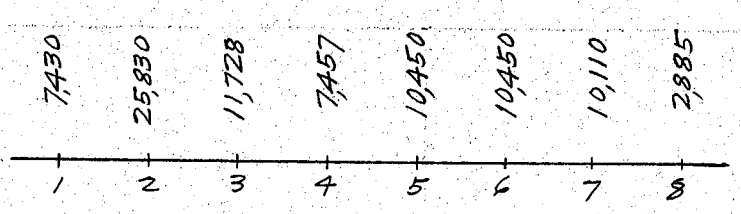
9,110 × .135 = 1,230
3,190
4,420

21,030 × .67 = 14,100
14,100 × 335/70 = 6,850
14,100 − 6,850 = 7,250
7,360
14,610

軸推力
33,522 × 0.957 = 32,080
13,286 × 0.286 = 3,800
35,880 kg

特殊荷重
M = 26,326 × 1.1 = 28,970 kgm
H = 33,522 × 1.1 = 36,900 kg
V = 13,286 × 1.1 = 14,620 〃
軸推力 = 35,880 × 1.1 = 39,450 〃

格点4　負弯曲率



格点		Mu	M	Ho	H	V。	V
1	7,430	-.3397	-2,522	1.054	783	.4158	3,090
2	25,830	-.3701	-9,550	.982	25,370	.3344	8,640
3	11,728	-.3590	-7,210	.871	10,220	.2582	3,027
4	7,457	-.3156	-2,353	.728	5,422	.1901	1,416
5	10,450	-.2533	-2,648	.569	5,945	.1316	1,375
6	10,450	-.1836	-1,920	.408	4,245	.0838	876
7	10,110	-.1169	-1,182	.259	2,617	.0476	481
8	2,885	-.0613	-177	.137	395	.0226	65
			-27,562 kgm		54,997 kg		18,970 kg

軸推力
54,997 × 0.957 = 52,600
18,970 × 0.286 = 5,420
58,020 kg

特殊荷重
M = -27,562 × 1.1 = -30,300 kgm
H = 54,997 × 1.1 = 60,500 kg
V = 18,970 × 1.1 = 20,870 〃
軸推力 = 58,020 × 1.1 = 63,800 〃

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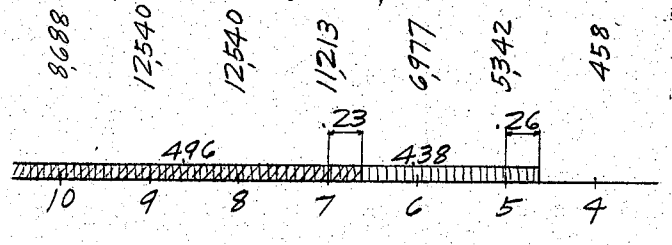
東京市品川區五反田五ノ一〇八
電話 穴崎 (49) 0678 番

設計	日付	類別	B
照査	日付	第	15 頁

上海地下鐵道鐵筋混凝土拱橋

格点 6　正彎曲率



41,640 ÷ 4,96 = 8,400
8,400 × ,23 = 1,930
41,640 ÷ 438 = 9,510
9,510 × ,26 = 2,470

8,400 × ,35 = 2,940
1,930 × 115/70 = 317
9,510 × ,35 = 3,330
2,470 × 13/70 = 458

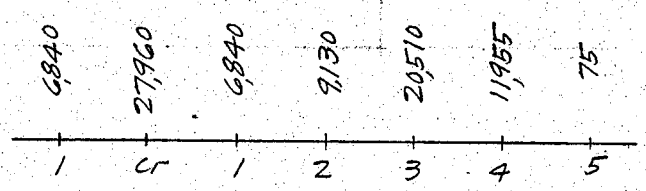
8,400 × ,135 = 1,135
1,930 − 317 = 1,613
9,510 × ,135 = 1,283
2,470 − 458 = 2,012

1,613	317	3,330
2,940	6,660	2,012
6,660	6,977	5,342
11,213		

格点		Mu	M	Ho	H
10	8,688	.0040	35	.004	35
9	12,540	.0552	692	.049	615
8	12,540	.1709	2,143	.137	1,718
7	11,213	.3561	3,990	.259	2,905
6	6,977	.6233	4,350	.408	2,845
5	5,342	.2751	1,469	.569	3,040
4	458	.0082	4	.728	333
			12,683 kgm		11,491 kg

特殊荷重
M = 12,683 × 1.1 = 13,950 kgm
H = 11,491 × 1.1 = 12,640 kg

格点 6　負彎曲率

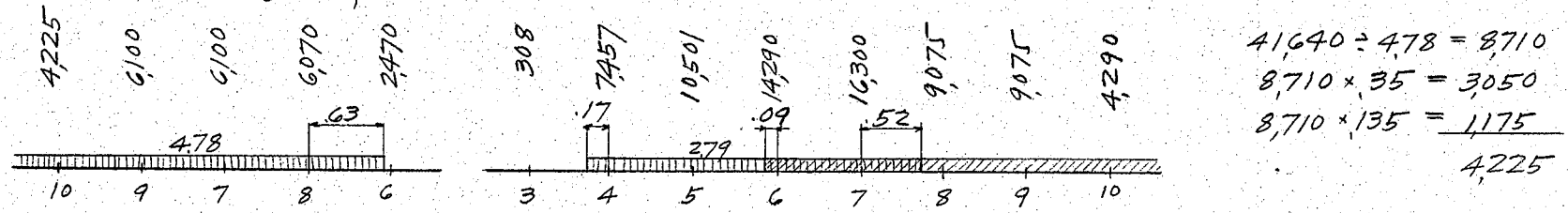


格点		Mu	M	Ho	H	Vo	V
1	6,840	-.3600	-2,462	1,054	7,210	.5842	4,000
Cr	27,960	-.3741	-10,460	1,079	30,170	.5000	13,970
1	6,840	-.3528	-2,413	1,054	7,210	.4158	2,845
2	9,130	-.3080	-2,812	.982	8,970	.3344	3,050
3	20,510	-.2500	-5,125	.871	17,860	.2582	5,290
4	11,955	-.1886	-2,255	.728	8,700	.1901	2,270
5	75	-.1303	-10	.569	43	.1316	10
			-25,537 kgm		80,163 kg		31,435 kg

軸推力　80,163 × 0.897 = 71,900
31,435 × 0.437 = 13,740
85,640 kg

特殊荷重
M = −25,537 × 1.1 = −28,100 kgm
H = 80,163 × 1.1 = 88,200 kg
V = 31,435 × 1.1 = 34,580 〃
軸推力 = 85,640 × 1.1 = 94,200 〃

格点 8　正彎曲率



41,640 ÷ 4,78 = 8,710
8,710 × ,35 = 3,050
8,710 × ,135 = 1,175
4,225

8,710 × ,63 = 5,490
5,490 × 315/70 = 2,470
5490 − 2,470 = 3,020
3,050
6,070

5,225
2,232
7,457
10,450
51
10,501

41,640 ÷ 4,71 = 8,840
8,840 × ,09 = 796
10,450
745
3095
14290

8,840 × ,35 = 3,095
796 × 045/70 = 51
5,225
4,885
6190
16300

8,840 × ,135 = 1,195
796 − 51 = 745
2885
6,190
9,075

3,095
1,195
4,290

増田橋梁建築設計事務所
東京市品川區五反田五ノ一〇八
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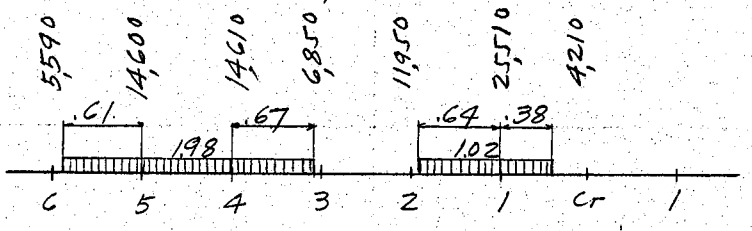
設計	日付	類別	B
照査	日付	第	16頁

上海地下鐵道鐵筋混凝土拱橋

格点		Mu	M	Ho	H
10	4,225	.0083	35	.004	17
9	6,100	.1085	662	.049	299
8	6,100	.3232	1,972	.137	836
7	6,070	-.0492	-299	.259	1,572
6	2,470	-.3004	-742	.408	1,008
3	308	.1549	48	.871	268
4	7,457	.1858	1,386	.728	5,425
5	10,510	.1862	1,955	.569	5,980
6	14,290	.1610	2,300	.408	5,830
7	16,300	.1176	1,917	.259	4,220
8	9,075	.0700	635	.137	1,243
9	9,075	.0279	253	.049	445
10	4,290	.0027	12	.004	17
			10,134 kgm		27,160 kg

格点 8　負弯曲率



41,640 ÷ 1.02 = 40,850
26,150 × .32/.70 = 11,950
40,850 × .38 = 15,520
15,520 − 4,210 = 11,310

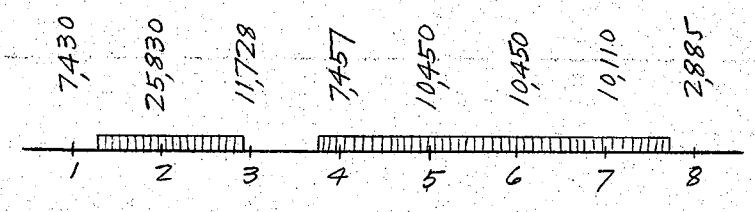
40,850 × .64 = 26,150
26,150 − 11,950 = 14,200
15,520 × .19/.70 = 4,210

格点		Mu	M	Ho	H	Vo	V
6	5,590	-.3004	-1,680	.408	2,280	.9162	5,120
5	14,600	-.4398	-6,420	.569	8,310	.8684	12,680
4	14,610	-.4850	-7,085	.728	10,630	.8099	11,825
3	6,850	-.4533	-3,105	.871	5,965	.7418	5,080
2	11,950	-.3667	-4,380	.982	11,730	.6656	7,950
1	25,510	-.2503	-6,385	1.054	26,870	.5842	14,920
Cr	4,210	-.1245	-5,240	1.079	4,540	.5000	2,105
			-34,295 kgm		70,325 kg		59,680 kg

軸推力
70,325 × 0.777 = 54,650
59,680 × 0.625 = 37,300
91,950 kg

特殊荷重
M = −34,295 × 1.1 = −37,700 kgm
H = 70,325 × 1.1 = 77,350 kg
V = 59,680 × 1.1 = 65,650 〃
軸推力 = 91,950 × 1.1 = 101,200 〃

格点 10　正弯曲率



格点		Mu	M	Ho	H	Vo	V
1	7,430	.9705	7,210	1.054	7,830	.4158	3,090
2	25,830	1.0732	27,730	.982	25,370	.3344	8,640
3	11,728	1.0825	12,700	.871	10,220	.2582	3,030
4	7,457	.9972	7,430	.728	5,425	.1901	1,416
5	10,450	.8441	8,820	.569	5,945	.1316	1,375
6	10,450	.6476	6,760	.408	4,260	.0838	876
7	10,110	.4343	4,390	.259	2,618	.0476	481
8	2,885	.2411	695	.137	395	.0226	65
			75,735 kgm		62,063 kg		18,973 kg

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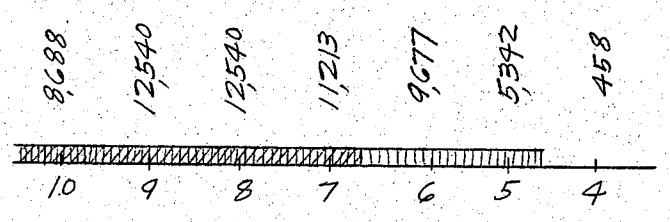
軸推力

62,063 × .600 = 37250
18,973 × .823 = 15620
52,870 kg

特殊荷重

M = 75,735 × 1.1 = 83,300 kgm
H = 62,063 × 1.1 = 68,300 kg
V = 18,973 × 1.1 = 20,870 〃
軸推力 = 52,870 × 1.1 = 58200 〃

格点 10　頁弯曲率

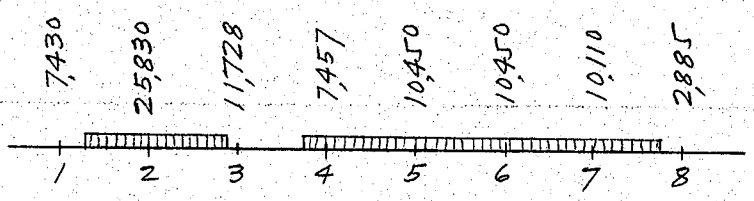


格点		Mu	M	Ho	H
10	8,688	.0149	130	.004	35
9	12,540	-.5089	-6,380	.049	614
8	12,540	-.8425	-10,570	.137	1,718
7	11,213	-.9993	-11,200	.259	2,903
6	9,677	-.9792	- 9,470	.408	3,950
5	5,342	-.8135	- 4,345	.569	3,040
4	458	-.5414	- 248	.728	333
			-42,083 kgm		12,593 kg

特殊荷重

M = -42,083 × 1.1 = - 46,300 kgm
H = 12,593 × 1.1 = 13,850 kg

起拱点　正弯曲率



格点		Mu	M	Ho	H	Vo	V
1	7,430	1.2903	9,580	1.054	7,830	.4158	3,090
2	25,830	1.3856	35,800	.982	25,370	.3344	8,640
3	11,728	1.3699	16,060	.871	10,220	.2582	3,028
4	7,457	1.2443	9,270	.728	5,425	.1901	1,415
5	10,450	1.0419	10,880	.569	5,950	.1316	1,375
6	10,450	.7922	8,275	.408	4,265	.0838	875
7	10,110	.5276	5,330	.259	2,618	.0476	481
8	2,885	.2912	840	.137	395	.0226	65
			96,035 kgm		62,073 kg		18,969 kg

軸推力

62,073 × .540 = 33,500
18,969 × .845 = 16,020
49,520 kg

特殊荷重

M = 96,035 × 1.1 = 105,600 kgm
H = 62,073 × 1.1 = 68,300 kg
V = 18,969 × 1.1 = 20,880 〃
軸推力 = 49,520 × 1.1 = 54,500 〃

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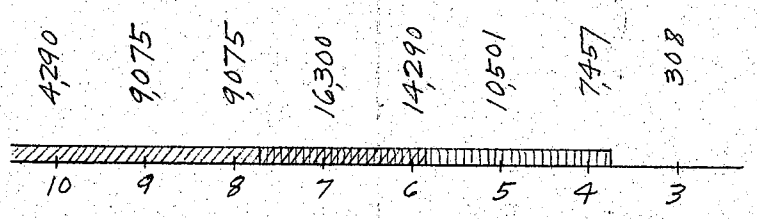
上海地下鐵道鐵筋混凝土拱橋

起拱点　負彎曲率



格点		Mu	M	H_0	H	V_0	V
10	4,290	-.2534	-1,087	.004	17	.9995	4,290
9	9,075	-.7569	-6,870	.049	445	.9928	9,020
8	9,075	-1,0502	-9,530	.137	1,243	.9774	8,870
7	16,300	-1,1502	-18,750	.259	4,220	.9524	15,530
6	14,290	-1,0594	-15,150	.408	5,830	.9162	13,100
5	10,501	-.8147	-8,550	.569	5,975	.8684	9,120
4	7,457	-.4617	-3,440	.728	5,423	.8099	6,040
3	308	-.0459	-14	.871	268	.7418	228
			-63,391 Kgm		23,421 Kg		66,198 Kg

特殊荷重
M = -63391 × 1.1 = -69,750 Kgm
H = 23421 × 1.1 = 25,770 Kg
V = 66,198 × 1.1 = 72800 〃
軸推力 = 68,550 × 1.1 = 75,400 〃

軸推力
23,421 × .540 = 12,650
66,198 × .845 = 55,900
68,550 Kg

温度應力

拱頂ニ於ケル水平推力 $H_0 = \dfrac{EwtJ\int\frac{ds}{I_0}}{2\left[\int\frac{ds}{I_0}\int y^2\frac{ds}{I_0} - \left(\int y\frac{ds}{I_0}\right)^2\right]} = \dfrac{G}{B}$

茲ニ E = 1,400,000,000 Kg/m²
w = 0.000012 (1°C ニ対スル膨張係数)
t = 温度ノ変化
l = 径間長 = 14.54 m
EwT = 252,000 Kg

温度 15°C ノ降下ニ対シテ

$H_0 = \dfrac{-252{,}000 \times 1454 \times 157.21}{33792.88} = -17{,}050$ Kg

$M_0 = -\dfrac{H_0\int y\frac{ds}{I_0}}{\int\frac{ds}{I_0}} = 17{,}050 \times \dfrac{109.94}{157.21} = 11{,}930$ Kgm

格点ノ温度應力

格点			彎曲率			軸推力	
2	11,930 - 17,050	× 0.100	= 10,225 Kgm	- 17,050	× .988	= -16,840 Kg
4	〃 〃	× 0.420	= 4,770 〃		× .957	= -16,320 〃
6	〃 〃	× 0.960	= -4,440 〃		× .897	= -15,300 〃
8	〃 〃	× 1.840	= -19,440 〃		× .777	= -13,250 〃
10	〃 〃	× 3.320	= -44,670 〃		× .600	= -10,220 〃
Sp	〃 〃	× 3.730	= -51,670 〃		× .540	= -9,210 〃

拱環ノ平均應力

拱頂ノ断面積
鐵筋ノ換算面積

2.6250
.3153
2.9403 m²

拱環ノ厚ノ比 = 起拱点ノ厚 / 拱頂ノ厚 = .700 / .350 = 2.00

ライズノ比 = 3.730 / 14.54 = 0.257

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上海地下鐵道鐵筋混凝土拱橋

拱頂=於ケルH

死荷重應力	150,280	÷ 29403	= 51,100	@	1.02	=	52,100	kg/m²
活荷重應力								
拱頂 +M	88,100	÷ 29403	= 29970	@	0.94	=	28150	kg/m²
−M	25,227	〃	= 8,580	@	1.04	=	8920	〃
格矣2 +M	68,250	〃	= 23220	@	0.94	=	21,830	〃
−M	48,650	〃	= 16,550	@	1.04	=	17200	〃
格矣4 +M	36,900	〃	= 12,550	@	0.95	=	11,930	〃
−M	60,500	〃	= 20,580	@	1.03	=	21,200	〃
格矣6 +M	12,640	〃	= 4300	@	0.96	=	4,130	〃
−M	88,200	〃	= 30,000	@	1.03	=	30,900	〃
格矣8 +M	27,160	〃	= 9240	@	0.96	=	8,870	〃
−M	77,350	〃	= 26,300	@	1.02	=	26,800	〃
格矣10 +M	68,300	〃	= 23230	@	0.97	=	22,530	〃
−M	13,850	〃	= 4,710	@	1.02	=	4,800	〃
起拱矣 +M	68,300	〃	= 23230	@	0.97	=	22,530	〃
−M	25,770	〃	= 8,760	@	1.02	=	8,940	〃
温度應力	−17,050	÷ 〃	= −5,800	@	0.78	=	−4,530	〃

拱環纖維應力

拱頂　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	150,280	−2,980	52,100
活荷重	88,100	27,300	28,150
温度變化	−17,050	11,930	−4,530
肋縮	−5030	3,520	−1340
	216,300 kg	39,770 kgm	74,380 kg/m²

$R = \frac{4530}{252,000+4,530} \times C = 0.0177C$

74380 ÷ 252,000 = 0.295
$d'/h = 4.5/35 = 0.129$, $A_s = 105.1\ cm^2$
$p = \frac{105.1}{750\times35} = 0.004$
$e = 39,770 \div 216,300 = 0.184$
$e/h = 18.4 \div 35 = 0.526$　$k = 0.46$, $C = 0.22$

$$f_c = \frac{N}{bhC} = \frac{216,300}{750\times35\times0.22} = 37.5\ kg/cm^2$$

$$f_s = 15\times37.5\times\frac{0.54}{0.46} = 660\ kg/cm^2$$

格矣2　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	151,385	−1,466	52,100
活荷重	69,650	36,350	21,830
温度變化	−16,840	10,225	−4,530
肋縮	−4,560	2,770	−1,230
	199,635 kg	47,879 kgm	68,170 kg/m²

68,170 ÷ 252,000 = 0.271
$d'/h = 4.5/36 = 0.125$　$A_s = 105.1\ cm^2$
$p = \frac{105.1}{750\times36} = 0.0039$
$e = 47,879 \div 199,635 = 0.24$
$e/h = 24 \div 36 = 0.667$　$k = 0.40$　$C = 0.17$

$$f_c = \frac{199,635}{750\times36\times0.17} = 43.5\ kg/cm^2$$

$$f_s = 15\times43.5\times\frac{.60}{.40} = 978\ kg/cm^2$$

格矣4　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	156,360	3041	52,100
活荷重	39,450	28,970	11,930
温度變化	−16,320	4,770	−4,530
肋縮	−3785	1,107	−1,050
	175,705 kg	37,888 kgm	58,450 kg/m²

58,450 ÷ 252,000 = 0.232
$d'/h = 4.5/38.5 = 0.117$　$A_s = 54.0\ cm^2$
$p = \frac{54.0}{750\times38.5} = 0.00187$
$e = 37,888 \div 175,705 = 0.216$
$e/h = 21.6 \div 38.5 = 0.561$
$k = 0.37$　$C = 0.165$

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格点6 負彎曲率

	軸推力	彎曲率	平均應力
死荷重	168270	1790	52100
活荷重	94200	-28100	30900
温度変化	-15300	-4440	-4530
肋縮	-4680	-1358	-1390
	242,490 kg	-32,108 kgm	77,080 kg/m²

77080 ÷ 252,000 = 0.306
d/h = 4.5/425 = 0.106 As = 54.0 cm²
p = 54.0 / (750×425) = 0.0017
e = 32,108 ÷ 242,490 = 0.132
e/h = 132 ÷ 425 = 0.311
K = 0.64 C = 0.33

$$f_c = \frac{242490}{750 \times 425 \times 0.33} = 23.1 \text{ kg/cm}^2$$

$$f_s = 15 \times 23.1 \times \frac{.36}{.64} = 195 \text{ kg/cm}^2$$

格点8 負彎曲率

	軸推力	彎曲率	平均應力
死荷重	194,400	-2,074	52,100
活荷重	101,200	-37,700	26,800
温度変化	-13,250	-19,440	-4,530
肋縮	-3840	-5640	-1316
	278,510 kg	-64,854 kgm	73,054 kg/m²

73054 ÷ 252,000 = 0.29
d/h = 4.5/51 = 0.088 As = 105.1 cm²
p = 105.1 / (750×51) = 0.00275
e = 64,854 ÷ 278,510 = 0.233
e/h = 233 ÷ 51 = 0.457
K = 0.485 C = 0.25

$$f_c = \frac{278510}{750 \times 51 \times .25} = 29.1 \text{ kg/cm}^2$$

$$f_s = 15 \times 29.1 \times \frac{.515}{.485} = 464 \text{ kg/cm}^2$$

格点10 正彎曲率

	軸推力	彎曲率	平均應力
死荷重	241,100	679	52,100
活荷重	58200	83,300	22,530
温度変化	10,220	44,670	4530
肋縮	-3160	-13,800	-1400
	306,360 kg	114,849 kgm	77,760 kg/m²

77760 ÷ 252,000 = 0.309
d/h = 4.5/65 = 0.0692 As = 105.1 cm²
p = 105.1 / (750×65) = 0.00216
e = 114,849 ÷ 306,360 = 0.375
e/h = 37.5 ÷ 65 = 0.577
K = 0.39 C = 0.178

$$f_c = \frac{306360}{750 \times 65 \times .178} = 35.3 \text{ kg/cm}^2$$

$$f_s = 15 \times 35.3 \times \frac{.61}{.39} = 828 \text{ kg/cm}^2$$

起拱点 正彎曲率

	軸推力	彎曲率	平均應力
死荷重	244,400	10,088	52,100
活荷重	54500	105,600	22,530
温度変化	9210	51,670	4,530
肋縮	-2850	-15,970	-1,400
	305,260 kg	151,388 kgm	77,760 kg/m²

d/h = 4.5/70 = 0.0643 As = 105.1 cm²
p = 105.1 / (750×70) = 0.002
e = 151,388 ÷ 305,260 = 0.496
e/h = 49.6 ÷ 70 = 0.708
K = 0.34 C = 0.14

$$f_c = \frac{305260}{750 \times 70 \times .14} = 41.6 \text{ kg/cm}^2$$

$$f_s = 15 \times 41.6 \times \frac{.66}{.34} = 1212 \text{ kg/cm}^2$$

若シ 19mmφ 40 cm c to c. 22mmφ 40 cm c. to c. トスレハ

2.84 × 19 = 54.0
3.801 × 18 = 68.4
As = 122.4 cm²

p = 122.4 / (750×70) = 0.00233
K = 0.355 C = 0.147

$$f_c = \frac{305260}{750 \times 70 \times .147} = 39.6 \text{ kg/cm}^2$$

$$f_s = 15 \times 39.6 \times \frac{.645}{.355} = 1080 \text{ kg/cm}^2$$

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起拱点 頁弯曲率

	軸推力	弯曲率	平均應力
死荷重	244400	10088	52100
活荷重	75400	-69750	8940
温度変化	-9210	-51670	-4530
肋縮	-2030	-11370	-1000
	308560 kg	-122702 kgm	55510 kg/m²

55510 ÷ 252000 = 0.22
d'/h = 0.0643, As = 122.4 cm²
p = 0.00233
e = 122702 ÷ 308560 = 0.398
e/h = 39.8 ÷ 70 = 0.569
K = 0.405 C = 0.185

$$f_c = \frac{308560}{750 \times 70 \times .185} = 31.8\ kg/cm^2$$

$$f_s = 15 \times 31.8 \times \frac{595}{405} = 700\ kg/cm^2$$

橋脚ノ設計

死荷重反力 Rd = 193240 kg
死荷重水平推力 Hd = 150280 kg
死荷重弯曲率 Md = 10088 kgm

活荷重

起拱点＝最大正弯曲率ノ起ル場合

反力 Rl = 20880 ÷ 1388 = 15050 kg
水平推力 Hl = 68300 〃 = 49200 kg
弯曲率 Ml = 105600 〃 = 76100 kgm

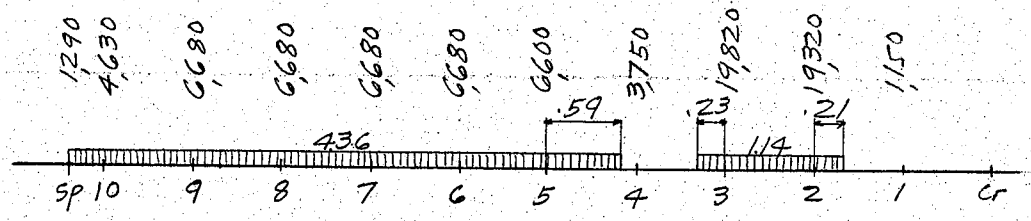
起拱点＝最大水平推力ノ起ル場合

水平推力 Hl = 88100 kg ÷ 1388 = 63400 kg

格点		Mu	M	Vo	V
1	6840	.7661	5240	.5842	3995
Cr	27960	1.0798	30200	.5000	13770
1	6840	1.2903	8820	.4158	2845
2	9130	1.3856	12650	.3344	3053
3	20510	1.3699	28100	.2582	5295
4	11955	1.2443	14870	.1901	2270
5	75	1.0419	78	.1316	10
			99958 kgm		31238 kg

Ml = 99958 × 1.1/1388 = 79200 kgm
Rl = 31238 × 1.1/1388 = 24750 kg

起拱点＝最大反力ノ起ル場合



41640 ÷ 436 = 9550
9550 × .35 = 3340
1290
4630 kg

9550 × .135 = 1290
9550 × .59 = 5630
5630 × .295/.70 = 2370
5630 − 2370 = 3260
3340
6600

41640 ÷ 114 = 36540
36540 × .23 = 8400
8400 − 1380 = 7020
12800
19820

36540 × .35 = 12800
8400 × .115/.70 = 1380
2370
3750

36540 × .21 = 7670
7670 − 1150 = 6520
12800
19320

7670 × .105/.70 = 1150

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上海地下鐵道鐵筋混凝土拱橋

格点		Mu	M	Ho	H	Vo	V
Sp	1,290	—	—	—	—	1.0000	1,290
10	4,630	-.2534	-1,173	0.004	19	.9995	4,630
9	6,680	-.7569	-5,060	0.049	327	.9928	6,635
8	6,680	-1.0502	-7,010	0.137	915	.9774	6,530
7	6,680	-1.1502	-7,680	0.259	1,730	.9524	6,365
6	6,680	-1.0594	-7,080	0.408	2,725	.9162	6,090
5	6,600	-.8147	-5,375	0.569	3,755	.8684	5,730
4	3,750	-.4617	-1,730	0.728	2,730	.8099	3,037
3	19,820	.0459	909	0.871	17,250	.7418	14,700
2	19,320	.3778	7,300	0.982	18,980	.6656	12,850
1	1,150	.7661	881	1.054	1,212	.5842	672
			-26,018 kgm		49,643 kg		68,529 kg

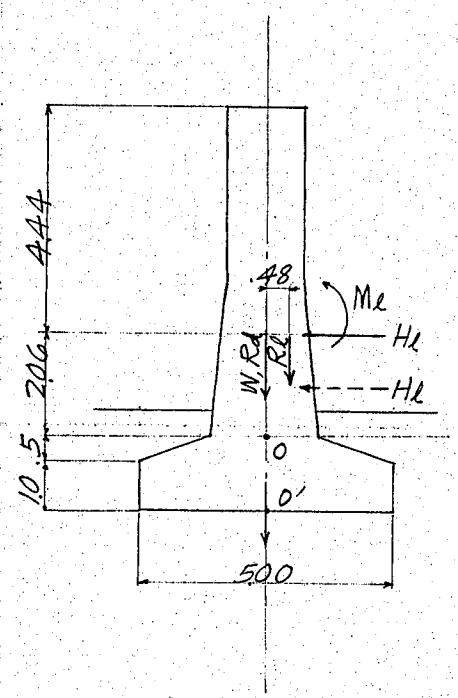
特殊荷重

反力　$Rl = 68,529 \times 1.1 = 75,400 \div 1.388 = 54,300$ kg
水平推力　$Hl = 49,643 \times 1.1 = 54,600$ 〃 $= 39,400$ kg
弯曲率　$Ml = -26,018 \times 1.1 = -28,600$ 〃 $= -20,700$ kgm

最大正弯曲率ノ起ル場合

橋脚上部ノ重量

軌道	2 × 600 × 150	= 1,800
道床	40 × 690 × 150 @ 1,900	= 7,870
填充砂	285 × 690 × 150 @ 1,700	= 50,100
側壁	2 @ 475 × 150 × 340 @ 2,400	= 11,620
橋脚体	165 × 310 × 900 @ 2,400	= 110,400
		W = 181,790 kg



死荷重反力　$Rd = 2 @ 193,240 = 386,480$ kg
衝撃係数　$i = \frac{0.5 \times 15,050}{15,050 + 386,480 + 181,790} = 0.013$

活荷重

反力	$Rl = 15,050 \times 1.013$	= 15,260 kg
水平推力	$Hl = 49,200 \times$ 〃	= 49,880 kg
弯曲率	$Ml = 76,100 \times$ 〃	= 77,200 kgm

0点ニ於ケル弯曲率

	V	H		M
W	181,790	×	0 =	0
Rd	386,480	×	0 =	0
Rl	15,260	×	0 =	0
Hl		49,880 ×	1.030 =	51,400
	583,530 kg	49,880 kg		51,400 kgm

$e = 51,400 \div 583,530 = 0.088$ m

基礎上ノ土ノ重量

2 @ 0.75 × 1.60 × 11.00 =	26.40
0.50 × 1.80 × 2.00 =	1.80
E = 28.20 @ 1,600 =	45,100 kg

基礎ノ重量

0.50 × 3.40 × 11.00 =	18.70
1.00 × 5.00 × 11.00 =	55.00
B = 73.70 × 2,400 =	176,700 kg

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設計	日付	類別	B
照査	日付	第	23 頁

上海地下鐵道鐵筋混凝土拱橋

$W+B = 181,790 + 176,700 = 358,490$ kg

衝撃係数 $i = \frac{0.5 \times 15,050}{15,050 + 386,480 + 358,490} = 0.01$

活荷重

反力	$Rl = 15,050 \times 1.01 =$	15,200 kg
水平推力	$Hl = 49,200 \times \,' =$	49,700 kg
弯曲率	$Ml = 76,100 \times \,' =$	76,900 kgm

0'点=於ケル能率

	V	H		M
W+B	358,490		× 0 =	0
Rd	386,480		× 0 =	0
Rl	15,200		× 0 =	0
Hl		49,700	× 2.53 =	151,200
E	45,100		× 0 =	0
	805,270	49,700		151,200 kgm

$e = 151,200 \div 805,270 = 0.188$ m

滑動係数 $49,700 \div 805,270 = 0.062$

支圧力 $= \frac{805,270}{5.00 \times 11.00} \times \left(1 \pm \frac{6 \times .188}{5.0}\right) =$ 17,950 kg/m²

11,330 〃

最大水平推力，起ル場合

衝撃係数 $i = \frac{0.5 \times 24,750}{24,750 + 386,480 + 181,790} = 0.021$

活荷重

反力	$Rl = 24,750 \times 1.021 =$	25,270 kg
水平推力	$Hl = 63,400 \times \,' =$	64,700 kg
弯曲率	$Ml = 79,200 \times \,' =$	80,800 kgm

0点=於ケル弯曲率

	V	H		M
W	181,790		× 0 =	0
Rd	386,480		× 0 =	0
Rl	25,270		× 0 =	0
Hl		64,700	× 1.03 =	66,600
	593,540 kg	64,700 kg		66,600 kgm

$e = 66,600 \div 593,540 = 0.112$ m

衝撃係数 $i = \frac{0.5 \times 24,750}{24,750 + 386,480 + 358,490} = 0.016$

活荷重

反力	$Rl = 24,750 \times 1.016 =$	25,130 kg
水平推力	$Hl = 63,400 \times \,' =$	64,400 kg
弯曲率	$Ml = 79,200 \times \,' =$	80,450 kgm

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照査　日付　第　24頁

上海地下鐵道鐵筋混凝土拱橋

0'点ニ於ケル能率

	V	H		M
W + B	358,490		× 0 =	0
Rd	386,480		× 0 =	0
Rl	25,130		× 0 =	0
Hl		64,400	× 253 =	163,000
E	45,100		× 0 =	0
Ml				
	815,200 kg	64,400 kg		163,000 kgm

$e = 163,000 \div 815,200 = 0.200\ m$

滑動係数　$64,400 \div 815,200 = 0.079$

支圧力 $= \frac{815,200}{5.00 \times 11.00} \times \left(1 \pm \frac{6 \times 0.200}{5.0}\right) = 18,380\ kg/m^2$　1.24
$11,260$ 〃　.74

最大反力ノ起心場合

衝撃係数 $i = \frac{0.5 \times 54,300}{54,300 + 386,480 + 181,790} = 0.044$

活荷重

反力	Rl	= 54,300 × 1.044 = 56,700 kg
水平推力	Hl	= 39,400 × 〃 = 41,150 〃
弯曲率	Ml	= −20,700 × 〃 = −21,620 kgm

0点ニ於ケル弯曲率

	V	H		M
W	181,790		× 0 =	0
Rd	386,480		× 0 =	0
Rl	56,700		× 0 =	0
Hl		41,150	× 1.030 =	42,380
	624,970 kg	41,150 kg		42,380 kgm

$e = 42,380 \div 624,970 = 0.07$

此ノ場合ハ前記ノ場合ヨリ安全ナルヿ明カ

断面ノ設計

橋脚体ノ断面 $M = 66,600$ kgm, $N = 593,540$ kg, $S = 64,700$ kg, $e = 11.2$ cm

$h = 150$ cm, $d'/h = 45/150 = 0.03$, $e/h = 11.2/150 = 0.075$

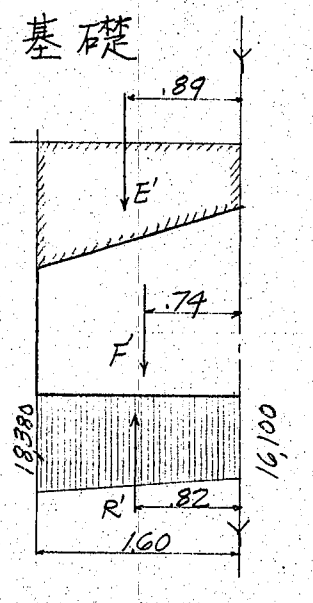
$A_s = 19$ mmφ 20 cm c.to c $= 45 \times 2.835 = 127.5\ cm^2$

$p = \frac{127.5}{90.0 \times 150} = 0.00095$　$C = 1.38$

$f_c = \frac{N}{bh} C = \frac{593,540}{90.0 \times 150} \times 1.38 = 6.1\ kg/cm^2$

$f_s = 15 \times 6.1 = 92\ kg/cm^2$ C

基礎



$E' = 0.75 \times 1.00 \times 1.60$ @ $1,600 = 1,920$ kg
$F' = 1.25 \times 1.00 \times 1.60$ @ $2,400 = 4,800$ kg
$R' = 17,240 \times 1.00 \times 1.60 = 27,600$ kg

Y−Y ニ於ケル弯曲率

R'	27,600 ×	0.82	= 22,600
E'	− 1,920 ×	0.89	= − 1,710
F'	− 4,800 ×	0.74	= − 3,550
	S = 20,880 kg		M = 17,340 kgm

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照査　日付　第　25　頁

上海地下鐵道鐵筋混凝土拱橋

所要有効厚　$d = \sqrt{\frac{17340 \times 100}{100 \times 7.13}} = 49.3$ cm

使用有効厚　140 cm　被覆　10 cm　總厚　150 cm

所要鐵筋量　$\frac{17340 \times 100}{1200 \times 7/8 \times 140} = 11.8$ cm²

鐵筋　19 mm φ　20 cm c. to c.　$A_s = 5 \times 2.835 = 14.2$ cm²

$p = \frac{14.2}{100 \times 140} = 0.001$　　$j = 0.946$　　$k = 0.16$

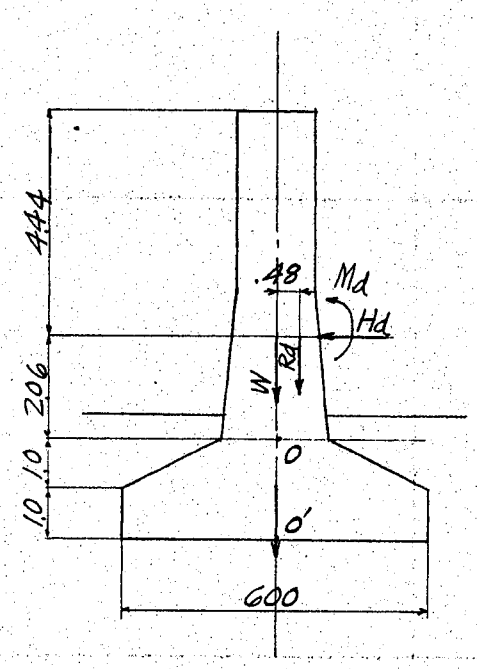
$f_s = \frac{17340 \times 100}{14.2 \times 0.946 \times 140} = 922$ kg/cm²

$f_c = \frac{2 \times 17340 \times 100}{0.946 \times 0.16 \times 100 \times 140^2} = 11.7$ kg/cm²

$s = \frac{20880}{100 \times 0.946 \times 140} = 1.6$ kg/cm²

鎮定橋脚 (Abutment Pier)

死荷重



反　力　Rd = 193,240 kg
水平推力　Hd = 150,280 kg
彎曲率　Md = 10,088 kgm

橋脚上部，重量　W = 181,790 kg

0 点ニ於ケル彎曲率

	V	H			M
W	181,790		×	0	= 0
Rd	193,240		×	0	= 0
Hd		150,280	×	2.06	= 309,500
	375,030 kg	150,280 kg			309,500 kgm

$e = 309{,}500 \div 375{,}030 = 0.826$ m

$h = 210$ cm，$d'/h = 45/210 = 0.021$，$e/h = 82.6/210 = 0.393$

$A_s = 19$ mm φ 20 cm c. to c. $= 45 \times 2.835 = 127.5$ cm²

$p = \frac{127.5}{900 \times 210} = 0.00067$　　$k = 0.45$　　$c = 0.22$

$f_c = \frac{309{,}500}{900 \times 210 \times 0.22} = 7.4$ kg/cm²

$f_s = 15 \times 7.4 \times \frac{0.55}{0.45} = 136$ kg/cm²

$s = \frac{150{,}280}{900 \times 7/8 \times 200} = 1.0$ kg/cm²

基礎上，土，重量

2 @ 1.00 × 1.95 × 11.00 = 42.88
0.50 × 2.10 × 2.00 = 2.10
E = 44.98 @ 1,600 = 72,000 kg

基礎，重量

1.00 × 4.05 × 11.00 = 44.55
1.00 × 6.00 × 11.00 = 66.00
B = 110.55 @ 2,400 = 265,200 kg

W + B = 181,790 + 265,200 = 446,990 kg

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照査	日付	第	26頁

上海地下鐵道鐵筋混凝土拱橋

O'点＝於ケル能率

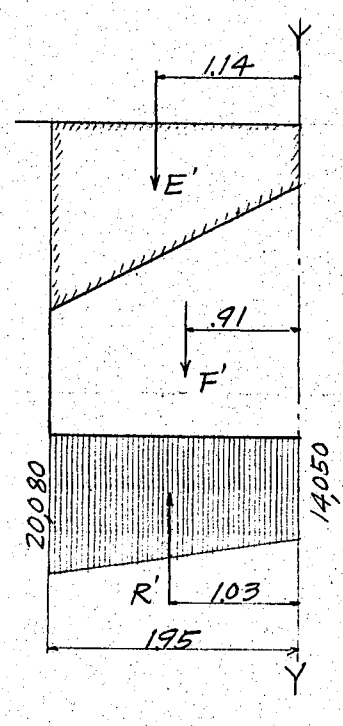
	V	H			M
W+B	446,990		×	0	= 0
Rd	193,240		×	0	= 0
Hd		150,280	×	4.06	= 610,000
E	72,000		×	0	= 0
	712,230 kg	150,280 kg			610,000 kgm

$e = 610,000 \div 712,230 = 0.86$ m

滑動係数 $150,280 \div 712,230 = 0.21$

支圧力 $= \frac{712,230}{6.00 \times 11.00} \times \left(1 \pm \frac{6 \times 0.86}{6.0}\right) = 20,080$ kg/m² (1.56 / .14)

1,510 ,



E' = 1.00 × 1.00 × 1.95 @ 1,600 = 3,120 kg
F' = 1.50 × 1.00 × 1.95 @ 2,400 = 7,020 kg
R' = 1.00 × 1.95 × 17,070 = 33,300 kg

Y-Y＝於ケル弯曲率

R'	33,300	× 1.03	=	34,300
E'	- 3,120	× 1.14	=	- 3,560
F'	- 7,020	× 0.91	=	- 6,390
	S = 23,160 kg			M = 24,350 kgm

所要有効厚 $d = \sqrt{\frac{24350 \times 100}{100 \times 7.13}} = 58.4$ cm

使用有効厚 190 cm 被覆 10 cm 總厚 200 cm

所要鐵筋量 $\frac{24350 \times 100}{1,200 \times 7/8 \times 190} = 12.2$ cm²

鐵筋 19mmφ 20 cm c.to c. $A_s = 5 @ 2.84 = 14.2$ cm²

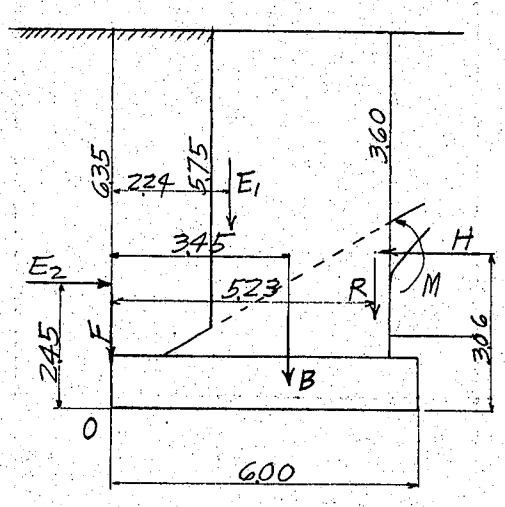
$p = \frac{14.2}{100 \times 190} = 0.00075$ $j = 0.954$ $k = 0.14$

$f_s = \frac{24,350 \times 100}{14.20 \times 0.954 \times 190} = 946$ kg/cm²

$f_c = \frac{2 \times 24350 \times 100}{0.96 \times 0.14 \times 100 \times 190^2} = 10.0$ kg/cm²

$s = \frac{23160}{100 \times 0.96 \times 190} = 1.3$ kg/cm²

橋臺，設計



死荷重

反力	Rd	= 193,240 kg
水平推力	Hd	= 150,280 kg
弯曲率	Md	= 10,088 kgm

躯体重量

2 @ 3.50 × .475 × 4.825	= 16.05	× 3.61	= 57.9
1.375 × 4.50 × 8.00	= 49.50	× 4.00	= 198.0
1.00 × 6.00 × 11.00	= 66.00	× 3.00	= 198.0
	131.55	3.45	453.9

B = 131.55 @ 2,400 = 316,000 kg

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上海地下鐵道鐵筋混凝土拱橋

上部荷重及砂ノ重量

6.35 × 1.00 × 11.00 @ 1,600	=	11,800	× 0.50	=	55,900
6.05 × 1.00 × 11.00 @ 1,600	=	106,500	× 1.49	=	158,700
3.50 × 4.675 × 6.90 @ 1,600	=	180,600	× 3.61	=	652,000
3.15 × 0.50 × 4.50 @ 1,600	=	11,350	× 3.00	=	34,050
2 @ 6.00 × 5.50	=	6,600	× 2.75	=	18,150
6.90 × 0.40 × 5.50 @ 1,900	=	28,850	× 2.75	=	79,300
	E_1 =	445,700 kg	2.24		998,100

土圧　$\frac{1}{3} \times wh = \frac{1}{3} \times 1,600 \times 7.35 = 3,920$ kg

$E_2 = \frac{1}{2} \times 3,920 \times 7.35 \times 11.00 = 158,500$ kg

土ノ摩擦

$\tan\theta = \tan 20° = 0.364$

$F = 158,500 \times 0.364 = 57,700$ kg

最大正彎曲率ノ起ル場合

衝撃係数　$i = \frac{0.5 \times 15,050}{15,050 + 193,240 + 316,000} = 0.014$

活荷重

反力	R_l =	15,050 × 1.014	=	15,270 kg
水平推力	H_l =	49,200 × 〃	=	49,900 〃
彎曲率	M_l =	76,100 × 〃	=	77,200 kgm

R =	193,240	+ 15,270	=	208,510 kg
H =	150,280	+ 49,900	=	200,180 kg
M =	10,088	+ 77,200	=	87,288 kgm

0 点ニ於ケル能率

	V	H			M
R	208,510		× 5.23	=	1,090,000
E_1	445,700		× 2.24	=	998,000
B	316,000		× 3.45	=	1,090,000
F	57,700		× 0	=	0
H		− 200,180	× 3.06	= −	612,000
E_2		158,500	× 2.45	=	388,500
M				= −	77,200
	1,027,910 kg	41,680 kg			2,877,300 kgm

2,877,300 ÷ 1,027,910 = 2.8 m

$e = 3.0 - 2.8 = 0.2$ m

滑動係数　41,680 ÷ 1,027,910 = 0.041

支圧力　$\frac{1,027,910}{6.0 \times 11.0} \times \left(1 \pm \frac{6 \times 0.2}{6.0}\right) =$ 18,700 kg/m²
12,470 〃

最大水平推力ノ起ル場合

衝撃係数　$i = \frac{0.5 \times 24,750}{24,750 + 193,240 + 316,000} = 0.023$

活荷重

反力	R_l =	24,750 × 1.023	=	25,350 kg
水平推力	H_l =	63,400 × 〃	=	64,950 〃
彎曲率	M_l =	79,200 × 〃	=	81,100 kgm

R =	193,240	+ 25,350	=	218,590 kg
H =	150,280	+ 64,950	=	215,230 〃
M =	10,088	+ 81,100	=	91,188 kgm

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照査	日付	第	28 頁

上海地下鐵道鐵筋混凝土拱橋

0点＝拱ケル能率

	V	H			M
R	218590		×	5.23 =	1143000
E_1	445700		×	2.24 =	998000
B	316000		×	3.45 =	1090000
F	57700		×	0 =	0
H		−215230	×	3.06 = −	658500
E_2		158500	×	2.45 =	388500
M			×	= −	91188
	1037990 Kg	56730 Kg			2869812 Kgm

2869812 ÷ 1037990 = 2.76 m

e = 3.00 − 2.76 = 0.24 m

滑動係数 56730 ÷ 1037990 = 0.055

支圧力 $\frac{1037990}{6.0 \times 11.0} \times \left(1 \pm \frac{6 \times 0.055}{6.0}\right) =$ 16,600 Kg/m²
14870 〃

最大反力ノ起ル場合

衝撃係数 $i = \frac{0.5 \times 54300}{54300 + 193240 + 316000} = 0.048$

活荷重

反力	Rl = 54300 × 1.048	= 57000 Kg
水平推力	Hl = 39400 × 〃	= 41300 〃
曲率	Ml = −20700 × 〃	= −21700 Kgm

R	193240 + 57000	= 250240 Kg
H	150280 + 41300	= 191580 〃
M	10088 − 21700	= −11612 Kgm

0点＝拱ケル能率

	V	H			M
R	250240		×	5.23 =	1308000
E_1	445700		×	2.24 =	998000
B	316000		×	3.45 =	1090000
F	57700		×	0 =	0
H		−191580	×	3.06 = −	586000
E_2		158500	×	2.45 =	388500
M				=	11612
	1069640 Kg	33080 Kg			3210112 Kgm

3210112 ÷ 1069640 = 3.00

e = 0

滑動係数 33080 ÷ 1069640 = 0.031

支圧力 $\frac{1069640}{6.0 \times 11.0} =$ 16200 Kg/m²

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上海高速鐵道

鐵筋混凝土拱橋應力計算書

純徑間 一五.〇米

複線軌道

増田橋梁建築設計事務所
東京市品川區五反田五ノ一〇八
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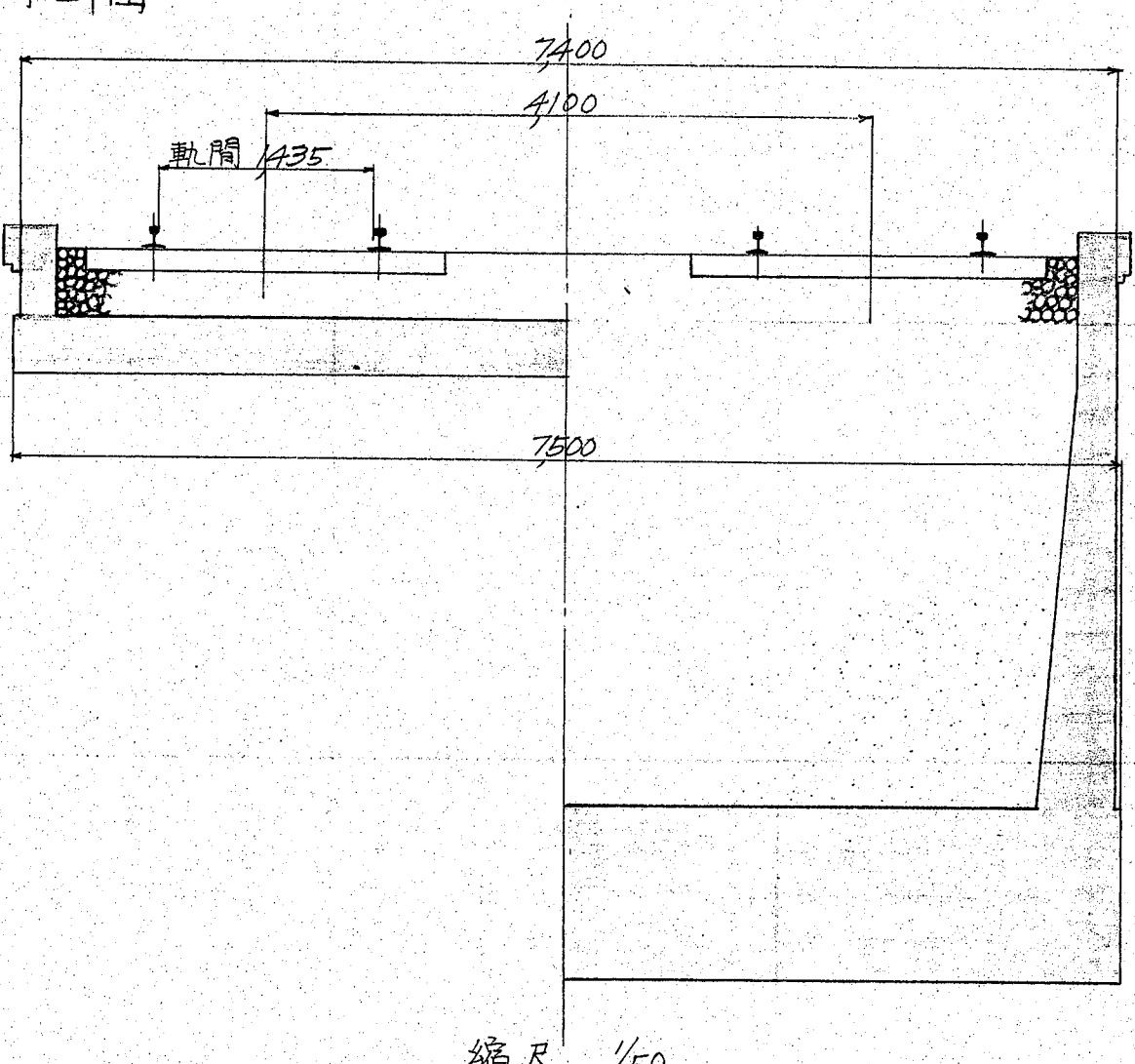
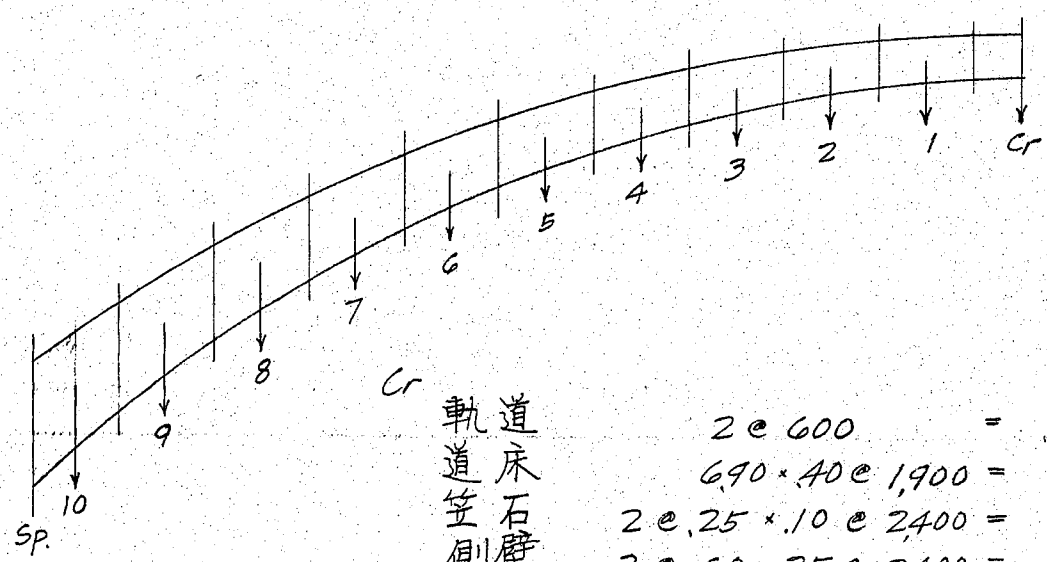
設計	日付	類別	C
照査	日付	第	/ 頁

上海地下鐵道鐵筋混凝土拱橋
複線電車軌道（60磅電車）
純徑間 15000 米， $l = 15.600\,m$， $h = 3.770\,m$， $t_0 = 0.40\,m$， $t_c = 0.80\,m$
橋梁斷面



縮尺 1/50

概算死荷重，計算



Cr

軌道	2 @ 600	= 1,200	
道床	6.90 × .40 @ 1,900	= 5,240	6,560
笠石	2 @ .25 × .10 @ 2,400	= 120	
側壁	2 @ .60 × .25 @ 2,400	= 720	
拱環	.40 × 7.50 @ 2,400	= 7,200	
		14,480 × 0.375 = 5,430 kg	

W1

軌道道床及笠石		= 6,560	
砂填充	6.90 × .035 @ 1,700	= 410	
側壁	2 @ .63 × .25 @ 2,400	= 760	
拱環	.405 × 7.5 @ 2,400	= 7,290	
		15,020 × 0.75 = 11,250 kg	

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上海地下鐵道鐵筋混凝土拱橋

W2
軌道道床及笠石 = 6,560
砂填充 6.90 × .12 @ 1,700 = 1,410
側壁 2@ .715 × .25 @ 2400 = 860
拱環 .42 × 7.5 @ 2,400 = 7,560
16,390 × 0.75 = 12,300 kg

W3
軌道道床及笠石 = 6,560
砂填充 6.90 × .253 @ 1,700 = 2,970
側壁 2@ .850 × .25 @ 2,400 = 1,020
拱環 .443 × 7.5 @ 2,400 = 7,970
18,520 × 0.75 = 13,880 kg

W4
軌道道床及笠石 = 6,560
砂填充 6.90 × .445 @ 1,700 = 5,220
側壁 2@ 1.04 × .25 @ 2400 = 1,250
拱環 .473 × 7.5 @ 2,400 = 8,520
21,550 × 0.75 = 16,150 kg

W5
軌道道床及笠石 = 6,560
砂填充 6.90 × .697 @ 1,700 = 8,170
側壁 2@ 1.29 × .25 @ 2,400 = 1,550
拱環 .515 × 7.5 @ 2,400 = 9,270
25,550 × 0.75 = 19,160 kg

W6
軌道道床及笠石 = 6,560
砂填充 6.90 × 1.015 @ 1,700 = 11,900
側壁 2@ 1.61 × .25 @ 2,400 = 1,930
拱環 .575 × 7.5 @ 2,400 = 10,350
30,740 × 0.75 = 23,020 kg

W7
軌道道床及笠石 = 6,560
砂填充 6.90 × 1.41 @ 1,700 = 16,530
側壁 2@ 2.01 × .25 @ 2,400 = 2,410
拱環 .655 × 7.5 @ 2,400 = 11,780
37,280 × 0.75 = 27,970 kg

W8
軌道道床及笠石 = 6,560
砂填充 6.90 × 1.88 @ 1,700 = 22,050
側壁 2@ 2.48 × .25 @ 2,400 = 2,980
拱環 .765 × 7.5 @ 2,400 = 13,770
45,360 × 0.75 = 34,020 kg

W9
軌道道床及笠石 = 6,560
砂填充 6.90 × 2.44 @ 1,700 = 28,600
側壁 2@ 3.04 × .25 @ 2,400 = 3,650
拱環 .93 × 7.5 @ 2,400 = 16,730
55,540 × 0.75 = 41,650 kg

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上海地下鐵道鐵筋混凝土拱橋

W10

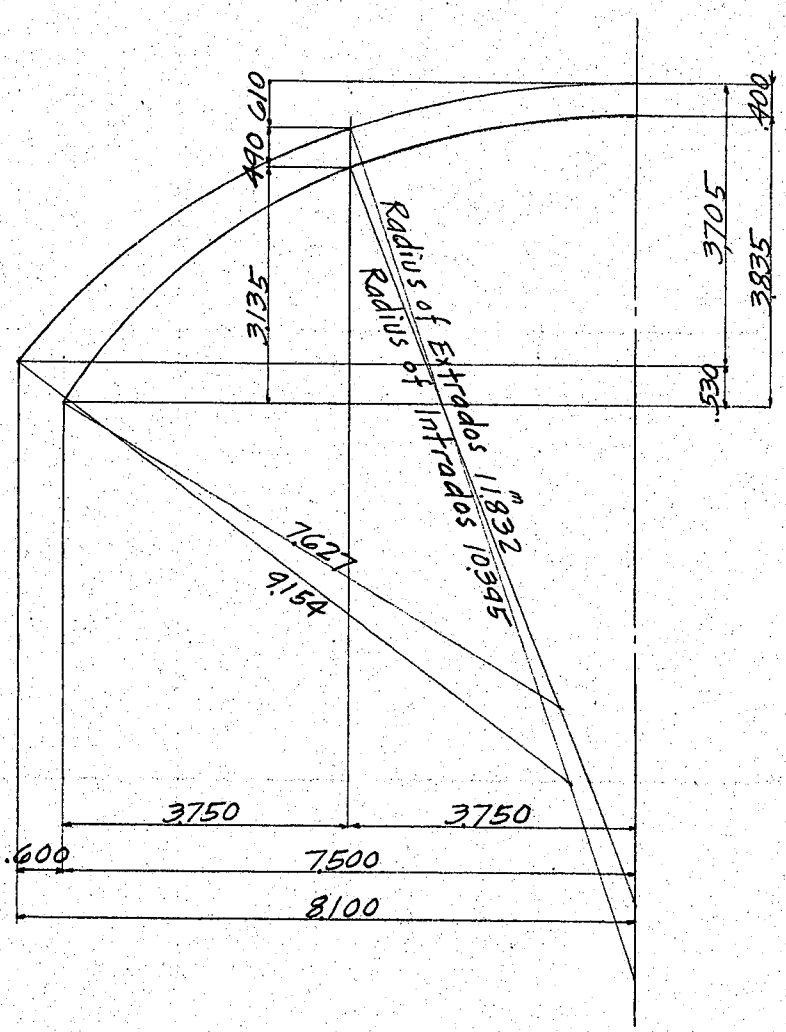
軌道道床及笠石 = 6,560
砂填充 6.90 × 2.75 @ 1,700 = 32,250
側壁 2 @ 3.35 × .25 @ 2,400 = 4,020
拱環 1.03 × 7.5 @ 2,400 = 18,530
61,360 × 0.375 = 23,000 kg

死荷重反力及拱頂並=起拱点ノ弯曲率ヲ0ト假定シタル場合ノ水平推力ノ概算

	荷重	距離	能率
Cr	5,430	7.800	42,350
W1	11,250	7.050	79,300
W2	12,300	6.300	77,500
W3	13,880	5.550	77,000
W4	16,150	4.800	77,500
W5	19,160	4.050	77,600
W6	23,020	3.300	76,000
W7	27,970	2.550	71,300
W8	34,020	1.800	61,200
W9	41,650	1.050	43,700
W10	23,000	.300	6,910
	227,830 kg		690,360 kgm

水平推力 690,360 ÷ 3.770 = 183,300 kg

拱環，寸法



鐵筋

拱頂 = 於テ ハ徑 19mm 鐵筋(斷面 2.84 cm²) ヲ 上下兩層 = 20 cm 間隔 = 使用
起拱点 = 於テ ハ徑 19mm 鐵筋 ヲ 上下兩層 = 20 cm 間隔 = 使用
其ノ他ノ点 = 於テ ハ徑 19mm 鐵筋 ヲ 上下兩層 = 40 cm 間隔 = 使用

拱頂	2.84 × 37 = 105.1 cm²	2 @ 105.1 = 210.2 cm²
起拱点	2.84 × 37 = 105.1 cm²	2 @ 105.1 = 210.2 cm²
其ノ他ノ点	2.84 × 19 = 54.0 cm²	2 @ 54.0 = 108.0 cm²

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上海地下鐵道鐵筋混凝土拱橋

混凝土，物量力率　$\frac{750d^3}{12} = 0.625d^3$

鐵筋，物量力率　$\frac{2102\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .3153\left(\frac{d}{2}-0.045\right)^2$　拱頂及起拱處

$\frac{1080\times15}{10000}\left(\frac{d}{2}-0.045\right)^2 = .1620\left(\frac{d}{2}-0.045\right)^2$　其，他，處

格處	d	d^3	$I_c=0.625d^3$	$\frac{d}{2}-0.045$	$\left(\frac{d}{2}-0.045\right)^2$		I_s	I_o	混凝土斷面
Cr	.400	.0640	.04000	0.155	0.0240	× .3153 =	0.00757	0.04757	3.000
1	.403	.0655	.04094	0.157	0.0246	〃	0.00776	0.04870	3.023
2	.410	.0689	.04306	0.160	0.0256	〃	0.00807	0.05113	3.075
3	.424	.0762	.04763	0.167	0.0279	× .1620	0.00452	0.05215	3.180
4	.442	.0864	.05400	0.176	0.0310	〃	0.00502	0.05902	3.315
5	.466	.1012	.06325	0.188	0.0353	〃	0.00572	0.06897	3.495
6	.497	.1213	.07581	0.204	0.0416	〃	0.00674	0.08255	3.728
7	.536	.1540	.09625	0.223	0.0497	〃	0.00805	0.10430	4.020
8	.585	.2002	.12513	0.248	0.0615	× .3153	0.01939	0.14452	4.388
9	.655	.2810	.17563	0.283	0.0801	〃	0.02526	0.20089	4.913
10	.750	.4219	.26369	0.330	0.1089	〃	0.03434	0.29803	5.625
Sp	.800	.5120	.32000	0.355	0.1260	〃	0.03973	0.35973	6.000

格處	x	x^2	y	y^2	d_s	I_o	$\frac{d_s}{I_o}$	$x\frac{d_s}{I_o}$	$x^2\frac{d_s}{I_o}$	$y\frac{d_s}{I_o}$	$y^2\frac{d_s}{I_o}$
Cr	0	0	0	0	.375	.04757	7.88	0	0	0	0
1	.750	.5625	.025	.0006	.755	.04870	15.50	11.63	8.72	.39	.01
2	1.500	2.250	.108	.0117	.760	.05113	14.86	22.29	33.44	1.60	.17
3	2.250	5.063	.230	.0529	.770	.05215	14.77	33.23	74.78	3.40	.78
4	3.000	9.000	.415	.1722	.780	.05902	13.22	39.66	118.98	5.49	2.28
5	3.750	14.063	.655	.4290	.800	.06897	11.60	43.50	163.13	7.60	4.98
6	4.500	20.250	.970	.9409	.830	.08255	10.05	45.23	203.51	9.75	9.46
7	5.250	27.563	1.365	1.8632	.880	.10430	8.44	44.31	232.63	11.52	15.73
8	6.000	36.000	1.875	3.5156	.960	.14452	6.64	39.84	239.04	12.45	23.34
9	6.750	45.563	2.510	6.3001	1.055	.20089	5.25	35.44	239.21	13.18	33.08
10	7.500	56.250	3.345	11.1890	.835	.29803	2.80	21.00	157.50	9.37	31.33
Sp	7.800	60.840	3.770	14.2129	.240	.35973	.67	5.23	40.76	2.53	9.52
							111.68	341.36	1511.70	77.28	130.68

	拱頂處					格處 1				格處 2			
格處	x	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$	m	$m\frac{d_s}{I_o}$	$mx\frac{d_s}{I_o}$	$my\frac{d_s}{I_o}$
Cr	0	0	0	0	0	0	0	0	0				
1	.750	.750	11.63	8.72	.29	0	0	0	0				
2	1.500	1.500	22.29	33.44	2.41	.750	11.15	16.72	1.20	0	0	0	0
3	2.250	2.250	33.23	74.78	7.64	1.500	22.16	49.85	5.10	.750	11.08	24.92	2.55
4	3.000	3.000	39.66	118.98	16.46	2.250	29.75	89.24	12.35	1.500	19.83	59.49	8.24
5	3.750	3.750	43.50	163.13	28.49	3.000	34.80	130.50	22.80	2.250	26.10	97.88	17.10
6	4.500	4.500	45.23	203.51	43.87	3.750	37.69	169.61	36.56	3.000	30.15	135.69	29.25
7	5.250	5.250	44.31	232.63	60.48	4.500	37.98	199.40	51.84	3.750	31.65	166.16	43.20
8	6.000	6.000	39.84	239.04	74.70	5.250	34.86	209.16	65.36	4.500	29.88	179.28	56.03
9	6.750	6.750	35.44	239.22	88.95	6.000	31.50	212.63	79.07	5.250	27.56	186.03	69.18
10	7.500	7.500	21.00	157.50	70.25	6.750	18.90	141.75	63.22	6.000	16.80	126.00	56.20
Sp	7.800	7.800	5.23	40.79	19.72	7.050	4.72	36.82	17.79	6.300	4.22	32.92	15.91
			341.36	1511.74	413.26		263.51	1255.68	355.29		197.27	1008.37	297.66

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上海地下鐵道鐵筋混凝土拱橋

格矣 3

格矣	x	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
4	3.000	.750	9.92	29.75	4.12	0	0	0	0
5	3.750	1.500	17.40	65.25	11.40	.750	8.70	32.63	5.70
6	4.500	2.250	22.61	101.77	21.94	1.500	15.08	67.85	14.63
7	5.250	3.000	25.32	132.93	34.56	2.250	18.99	99.70	25.92
8	6.000	3.750	24.90	149.40	46.69	3.000	19.92	119.52	37.35
9	6.750	4.500	23.63	159.50	59.31	3.750	19.69	132.91	49.42
10	7.500	5.250	14.70	110.25	49.17	4.500	12.60	94.50	42.15
Sp	7.800	5.550	3.72	29.02	14.02	4.800	3.22	25.12	12.14
			142.20	777.87	241.21		98.20	572.23	187.31

格矣	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
4.050	0	0	0	0
	.750	2.71	21.14	10.22
		64.10	396.23	137.47

格矣 6

格矣	x	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
7	5.250	.750	6.33	33.23	8.64	0	0	0	0
8	6.000	1.500	9.96	59.76	18.68	.750	4.98	29.88	9.34
9	6.750	2.250	11.81	79.72	29.64	1.500	7.88	53.19	19.78
10	7.500	3.000	8.40	63.00	28.10	2.250	6.30	47.25	21.07
Sp.	7.800	3.300	2.21	17.24	8.33	2.550	1.71	13.34	6.45
			38.71	252.95	93.39		20.87	143.66	56.64

格矣	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
7	0	0	0	0
8	.750	3.94	26.60	9.89
9	1.500	4.20	31.50	14.05
10	1.800	1.21	9.44	4.56
		9.35	67.54	28.50

格矣 9

格矣	x	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$	m	$m\frac{ds}{I_0}$	$mx\frac{ds}{I_0}$	$my\frac{ds}{I_0}$
10	7.500	.750	2.10	15.75	7.02	0	0	0	0
Sp	7.800	1.050	.70	5.46	2.64	.300	.20	1.56	.75
			2.80	21.21	9.66		.20	1.56	.75

拱頂矣推力 $H_0=\frac{\int\frac{ds}{I_0}\int my\frac{ds}{I_0}-\int m\frac{ds}{I_0}\int y\frac{ds}{I_0}}{2\left[\int\frac{ds}{I_0}\int y^2\frac{ds}{I_0}-\left(\int y\frac{ds}{I_0}\right)^2\right]}=\frac{A}{B}$　　$B=2\times 8622.14=17,244.28$

荷重矣

							A		B		H_0
Cr	111.68	×	413.26	=	46,152.88	−	341.36 × 77.28	=	26,380.30	19,772.58	÷ 17,244.28	=	1.147
1	〃		355.29	=	39,678.79	−	263.51	〃	20,364.05	19,314.74	〃	=	1.120
2	〃		297.66	=	33,242.67	−	197.27	〃	15,245.03	17,997.64	〃	=	1.044
3	〃		241.21	=	26,938.33	−	142.20	〃	10,989.22	15,949.11	〃	=	.925
4	〃		187.31	=	20,918.78	−	98.20	〃	7,588.40	13,329.88	〃	=	.773
5	〃		137.47	=	15,352.65	−	64.10	〃	4,953.65	10,399.00	〃	=	.603
6	〃		93.39	=	10,429.80	−	38.71	〃	2,991.51	7,438.29	〃	=	.431
7	〃		56.64	=	6,325.56	−	20.87	〃	1,612.83	4,712.73	〃	=	.273
8	〃		28.50	=	3,182.88	−	9.35	〃	722.57	2,460.31	〃	=	.143
9	〃		9.66	=	1,078.83	−	2.80	〃	216.38	862.45	〃	=	.050
10	〃		.75	=	83.76	−	.20	〃	15.46	68.30	〃	=	.004

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上海地下鐵道鐵筋混凝土拱橋

拱頂点弯曲率 $M_0 = \dfrac{-H_0 2\int y\frac{ds}{I_0} + \int m\frac{ds}{I_0}}{2\int\frac{ds}{I_0}} = \dfrac{C}{D}$　　$D = 2 \times 111.68 = 223.36$

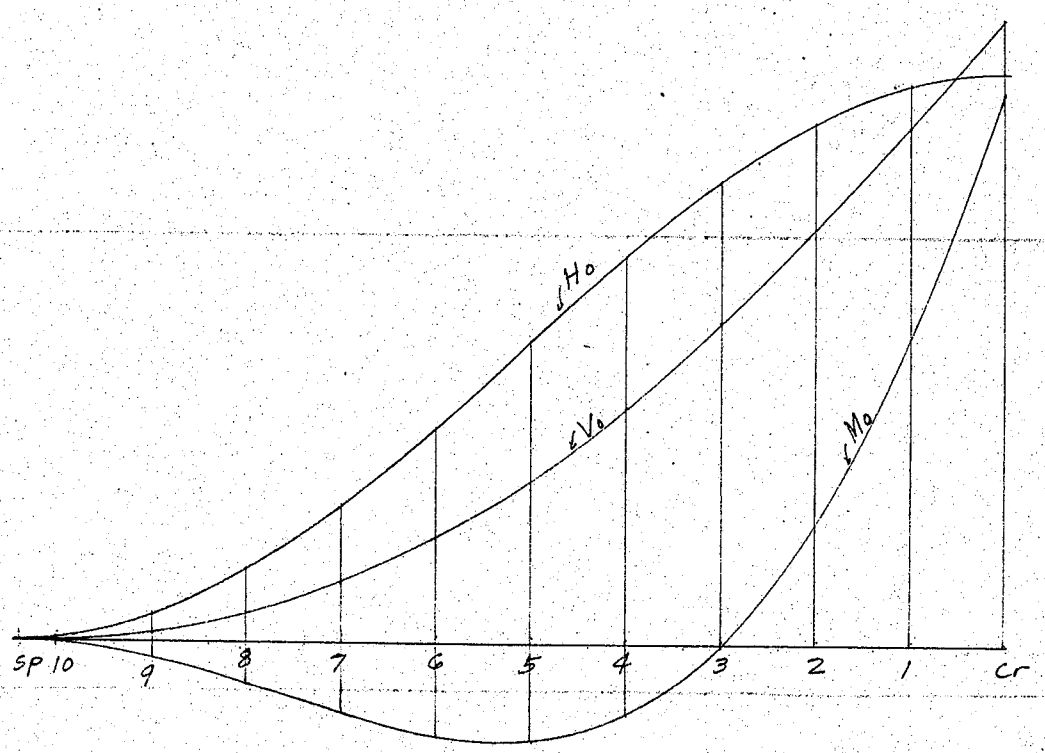
荷重点

						C		D		M_0
Cr	− 2 × 1.147	× 77.28	=	− 177.28	+ 341.36	=	164.08	÷ 223.36	=	.7346
1	1.120	〃	=	− 173.11	+ 263.51	=	90.40	〃	=	.4047
2	1.044	〃	=	− 161.36	+ 197.27	=	35.91	〃	=	.1608
3	.925	〃	=	− 142.97	+ 142.20	=	− 0.77	〃	=	−.0034
4	.773	〃	=	− 119.47	+ 98.20	=	−21.27	〃	=	−.0952
5	.603	〃	=	− 93.20	+ 64.10	=	−29.10	〃	=	−.1303
6	.431	〃	=	− 66.62	+ 38.71	=	−27.91	〃	=	−.1250
7	.273	〃	=	− 42.19	+ 20.87	=	−21.32	〃	=	−.0955
8	.143	〃	=	− 22.10	+ 9.35	=	−12.75	〃	=	−.0571
9	.050	〃	=	− 7.73	+ 2.80	=	− 4.93	〃	=	−.0221
10	.004	〃	=	− .62	+ .20	=	− .42	〃	=	−.0019

拱頂点剪力 $V_0 = \dfrac{\int mx\frac{ds}{I_0}}{2\int x^2\frac{ds}{I_0}} = \dfrac{E}{F}$

荷重点	E		F		V_0	$1-V_0$
Cr	1511.74	÷	3023.40	=	.5000	.5000
1	1255.68		〃	=	.4153	.5847
2	1008.37		〃	=	.3335	.6665
3	777.87		〃	=	.2573	.7427
4	572.23		〃	=	.1893	.8107
5	396.23		〃	=	.1311	.8689
6	252.95		〃	=	.0837	.9163
7	143.66		〃	=	.0475	.9525
8	67.54		〃	=	.0223	.9777
9	21.21		〃	=	.0070	.9930
10	1.56		〃	=	.0005	.9995

拱頂＝於ケル水平推力，弯曲率及剪力ノ影響線



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上海地下鐵道鐵筋混凝土拱橋
格点ノ單位荷重ニヨル彎曲率

左半分ノ彎曲率　$M_L = M_0 + H_0 y + V_0 x - d'$
右半分ノ彎曲率　$M_R = M_0 + H_0 y - V_0 x$

起拱点　$x = 7.800,\ y = .3770$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	.7346	.43242	3.9000	7.800	1.1588	1.1588
1	.4047	.42224	3.2393	7.050	.8164	1.3878
2	.1608	.39359	2.6013	6.300	.3980	1.4954
3	-.0034	.34873	2.0069	5.550	-.0592	1.4770
4	-.0952	.29142	1.4765	4.800	-.5045	1.3425
5	-.1303	.22733	1.0226	4.050	-.8844	1.1204
6	-.1250	.16249	.6529	3.300	-1.1472	.8470
7	-.0955	.10292	.3705	2.550	-1.2458	.5632
8	-.0571	.05391	.1739	1.800	-1.1441	.3081
9	-.0221	.01885	.0546	1.050	-.8290	.1118
10	-.0019	.00151	.0039	.300	-.2829	.0093
Sp	0	0	0	0	0	0

格点 10　$x = 7.500,\ y = .3345$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	.7346	.38367	3.7500	7.500	.8213	.8213
1	.4047	.37464	3.1148	6.750	.5159	1.0363
2	.1608	.34922	2.5013	6.000	.1543	1.1517
3	-.0034	.30941	1.9298	5.250	-.2295	1.1609
4	-.0952	.25857	1.4198	4.500	-.5897	1.0707
5	-.1303	.20170	.9833	3.750	-.8800	.9034
6	-.1250	.14417	.6278	3.000	-1.0555	.6889
7	-.0955	.09132	.3563	2.250	-1.0760	.4614
8	-.0571	.04783	.1673	1.500	-.9115	.2539
9	-.0221	.01673	.0525	.750	-.5523	.0927
10	-.0019	.00134	.0038	0	.0153	.0077
Sp	0	0	0		0	0

格点 8　$x = 6.000,\ y = 1.875$

格点	M_0	$H_0 y$	$V_0 x$	d'	M_L	M_R
Cr	.7346	2.1506	3.0000	6.000	-.1148	-.1148
1	.4047	2.1000	2.4918	5.250	-.2535	.0129
2	.1608	1.9575	2.0010	4.500	-.3807	.1173
3	-.0034	1.7344	1.5438	3.750	-.4752	.1872
4	-.0952	1.4494	1.1358	3.000	-.5100	.2184
5	-.1303	1.1306	.7866	2.250	-.4631	.2137
6	-.1250	.8081	.5022	1.500	-.3147	.1809
7	-.0955	.5119	.2850	.750	-.0486	.1314
8	-.0571	.2681	.1338	0	.3448	.0772
9	-.0221	.0938	.0420		.1137	.0297
10	-.0019	.0075	.0030		.0086	.0026
Sp	0	0	0		0	0

増田橋梁建築設計事務所

東京市品川區五反田五ノ一〇八
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設計	日付	類別	C
照査	日付	第	8 頁

上海地下鐵道鐵筋混凝土拱橋

格点 6　　x = 4.500,　y = .970

格点	Mo	Hoy	Vox	d'	ML	MR
Cr	.7346	1.1126	2.2500	4.500	-.4028	-.4028
1	.4047	1.0864	1.8689	3.750	-.3900	-.3778
2	.1608	1.0127	1.5008	3.000	-.3257	-.3273
3	-.0034	.8973	1.1579	2.250	-.1982	-.2640
4	-.0952	.7498	.8519	1.500	.0065	-.1973
5	-.1303	.5849	.5900	.750	.2946	-.1354
6	-.1250	.4181	.3767	0	.6698	-.0836
7	-.0955	.2648	.2138		.3831	-.0445
8	-.0571	.1387	.1004		.1820	-.0188
9	-.0221	.0485	.0315		.0579	-.0051
10	-.0019	.0039	.0022		.0042	-.0002
Sp	0	0	0		0	0

格点 4　　x = 3.000,　y = .415

格点	Mo	Hoy	Vox	d'	ML	MR
Cr	.7346	.4760	1.5000	3.000	-.2894	-.2894
1	.4047	.4648	1.2459	2.250	-.1346	-.3764
2	.1608	.4333	1.0005	1.500	.0946	-.4064
3	-.0034	.3839	.7719	.750	.4024	-.3914
4	-.0952	.3208	.5679	0	.7935	-.3423
5	-.1303	.2502	.3933		.5132	-.2734
6	-.1250	.1789	.2511		.3050	-.1972
7	-.0955	.1133	.1425		.1603	-.1247
8	-.0571	.0593	.0669		.0691	-.0647
9	-.0221	.0208	.0210		.0197	-.0223
10	-.0019	.0017	.0015		.0013	-.0017
Sp	0	0	0		0	0

格点 2　　x = 1.500　　y = .108

格点	Mo	Hoy	Vox	d'	ML	MR
Cr	.7346	.1239	.7500	1.500	.1085	.1085
1	.4047	.1210	.6230	.750	.3987	-.0973
2	.1608	.1128	.5003	0	.7739	-.2267
3	-.0034	.0999	.3860		.4825	-.2895
4	-.0952	.0835	.2840		.2723	-.2957
5	-.1303	.0651	.1967		.1315	-.2619
6	-.1250	.0465	.1256		.0471	-.2041
7	-.0955	.0295	.0713		.0053	-.1373
8	-.0571	.0154	.0335		-.0082	-.0752
9	-.0221	.0054	.0105		-.0062	-.0272
10	-.0019	.0004	.0008		-.0007	-.0023
Sp	0	0	0		0	0

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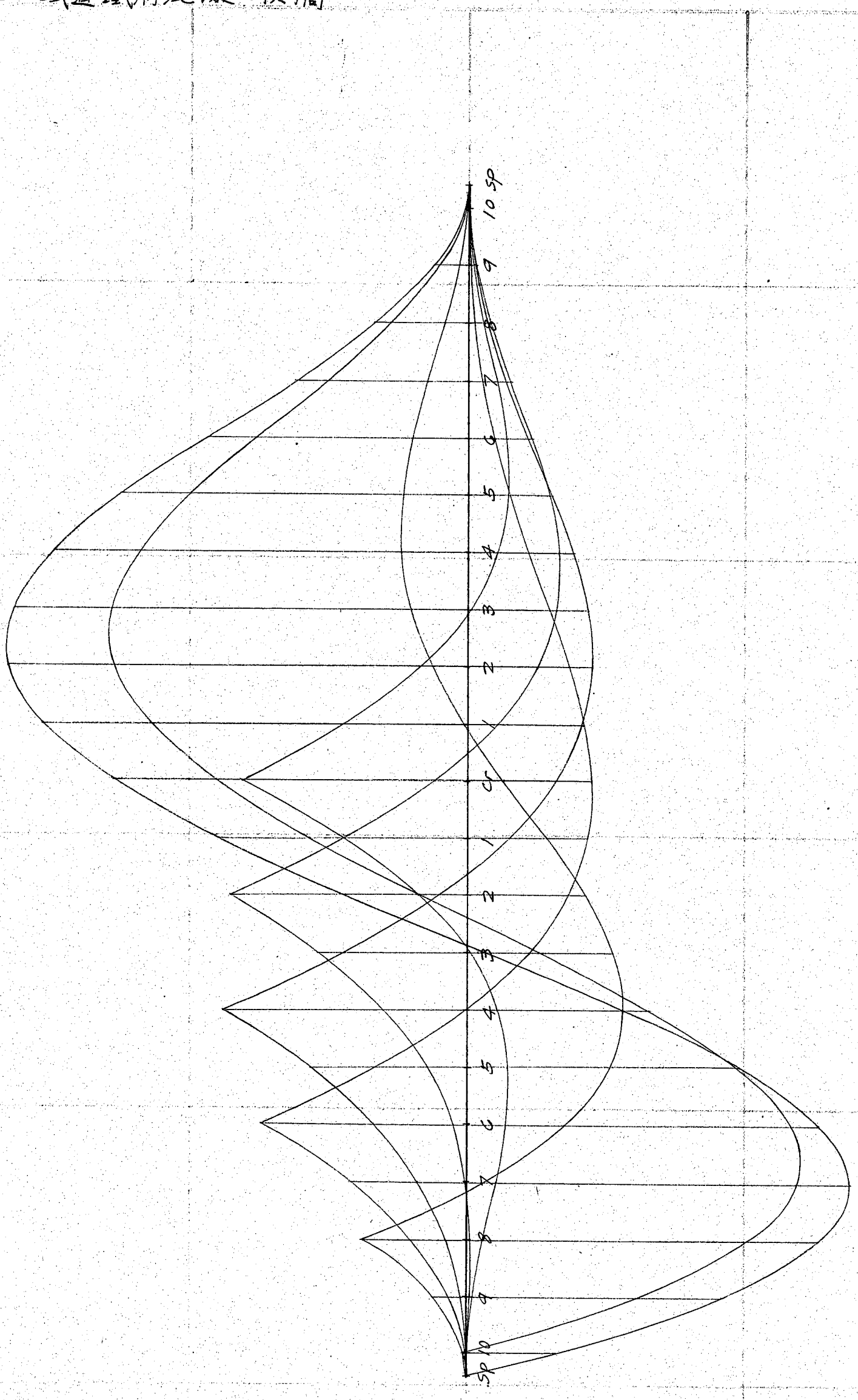
設計　日付　類別　C

照査　日付　第　9　頁

上海地下鐵道鐵筋混凝土拱橋



縮尺　距離　1/60
彎曲率　1cm = 0.15

増田橋梁建築設計事務所

東京市品川區五反田五ノ一〇八
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設計	日付	類別 C
照査	日付	第 10頁

上海地下鐵道鐵筋混凝土拱橋

格矣，死荷重彎曲率

拱頂

格矣	荷重	M_0	M
Cr	5,430	0.7346	3,990
1	11,250	.4047	4,550
2	12,300	.1608	1,980
3	13,880	-.0034	- 47
4	16,150	-.0952	- 1,537
5	19,160	-.1303	- 2,500
6	23,020	-.1250	- 2,878
7	27,970	-.0955	- 2,670
8	34,020	-.0571	- 1,942
9	41,650	-.0221	- 920
10	23,000	-.0019	- 44
			10,520
			-12,538
			-2,018 × 2 = -4,036 kgm

格矣	格矣 2		M_2	格矣 4		M_4	格矣 6		M_6	格矣 8		M_8
10^L	23,000	-.0007	- 16	.0013	30	.0042	97	.0086	198
9	41,650	-.0062	-258	.0197	820	.0579	2,410	.1137	4,735
8	34,020	-.0082	-279	.0691	2,350	.1820	6,183	.3448	11,720
7	27,970	.0053	148	.1603	4,472	.3831	10,720	-.0486	- 1,358
6	23,020	.0471	1,084	.3050	7,020	.6698	15,400	-.3147	- 7,230
5	19,160	.1315	2,520	.5132	9,830	.2946	5,640	-.4631	- 8,870
4	16,150	.2723	4,400	.7935	12,800	.0065	105	-.5100	- 8,230
3	13,880	.4825	6,700	.4024	5,590	-.1982	-2,752	-.4752	- 6,600
2	12,300	.7739	9,510	.0946	1,163	-.3257	-4,005	-.3807	- 4,680
1	11,250	.3987	4,485	-.1346	-1,515	-.3900	-4,387	-.2535	- 2,850
Cr	10,860	.1085	1,177	-.2894	-3,143	-.4028	-4,373	-.1148	- 1,247
1	11,250	-.0973	-1,095	-.3764	-4235	-.3778	-4,250	.0129	145
2	12,300	-.2267	-2787	-.4064	-5,000	-.3273	-4,027	.1173	1,443
3	13,880	-.2895	-4,020	-.3914	-5,440	-.2640	-3,663	.1872	2,598
4	16,150	-.2957	-4,773	-.3423	-5530	-.1973	-3,188	.2184	3,530
5	19,160	-.2619	-5,020	-.2734	-5,240	-.1354	-2,595	.2137	4,090
6	23,020	-.2041	-4,695	-.1972	-4,535	-.0836	-1,922	.1809	4,160
7	27,970	-.1373	-3,840	-.1247	-3,513	-.0445	-1,244	.1314	3,670
8	34,020	-.0752	-2,557	-.0647	-2,200	-.0188	- 639	.0772	2,623
9	41,650	-.0272	-1,134	-.0223	- 929	-.0051	- 212	.0297	1,237
10^R	23,000	-.0023	- 53	-.0017	- 39	-.0002	- 5	.0026	60
			-30527		44,075		40,555		40,209
			30,024		-41,319		-37,262		-41,065
			- 503 kgm		2,756 kgm		3,293 kgm		- 856 kgm

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設計	日付	類別	C
照査	日付	第	11頁

上海地下鐵道鐵筋混凝土拱橋

格点 10　　起拱点

格点			Mi0		
10L	23,000	.0153	352	-.2829	-6,505
9	41,650	-.5523	-23,000	-.8290	-34,530
8	34,020	-.9115	-31,000	-1.1441	-38,900
7	27,970	-1.0760	-30,080	-1.2458	-34,830
6	23,020	-1.0555	-24,270	-1.1472	-26,400
5	19,160	-.8800	-16,860	-.8844	-16,950
4	16,150	-.5897	-9,520	-.5045	-8,150
3	13,880	-.2295	-3,186	-.0592	-822
2	12,300	.1543	1,898	.3980	4,895
1	11,250	.5159	5,800	.8164	9,190
Cr	10,860	.8213	8,920	1.1588	12,580
1	11,250	1.0363	11,650	1.3878	15,600
2	12,300	1.1517	14,150	1.4954	18,400
3	13,880	1.1609	16,120	1.4770	20,500
4	16,150	1.0707	17,280	1.3425	21,680
5	19,160	.9034	17,300	1.1204	21,460
6	23,020	.6889	15,860	.8470	19,480
7	27,970	.4614	12,900	.5632	15,730
8	34,020	.2539	8,638	.3081	10,480
9	41,650	.0927	3,860	.1118	4,660
10R	23,000	.0077	177	.0093	214
			134,905		-167,087
			-137,916		174,869
			-3,011 Kgm		7,782 Kgm

死荷重推力

格点	荷重	H。	H	水平推力ニヨル軸推力		垂直剪力ニヨル軸推力	總計
Cr	5,430	1.147	6,225	186,230 × 1.000 = 186,230	0 × 0.000 =	0	186,230
1	11,250	1.120	12,600				
2	12,300	1.044	12,830	× .992 = 184,800	22,830 × 0.135 =	3,080	187,880
3	13,880	.925	12,840				
4	16,150	.773	12,480	× .963 = 179,300	50,935 × 0.271 =	13,800	193,100
5	19,160	.603	11,560				
6	23,020	.431	9,920	× .903 = 168,200	89,680 × 0.428 =	38,400	206,600
7	27,970	.273	7,630				
8	34,020	.143	4,860	× .792 = 147,500	146,170 × 0.607 =	88,700	236,200
9	41,650	.050	2,080				
10	23,000	.004	90	× .618 = 115,200	216,330 × 0.784 =	169,600	284,800
Sp				× .590 = 109,900	227,830 × 0.807 =	183,800	293,700
	227,830		93,115				
			× 2				
			186,230 kg				

増田橋梁建築設計事務所
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設計　日付　類別 C
照査　日付　第 12 頁

上海地下鐵道鐵筋混凝土拱橋

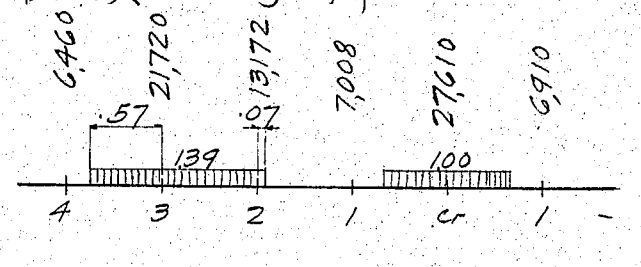
活荷重應力

電車輪荷重
衝撃荷重　$i = \frac{25}{50+15.60} = 0.381$

30,000
11,430
41,430 kg

特殊荷重　3300 kg

拱頂　正彎曲率



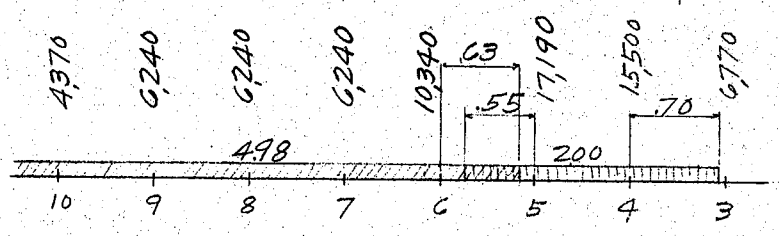
41,430 × 0.5 × $\frac{.25}{.75}$ = 6,910
41,430 ÷ 1.39 = 29,830
29,830 × .07 = 2,090
2,090 × $\frac{.035}{.75}$ = 98

29,830 × 0.375 = 11,180
29,830 × 0.57 = 17,000
17,000 × $\frac{.285}{.75}$ = 6,460

格点		Mu	M	Ho	H
4	6,460	-.0952	-615	.773	4,990
3	21,720	-.0034	- 74	.925	20,100
2	13,172	.1608	2,118	1.044	13,750
1	7,008	.4047	2836	1.120	7,850
cr	27,610	.7346	20,300	1.147	31,650
1	6,910	.4047	2795	1.120	7740
			27,360 kgm		86,080 kg

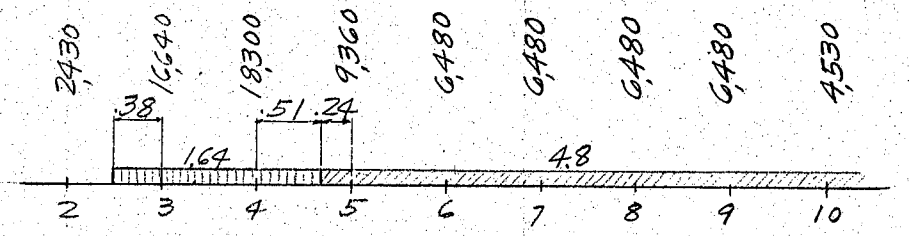
特殊荷重
M = 27,360 × 1.1 = 30,100 kgm
H = 86,080 × 1.1 = 94,700 kg

拱頂　負彎曲率



41,430 ÷ 2.00 = 20,715
20,715 × 0.70 = 14,500
14,500 × $\frac{.35}{.75}$ = 6,770
20,715 × 0.375 = 7,770

20,715 × .55 = 11,400
11,400 × $\frac{.275}{.75}$ = 4,180
41,430 ÷ 4.98 = 8,320
8,320 × .63 = 5,240
5,240 × $\frac{.315}{.75}$ = 2,200



8,320 × 0.375 = 3,120
8,320 × 0.525 = 4,370
41,430 ÷ 1.64 = 25,270
25,270 × 0.38 = 9,600
9,600 × $\frac{.19}{.75}$ = 2,430

25,270 × 0.375 = 9,470
25,270 × 0.51 = 12,880
12,880 × $\frac{.495}{.75}$ = 8,500
41,430 ÷ 4.8 = 8,630
8,630 × 0.24 = 2,070
2,070 × $\frac{.12}{.75}$ = 330

8,630 × .375 = 3,240
8,630 × .525 = 4,530

格点		Mu	M	Ho	H
10L	4,370	-.0019	- 8	.004	17
9	6,240	-.0221	-138	.050	312
8	6,240	-.0571	-356	.143	892
7	6,240	-.0955	-596	.273	1,703
6	10,340	-.1250	-1,292	.431	4460
5	17,190	-.1303	-2240	.603	10,370
4	15,500	-.0952	-1,475	.773	11,980
3	6,770	-.0034	- 23	.925	6,260
2'	2430	.1608	391	1.044	2537
3	16,640	-.0034	- 57	.925	15,380
4	18,300	-.0952	-1,742	.773	14,150
5	9,360	-.1303	-1,220	.603	5,645
6	6,480	-.1250	- 810	.431	2,793
7	6,480	-.0955	- 619	.273	1,770
8	6,480	-.0571	- 370	.143	926
9	6,480	-.0221	- 143	.050	312
10R	4,530	-.0019	- 9	.004	18
			-10,707 kgm		79,525 kg

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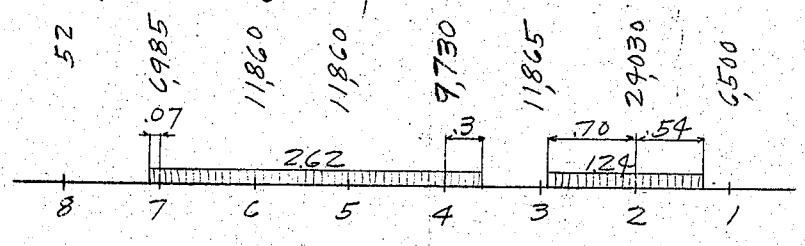
設計　日付　類別 C
照査　日付　第 13 頁

上海地下鐵道鐵筋混凝土拱橋

格点 2　正彎曲率



41,430 ÷ 2.62 = 15,820
15,820 ÷ .07 = 1,107
1,107 × .035/.75 = 52
15,820 × .0375 = 5,930
15,820 × .03 = 4,745
4,745 × .60/.75 = 3,800

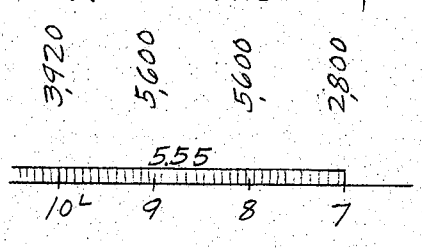
41,430 ÷ 1.24 = 33,430
33,430 × .07 = 23,400
23,400 × .35/.75 = 10,920
33,430 × .54 = 18,050
18,050 × .27/.75 = 6,500

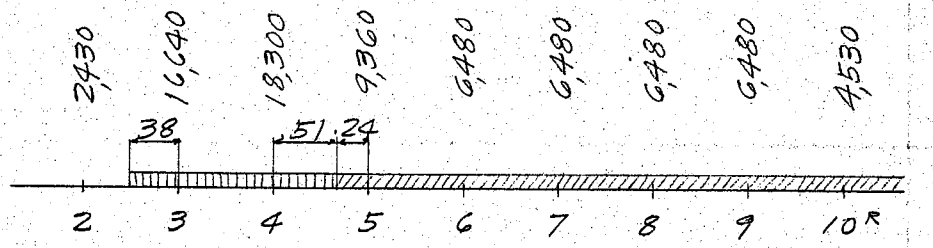
格点		Mu	M	Ho	H	Vo	V
8	52	-.0082	—	.143	7	-.0223	- 1
7	6,985	.0053	37	.273	1,907	-.0475	- 332
6	11,860	.0471	559	.431	5,110	-.0837	- 992
5	11,860	.1315	1,560	.603	7,150	-.1311	-1,555
4	9,730	.2723	2,650	.773	7,520	-.1893	-1,842
3	11,865	.4825	5,720	.925	10,970	-.2573	-3,055
2	24,030	.7739	18,600	1.044	25,100	.6665	16,020
1	6,500	.3987	2,590	1.120	7,280	.5847	3,800
			31,716 kgm		65,044 kg		12,043 kg

軸推力
65,044 × .992 = 64,500
12,043 × .135 = 1,625
N = 66,125 kg

特殊荷重
M = 31,716 × 1.1 = 34,870 kgm
H = 65,044 × 1.1 = 71,600 kg
N = 66,125 × 1.1 = 72,700 kg

格点 2　負彎曲率





41,430 ÷ 5.55 = 7,470
7,470 × 0.375 = 2,800
7,470 × 0.525 = 3,920

格点		Mu	M	Ho	H	Vo	V
10L	3,920	-.0007	- 3				
9	5,600	-.0062	-35				
8	5,600	-.0082	-46				
7	2,800	.0053	15				
2	2,430	-.2267	- 551	1.044	2,537	.3335	810
3	16,640	-.2895	-4,815	.925	15,380	.2573	4,283
4	18,300	-.2957	-5,410	.773	14,140	.1893	3,460
5	9,360	-.2619	-2,450	.603	5,645	.1311	1,227
6	6,480	-.2041	- 1,323	.431	2,793	.0837	542
7	6,480	-.1373	- 890	.273	1,770	.0475	308
8	6,480	-.0752	- 487	.143	927	.0223	145
9	6,480	-.0272	- 176	.050	324	.0070	45
10R	4,530	-.0023	- 10	.004	18	.0005	2
			-16,181 kgm		43,534 kg		10,822 kg

-16,112 kgm

特殊荷重
M = -16,181 × 1.1 = -17,800 kgm
H = 43,534 × 1.1 = 47,900 kg
V = 10,822 × 1.1 = 11,900 kg
47,900 × .992 = 47,500
11,900 × .135 = 1,610
N = 49,110 kg

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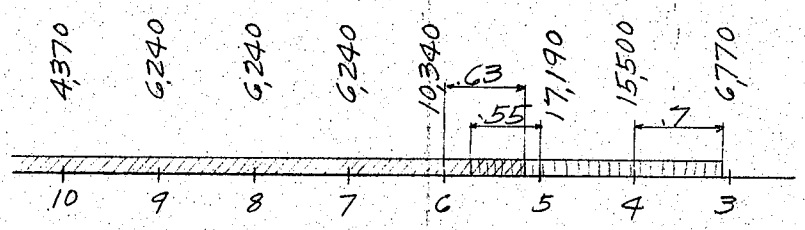
設計　日付　類別 C

照査　日付　第 14 頁

上海地下鐵道鐵筋混凝土拱橋

格点4　正彎曲率

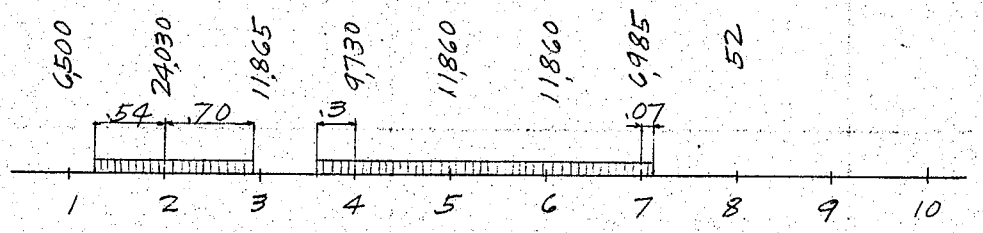


格点		Mu	M	Ho	H	Vo	V
10'	4,370	.0013	6	.004	17	-.0005	- 2
9	6,240	.0197	123	.050	312	-.0070	- 44
8	6,240	.0691	431	.143	892	-.0223	-139
7	6,240	.1603	1,000	.273	1,703	-.0475	-297
6	10,340	.3050	3,152	.431	4,455	-.0837	-866
5	17,190	.5132	8,820	.603	10,360	-.1311	-2,253
4	15,500	.7935	12,300	.773	11,980	.8107	12,570
3	6,770	.4024	2,725	.925	6,260	.7427	5,030
			28,557 Kgm		35,979 Kg		13,999 Kg

軸推力　35,979 × .963 = 34,650
13,999 × .271 = 3,790
N = 38,440 Kg

特殊荷重　M = 28,557 × 1.1 = 31,400 Kgm
H = 35,979 × 1.1 = 39,550 Kg
N = 38,440 × 1.1 = 42,300 Kg

格点4　負彎曲率



格点		Mu	M	Ho	H	Vo	V
1	6,500	-.3764	-2,447	1,120	7,280	.4153	2,700
2	24,030	-.4064	-9,770	1,044	25,100	.3335	8,020
3	11,865	-.3914	-4,645	.925	10,970	.2573	3,055
4	9,730	-.3423	-3,332	.773	7,520	.1893	1,840
5	11,860	-.2734	-3,242	.603	7,150	.1311	1,555
6	11,860	-.1972	-2,340	.431	5,110	.0837	993
7	6,985	-.1247	- 871	.273	1,910	.0475	332
8	52	-.0647	- 3	.143	10	.0223	1
			-26,650 Kgm		65,050 Kg		18,496 Kg

軸推力　65,050 × .963 = 62,700
18,496 × .271 = 5,010
67,710 Kg

特殊荷重　M = -26,650 × 1.1 = -29320 Kgm
H = 65,050 × 1.1 = 71,600 Kg
N = 67,710 × 1.1 = 74,500 Kg

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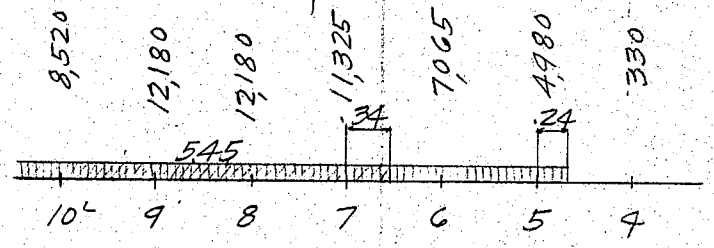
上海地下鐵道鐵筋混凝土拱橋
格点 6　正弯曲率



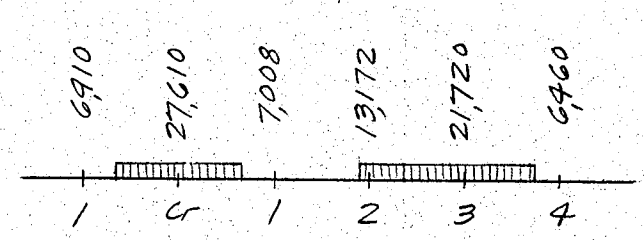
41,430 ÷ 545 = 7,600　　7,600 × 0.375 = 2,850
7,600 × 0.34 = 2,580　　7,600 × 0.525 = 3,990
2,580 × 17/75 = 585

格点		Mu	M	Ho	H	Vo	V
10	8,520	.0042	36	.004	34	-.0005	-4
9	12,180	.0579	706	.050	609	-.0070	-85
8	12,180	.1820	2,220	.143	1,742	-.0223	-272
7	11,325	.3831	4,340	.273	3,092	-.0475	-538
6	7,065	.6698	4,730	.431	3,045	.9163	6,000
5	4,980	.2946	1,353	.603	2,770	.8689	4,330
4	330	.0065	2	.773	255	.8107	268
			13,387 Kgm		11,547 Kg		9,699 Kg

軸推力　11,547 × .903 = 10,420
9,699 × .428 = 4,150
N = 14,570 Kg

特殊荷重　M = 13,387 × 1.1 = 14,720 Kgm
H = 11,547 × 1.1 = 12,700 Kg
N = 14,570 × 1.1 = 16,020 Kg

格点 6　負弯曲率



格点		Mu	M	Ho	H	Vo	V
1	6,910	-.3900	-2,695	1,120	7,740	.5847	4,040
Cr	27,610	-.4028	-11,120	1,147	31,650	.5000	13,800
1	7,008	-.3778	-2,648	1,120	7,850	.4153	2,912
2	13,172	-.3273	-4,312	1,044	13,740	.3335	4,392
3	21,720	-.2640	-5,735	.925	20,100	.2573	5,590
4	6,460	-.1973	-1,275	.773	5,000	.1893	1,223
			-27,785 Kgm		86,080 Kg		31,957 Kg

軸推力　86,080 × .903 = 77,700
31,957 × .428 = 13,670
N = 91,370 Kg

特殊荷重　M = -27,785 × 1.1 = -30,550 Kgm
H = 86,080 × 1.1 = 94,700 Kg
N = 91,370 × 1.1 = 100,500 Kg

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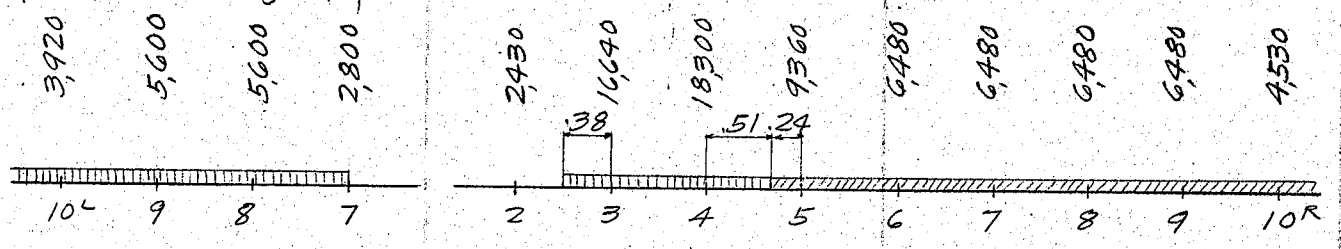
上海地下鐵道鐵筋混凝土拱橋

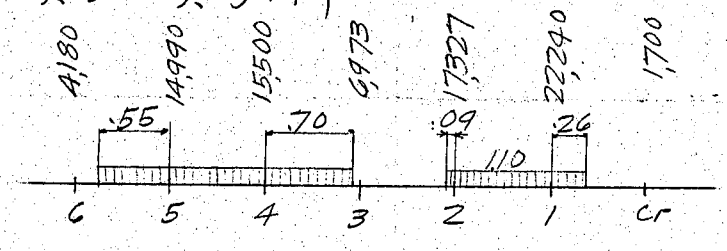
格点8　正弯曲率



格点		Mu	M	Ho	H	Vo	V
10L	3,920	.0086	34	.004	16	-.0005	-2
9	5,600	.1137	636	.050	280	-.0070	-39
8	5,600	.3448	1,930	.143	801	.9777	5,470
7	2,800	-.0486	-136	.273	764	.9525	2,668
2	2,430	.1173	285	1.044	2,537	.3335	810
3	16,640	.1872	3,115	.925	15,380	.2573	4,285
4	18,300	.2184	4,000	.773	14,150	.1893	3,465
5	9,360	.2137	2,000	.603	5,640	.1311	1,227
6	6,480	.1809	1,172	.431	2,793	.0837	542
7	6,480	.1314	852	.273	1,769	.0475	308
8	6,480	.0772	462	.143	855	.0223	133
9	6,480	.0297	192	.050	324	.0070	45
10R	4,530	.0026	12	.004	18	.0005	2
			14,554 kgm		45,327 kg		18,914 kg

軸推力　45,327 × .792 = 35,900
18,914 × .607 = 11,480
N = 47,380 kg

格点8　負弯曲率



41,430 ÷ 1.10 = 37,700
37,700 × .09 = 3,390
3,390 × .045/.75 = 203
37,700 × .0375 = 14,140
37,700 × .026 = 9,800
9,800 × .13/.75 = 1,700

格点		Mu	M	Ho	H	Vo	V
6	4,180	-.3147	-1,314	.431	1,800	.9163	3,830
5	14,990	-.4631	-6,940	.603	9,040	.8689	13,030
4	15,500	-.5100	-7,900	.773	11,980	.8107	12,570
3	6,973	-.4752	-3,312	.925	6,450	.7427	5,180
2	17,327	-.3807	-6,590	1.044	11,080	.6665	11,550
1	22,240	-.2535	-5,640	1.120	24,920	.5847	13,000
Cr	1,700	-.1148	-195	1.147	1,950	.5000	850
			-31,891 kgm		67,220 kg		60,010 kg

軸推力　67,220 × .792 = 53,250
60,010 × .607 = 36,420
89,670 kg

特殊荷重　M = -31,891 × 1.1 = -35,080 kgm
H = 67,220 × 1.1 = 74,000 kg
N = 89,670 × 1.1 = 98,650 kg

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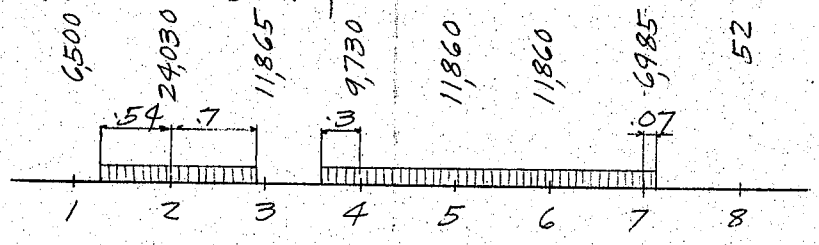
上海地下鐵道鐵筋混凝土拱橋

格点10　正弯曲率

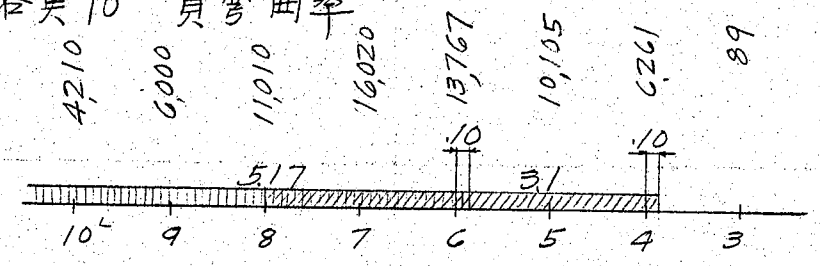


格点		Mu	M	H_0	H	V_0	V
1	6,500	1.0363	6,730	1,120	7,280	.4153	2,700
2	24,030	1.1517	27,700	1.044	25,100	.3335	8,020
3	11,865	1.1609	13,770	.925	10,970	.2573	3,055
4	9,730	1.0707	10,420	.773	7,520	.1893	1,843
5	11,860	.9034	10,720	.603	7,150	.1311	1,555
6	11,860	.6889	8,170	.431	5,110	.0837	992
7	6,985	.4614	3,225	.273	1,907	.0475	332
8	52	.2539	13	.143	7	.0223	1
			80,748 kgm		65,044 kg		18,498 kg

軸推力　65,044 × .618 = 40,200
18,498 × .784 = 14,500
54,700 kg

特殊荷重　M = 80,748 × 1.1 = 88,800 kgm
H = 65,044 × 1.1 = 71,550 kg
N = 54,700 × 1.1 = 60,200 kg

格点10　負弯曲率



41,430 ÷ 3.1 = 13,370
13,370 × .10 = 1,340
1,340 × .05/.75 = 89
13,370 × .375 = 5,010

41,430 ÷ 5.17 = 8,020
8,020 × 0.1 = 800
800 × .05/.75 = 53
8,020 × .375 = 3,000
8,020 × .525 = 4,210

格点		Mu	M	H_0	H	V_0	V
10'	4,210	.0153	64	.004	17	.9995	4,208
9	6,000	-.5523	-3,315	.050	300	.9930	5,960
8	11,010	-.9115	-10,030	.143	1,575	.9777	10,760
7	16,020	-1.0760	-17,220	.273	4,370	.9525	15,250
6	13,767	-1.0555	-14,500	.431	5,930	.9163	12,620
5	10,105	-.8800	-8,890	.603	6,090	.8689	8,770
4	6,261	-.5897	-3,690	.773	4,840	.8107	5,080
3	89	-.2295	-20	.925	82	.7427	66
			-57,601 kgm		23,204 kg		62,714 kg

軸推力　23,204 × .618 = 14,340
62,714 × .784 = 49,150
N = 63,490 kg

特殊荷重　M = -57,601 × 1.1 = -63,400 kgm
H = 23,204 × 1.1 = 25,500 kg
N = 62,714 × 1.1 = 69,000 kg

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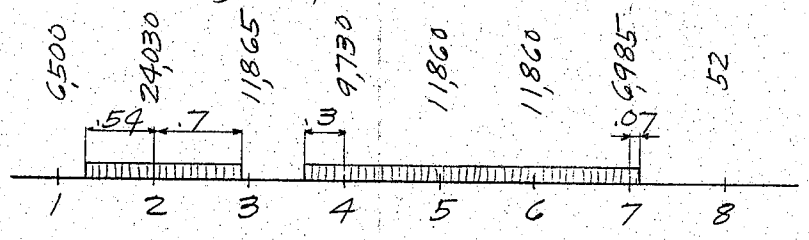
上海地下鐵道鐵筋混凝土拱橋

起拱点　正弯曲率

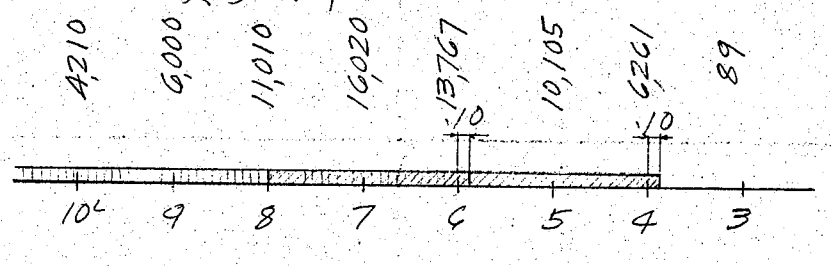


格点		Mu	M	Ho	H	Vo	V
1	6,500	13878	9,020	1,120	7,280	.4153	2,700
2	24,030	14954	35,950	1044	25,100	.3335	8,020
3	11,865	14770	17,520	.925	10,970	.2573	3,055
4	9,730	13425	13,050	.773	7,520	.1893	1,843
5	11,860	1.1204	13,280	.603	7,150	.1311	1,554
6	11,860	.8470	10,050	.431	5,110	.0837	993
7	6,985	.5632	3,935	.273	1,905	.0475	332
8	52	.3081	16	.143	7	.0223	1
			102,821 kgm		65,042 kg		18,498 kg

軸推力
65,042 × .590 = 38,350
18,498 × .807 = 14,930
53,280 kg

特殊荷重
M = 102,821 × 1.1 = 113,200 kgm
H = 65,042 × 1.1 = 71,600 kg
N = 53,280 × 1.1 = 58,650 kg
V = 18,498 × 1.1 = 20,330 kg

起拱点　負弯曲率



格点		Mu	M	Ho	H	Vo	V
10L	4,210	-.2829	-1,190	.004	17	.9995	4,208
9	6,000	-.8290	-4,975	.050	300	.9930	5,960
8	11,010	-1,1441	-12,600	.143	1,575	.9777	10,760
7	16,020	-1,2458	-19,950	.273	4,370	.9525	15,250
6	13,767	-1,1472	-15,780	.431	5,930	.9163	12,620
5	10,105	-.8844	-8,940	.603	6,090	.8689	8770
4	6,261	-.5045	-3,160	.773	4,840	.8107	5,080
3	89	-.0592	- 5	.925	82	.7427	66
			-66,600 kgm		23,204 kg		62,714 kg

軸推力
23,204 × .590 = 13,680
62,714 × .807 = 50,600
64,280 kg

特殊荷重
M = -66,600 × 1.1 = -73,300 kgm
H = 23,204 × 1.1 = 25,500 kg
N = 64,280 × 1.1 = 70,700 kg

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上海地下鐵道鐵筋混凝土拱橋

温度應力

拱頂＝於ケル水平推力　$H_0 = \frac{Ew\tau l \int \frac{ds}{I_0}}{2\left[\int \frac{ds}{I_0} \int y^2 \frac{ds}{I_0} - \left(y \frac{ds}{I_0}\right)^2\right]} = \frac{G}{B}$

茲＝ $E = 1,400,000,000\ kg/m^2$
$w = 0.000012$ (1°C＝対スル膨張係数)
τ = 温度ノ変化 = 15°C
l = 径間長 = 15.60 m
$Ew\tau = 252000$

温度 15°C ノ降下＝対シテ

$H_0 = \frac{-252,000 \times 15.60 \times 111.68}{17244.28} = -25,450\ kg$

$M_0 = -\frac{H_0 \int y \frac{ds}{I_0}}{\int \frac{ds}{I_0}} = 25450 \times \frac{7728}{111.68} = 17,600\ kgm$

格矣ノ温度應力

格矣			彎曲率			軸推力	
2	17,600 − 25,450 ×	.108	= 14,850	kgm	− 25,450 × .992	= −25,250	kg
4	〃 〃	.415	= 7,040	〃	〃 × .963	= −24,500	〃
6	〃 〃	.970	= −7,100	〃	〃 × .903	= −23,000	〃
8	〃 〃	1.875	= −30,100	〃	〃 × .792	= −20,160	〃
10	〃 〃	3.345	= −67,500	〃	〃 × .618	= −15,730	〃
Sp	〃 〃	3.770	= −78,300	〃	〃 × .590	= −15,020	〃

拱環ノ平均應力

拱頂ノ断面積　30000
鐵筋ノ換算面積　3153
33153 m^2

拱環ノ厚ノ比 = 起拱矣ノ厚 / 拱頂ノ厚 = .800 / .400 = 2.00

ライズノ比 = 3770 / 1560 = 0.242

死荷重應力　拱頂＝於ケルH　186,230 ÷ 33153 = 5.6200 @ 1.00 = 5,6200 kg/m^2

活荷重應力

拱頂	+ M	94,700	÷ 33153 =	28,560	@ 0.94	= 26,850	kg/m^2
	− M	79,525	〃 =	24,000	@ 1.02	= 24,500	〃
格矣2	+ M	71,600	〃 =	21,600	@ 0.94	= 20,300	〃
	− M	47900	〃 =	14,450	@ 1.02	= 14,730	〃
格矣4	+ M	39,550	〃 =	11,930	@ 0.95	= 12,570	〃
	− M	71,600	〃 =	21,600	@ 1.02	= 22,040	〃
格矣6	+ M	12,700	〃 =	3,830	@ 0.95	= 3,640	〃
	− M	94,700	〃 =	28,550	@ 1.01	= 28,850	〃
格矣8	+ M	45,327	〃 =	13,670	@ 0.96	= 13,120	〃
	− M	74000	〃 =	22,320	@ 1.01	= 22,550	〃
格矣10	+ M	71,550	〃 =	21,600	@ 0.96	= 20,730	〃
	− M	25,500	〃 =	7,690	@ 1.01	= 8,460	〃
起拱矣	+ M	71,600	〃 =	21,600	@ 0.96	= 20,730	〃
	− M	25,500	〃 =	7,690	@ 1.01	= 8,460	〃

温度應力　−25,450 〃 = −7,680 @ 0.77 = −5,910 kg/m^2

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上海地下鐵道鐵筋混凝土拱橋

拱環ノ纖維應力

拱頂　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	186,230	-4,036	56,200
活荷重	94,700	30,100	26,850
温度變化	-25,450	17,600	-5,910
肋　縮	-7,610	5,260	-1,770
	247,870 kg	48,924 kgm	75,370 kg/m²

$R = \frac{5910}{252,000+5910} \times C = 0.0229C$

$75370 \div 252,000 = 0.299$

$d'/h = 4.5/40 = 0.112$, $A_s = 105.1\,cm^2$

$p = \frac{105.1}{750\times40} = 0.0035$

$e = 48924 \div 247,870 = 0.197\,m$

$e/h = 19.7 \div 40 = 0.492$

$K = 0.47$,　$C = 0.227$

$$f_c = \frac{N}{bhC} = \frac{247,870}{750\times40\times.227} = 36.4\ kg/cm^2$$

$$f_s = 15\times36.4\times\frac{.53}{.47} = 616\ kg/cm^2$$

拱頂　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	186,230	-4,036	56,200
活荷重	79,525	-10,707	24,500
温度變化	25,450	-17,600	5,910
肋　縮	-8,550	5,910	-1,985
	282,655 kg	-26,433 kgm	84,625 kg/m²

$84,625 \div 252,000 = 0.336$

$e = 26,433 \div 282,655 = 0.094\,m$

$e/h = 9.4 \div 40 = 0.235$

$K = 0.855$　$C = 0.472$

$$f_c = \frac{282,655}{750\times40\times.472} = 19.9\ kg/cm^2$$

$$f_s = 15\times19.9\times\frac{.145}{.855} = 50.6\ kg/cm^2$$

格点2　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	187,880	-503	56,200
活荷重	72,700	34,870	20,300
温度變化	-25,250	14,850	-5,910
肋　縮	-6,920	4,070	-1,620
	228,410 kg	53,287 kgm	68,970 kg/m²

$68,970 \div 252,000 = 0.274$

$e = 53,287 \div 228,410 = 0.233\,m$

$e/h = 233 \div 41 = 0.568$

$d'/h = 4.5/41 = 0.110$, $A_s = 105.1\,cm^2$

$p = \frac{1051}{750\times41} = 0.0034$

$K = 0.435$　$C = 0.202$

$$f_c = \frac{228,410}{750\times41\times.202} = 36.8\ kg/cm^2$$

$$f_s = 15\times36.8\times\frac{.565}{.435} = 717\ kg/cm^2$$

格点4　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	193,100	2,756	56,200
活荷重	42,300	31,400	12,570
温度變化	-24,500	7,040	-5,910
肋　縮	-5,980	1,720	-1,440
	204,920 kg	42,916 kgm	61,420 kg/m²

$61,420 \div 252,000 = 0.244$

$d'/h = 4.5/44.2 = 0.102$, $A_s = 54.0\,cm^2$

$p = \frac{54.0}{750\times44.2} = 0.00163$

$e = 42,916 \div 204,920 = 0.209\,m$

e/h　$20.9 \div 44.2 = 0.473$

$K = 0.415$　$C = 0.195$

$$f_c = \frac{204,920}{750\times442\times.195} = 31.7\ kg/cm^2$$

$$f_s = 15\times31.7\times\frac{.585}{.415} = 670\ kg/cm^2$$

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格点 6　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	206,600	3,293	56,200
活荷重	100,500	-30,550	28850
温度變化	-23000	-7,100	-5910
肋縮	-7,060	-2,180	-1,810
	277,040 kg	-36,537 kgm	77330 kg/m²

77330 ÷ 252000 = 0,307
d'/h = 45 ÷ 497 = 0,091, As = 540 cm²
$p = \frac{540}{750 \times 497} = 0.00145$
e = 36537 ÷ 277,040 = 0,132 m
e/h = 132/497 = 0266
K = 0,75　C = 0,38

$f_c = \frac{277,040}{750 \times 497 \times .38} = 19.6 \text{ kg/cm}^2$

$f_s = 15 \times 19.6 \times \frac{.25}{.75} = 98.0 \text{ kg/cm}^2$

格点 8　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	236,200	-856	56,200
活荷重	98,650	-35,080	22,550
温度變化	-20,160	-30,100	-5,910
肋縮	-5700	-8,520	-1,670
	308,990 kg	-74,556 kgm	71,170 kg/m²

71,170 ÷ 252,000 = 0,283
d'/h = 45 ÷ 585 = .0769, As = 105.1 cm²
$p = \frac{105.1}{750 \times 58.5} = 0.0024$
e = 74556 ÷ 308,990 = 0,241 m
e/h = 241/585 = 0.412
K = 0,53　C = 0,267

$f_c = \frac{308,990}{750 \times 585 \times .267} = 263 \text{ kg/cm}^2$

$f_s = 15 \times 263 \times \frac{.47}{.53} = 350 \text{ kg/cm}^2$

格点 10　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	284,800	-3,011	56,200
活荷重	60,200	88,800	20,730
温度變化	15,730	67,500	5,910
肋縮	-5050	-21,670	-1,900
	355,680 kg	131,619 kgm	80,940 kg/m²

80,940 ÷ 252,000 = 0,321
d'/h = 4.5 ÷ 75 = 0.06, As = 105.1 cm²
$p = \frac{105.1}{750 \times 75} = 0.00187$
e = 131,619 ÷ 355,680 = 0,37
e/h = 37 ÷ 75 = 0.494
K = 0,43　C = 0,205

$f_c = \frac{355,680}{750 \times 75 \times .205} = 30.9 \text{ kg/cm}^2$

$f_s = 15 \times 30.9 \times \frac{.57}{.43} = 506 \text{ kg/cm}^2$

格点 10　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	284,800	-3,011	56,200
活荷重	69,000	-63,400	8,460
温度變化	-15,730	-67,500	-5,910
肋縮	-3,590	-15,380	-1,345
	334,480 kg	-149,291 kgm	57,405 kg/m²

57,405 ÷ 252,000 = 0,228
e = 149,291 ÷ 334,480 = 0,446
e/h = 44.6 ÷ 75 = 0.595
K = 0.37　C = 0,165

$f_c = \frac{334480}{750 \times 75 \times .165} = 36.0 \text{ kg/cm}^2$

$f_s = 15 \times 36.0 \times \frac{.63}{.37} = 920 \text{ kg/cm}^2$

起拱点　正彎曲率

	軸推力	彎曲率	平均應力
死荷重	293,700	7,782	56,200
活荷重	58,650	113,200	20,730
温度變化	15,020	78,300	5,910
肋縮	4,820	-25,130	-1,900
	372,190 kg	174,152 kgm	80,940 kg/m²

80,940 ÷ 252,000 = 0,321
d'/h = 45 ÷ 80 = 0.056, As = 105.1 cm²
$p = \frac{105.1}{750 \times 80} = 0.00175$
e = 174,152 ÷ 372,190 = 0,468
e/h = 46.8 ÷ 80 = 0.585

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$$f_c = \frac{372{,}190}{750\times 80\times .165} = 37.6 \text{ kg/cm}^2$$

$$f_s = 15\times 37.6\times \frac{.63}{.37} = 960 \text{ kg/cm}^2$$

K = 0.37　C = 0.165

起拱点　負彎曲率

	軸推力	彎曲率	平均應力
死荷重	293,700	7,782	50,200
活荷重	70,700	-73,300	8,460
温度變化	-15,020	-78,300	-5,910
肋縮	-3,420	-17,850	-1,345
	345,960 kg	-161,668 kgm	57,405 kg/m²

57,405 ÷ 252,000 = 0.228
e = 161,668 ÷ 345,960 = 0.468 m
e/h = 468 ÷ 80 = 0.585
K = 0.37　C = 0.166

$$f_c = \frac{345960}{750\times 80\times .166} = 34.7 \text{ kg/cm}^2$$

$$f_s = 15\times 34.7\times \frac{.63}{.37} = 886 \text{ kg/cm}^2$$

橋脚ノ設計

死荷重反力　Rd = 227,830 kg
死荷重水平推力　Hd = 186,230 kg
死荷重彎曲率　Md = 7,782 kgm

活荷重

起拱点＝最大正彎曲率ノ起ル場合

反力　Rl = 20,330 ÷ 1.381 = 14,730 kg
水平推力　Hl = 71,600 〃 = 51,900 kg
彎曲率　Ml = 113,200 〃 = 82,000 kgm

起拱点＝最大水平推力ノ起ル場合

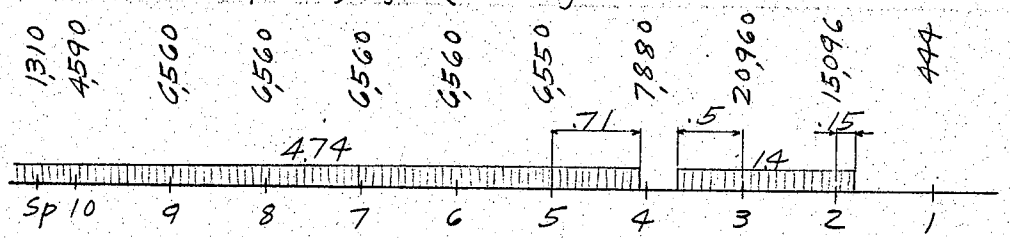
格点		H_o	H	M_o	M	V_o	V
4	6,460	.773	4,990	13425	8,670	.1893	1,223
3	21,720	.925	20,100	14770	32,100	.2573	5,590
2	13,172	1.044	13,750	14954	19,680	.3335	4,390
1	7,008	1.120	7,850	13878	9,720	.4153	2,910
G	27,610	1.147	31,650	1.1588	31,950	.5000	13,800
1	6,910	1.120	7,740	.8164	5,650	.5847	4,040
			86,080 kg		107,770 kgm		31,953 kg

$$H = 86{,}080\times\frac{1.1}{1.381} = 68{,}600 \text{ kg}$$

$$M = 107{,}770\times\frac{1.1}{1.381} = 85{,}900 \text{ kgm}$$

$$V = 31{,}953\times\frac{1.1}{1.381} = 25{,}450 \text{ kg}$$

起拱点＝最大反力ノ起ル場合



41,430 ÷ 4.74 = 8,740
8,740 × .15 = 1,310
8,740 × .525 = 4,590
8,740 × .375 = 3,280
8,740 × .71 = 6,210
6,210 × .355/.75 = 2,940

41,430 ÷ 1.4 = 29,600
29,600 × .5 = 14,800
14,800 × .25/.75 = 4,940

29,600 × .375 = 11,100
29,600 × .15 = 4,440
4,440 × .075/.75 = 444

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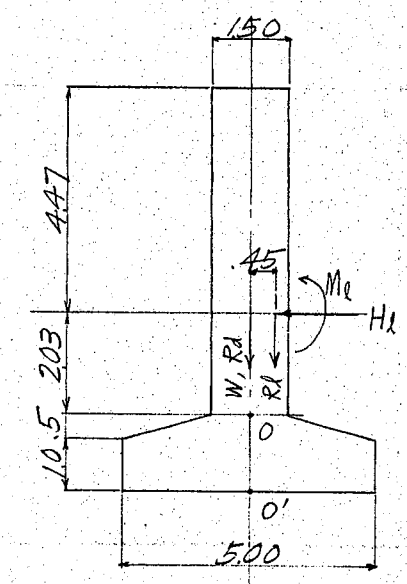
上海地下鐵道鐵筋混凝土拱橋

格奥		Mu	M	Ho	H	Vo	V
Sp	1,310	—	—	—	—	1.0000	1,310
10	4,590	-.2829	-1,298	.004	18	.9995	4,588
9	6,560	-.8290	-5,440	.050	328	.9930	6,510
8	6,560	-1,1441	-7,500	.143	938	.9777	6,415
7	6,560	-1,2458	-8,170	.273	1,790	.9525	6,250
6	6,560	-1,1472	-7,520	.431	2,827	.9163	6,018
5	6,550	-.8844	-5,795	.603	3,950	.8689	5,690
4	7,880	-.5045	-3,975	.773	6,090	.8107	6,390
3	20,960	-.0592	-1,240	.925	19,380	.7427	15,570
2	15,096	.3980	6,000	1.044	15,750	.6665	10,060
1	444	.8164	363	1.120	497	.5847	260
			-34,575 kgm		51,568 kg		69,061 kg

特殊荷重

反　力　$Rl = 69,061 \times 1.1 \div 1.381 = 55,000$ kg
水平推力　$Hl = 51,568 \times 1.1 \div 〃 = 41,100$ kg
彎曲率　$Ml = -34,575 \times 1.1 \div 〃 = -27,550$ kgm



橋脚上部，重量

軌　道	2 × 600 × 150	= 1,800
道　床	40 × 690 × 150 @ 1,900	= 7,870
填充砂	300 × 690 × 150 @ 1,700	= 52,800
側　壁	2@ 105 × 150 × 355 @ 2,400	= 26,850
橋脚体	150 × 295 × 900 @ 2,400	= 95,600
		W = 184,920 kg

最大正彎曲率，起ル場合

死荷重反力　$Rd = 2 @ 227830 = 455,660$ kg
衝撃係数　$i = \dfrac{0.5 \times 14,730}{14,730 + 455,660 + 184,920} = 0.011$

活荷重

反　力　$Rl = 14,730 \times 1.011 = 14,880$ kg
水平推力　$Hl = 51,900 \times 1.011 = 52,450$ kg
彎曲率　$Ml = 82,000 \times 1.011 = 82,900$ kgm

0 奥＝於ケル彎曲率

	V	H		M
W	184,920	×	0 =	0
Rd	455,660	×	0 =	0
Rl	14,880	×	-0.45 =	-6,700
Hl		52,450 ×	2.03 =	106,500
Ml			=	82,900
	655,460 kg	52,450 kg		182,700 kgm

$e = 182,700 \div 655,460 = 0.279$ m

基礎上，土，重量

2 @ 0.75 × 1.75 × 11.00 = 28.88
2 @ 0.75 × 1.00 × 1.50 = 2.25
E = 31.13 @ 1,600 = 49,800 kg

基礎，重量

5.00 × 1.00 × 11.00 = 55.00
3.25 × .50 × 10.00 = 16.25
B = 71.25 × 2,400 = 171,000 kg

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上海地下鐵道鐵筋混凝土拱橋

$W+B = 184,920 + 171,000 = 355,920$ kg

衝撃係数 $i = \frac{0.5 \times 14,730}{14,730 + 455,660 + 355,920} = 0.009$

活荷重

反力	Rl	$= 14,730 \times 1.009 =$	$14,870$	kg
水平推力	Hl	$= 51,900 \times 1.009 =$	$52,400$	kg
彎曲率	Ml	$= 82,000 \times 1.009 =$	$82,800$	kgm

0'点ニ於ケル彎曲率

	V	H			M
W+B	355,920		× 0	=	0
Rd	455,660		× 0	=	0
Rl	14,870		× -0.45	=	-6,690
Hl		52,400	× 3.53	=	185,000
E	49,800		× 0	=	0
Ml				=	82,800
	876,250 kg	52,400 kg			261,110 kgm

$e = 261,110 \div 876,250 = 0.298$ m

滑動係数 $52,400 \div 876,250 = 0.06$ m

支圧力 $= \frac{876,250}{5.00 \times 11.00} \times \left(1 \pm \frac{6 \times 0.298}{5.0}\right) = 21,650$ kg/m²
$10,230$ 〃

最大水平推力ノ場合

衝撃係数 $i = \frac{0.5 \times 25,450}{25,450 + 455,660 + 184,920} = 0.019$

活荷重

反力	Rl	$= 25,450 \times 1.019 =$	$25,950$	kg
水平推力	Hl	$= 68,600 \times 1.019 =$	$70,000$	kg
彎曲率	Ml	$= 85,900 \times 1.019 =$	$87,600$	kgm

0点ニ於ケル彎曲率

	V	H			M
W	184,920		× 0	=	0
Rd	455,660		× 0	=	0
Rl	25,950		× -0.45	=	-11,670
Hl		70,000	× 2.03	=	142,200
Ml				=	87,600
	666,530 kg	70,000 kg			218,130 kgm

$e = 218,130 \div 666,530 = 0.328$ m

衝撃係数 $i = \frac{0.5 \times 25,450}{25,450 + 455,660 + 355,920} = 0.015$

活荷重

反力	Rl	$= 25,450 \times 1.015 =$	$25,840$	kg
水平推力	Hl	$= 68,600 \times 1.015 =$	$69,630$	kg
彎曲率	Ml	$= 85,900 \times 1.015 =$	$87,200$	kgm

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上海地下鐵道鐵筋混凝土拱橋

0′点ニ於ケル彎曲率

	V	H			M
W+B	355,920		×	0 =	0
Rd	455,660		×	0 =	0
Rl	25,840		×	−0.45 =	−11,630
Hl		69,630	×	2.03 =	141,300
E	49,800		×	0 =	0
Ml				=	87,200
	887,220 kg	69,630 kg			216,870 kgm

$e = 216870 \div 887220 = 0.244$ m

滑動係数 $69,630 \div 887,220 = 0.079$

支圧力 $= \frac{887220}{5.00 \times 11.00} \times \left(1 \pm \frac{6 \times 0.244}{5.0}\right) = 20,860$ kg/m² , 11,400 〃

最大反力，起ル場合

衝撃係数 $\lambda = \frac{0.5 \times 55000}{55,000 + 455,660 + 184,920} = 0.040$

活荷重

反力	Rl = 55,000 × 1.040	=	57,200 kg
水平推力	Hl = 41,100 × 〃	=	42,800 kg
彎曲率	Ml = −27,550 × 〃	=	−28,650 kgm

0点ニ於ケル彎曲率

	V	H			M
W	184,920		×	0 =	0
Rd	455,660		×	0 =	0
Rl	57,200		×	−0.45 =	−25,750
Hl		42,800	×	2.03 =	86,900
Ml				=	−28,650
	697,780 kg	42,800 kg			32,500 kgm

$e = 32500 \div 697780 = 0.047$ m

此ノ場合ハ前記ノ場合ヨリ安全ナル事明ナリ

断面，設計

橋脚体，断面

$M = 218,130$ kgm , $N = 666,530$ kg , $S = 70,000$ kg , $e = 32.8$ m

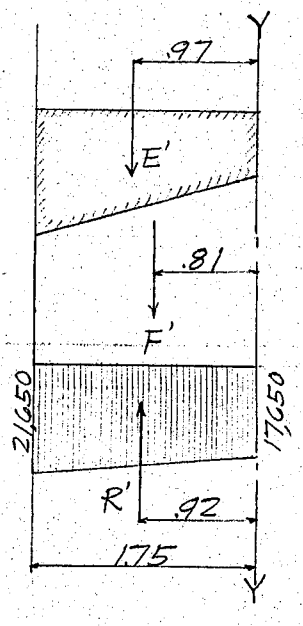
$h = 150$ cm , $d'/h = 4.5/150 = 0.03$, $e/h = 32.8/150 = 0.219$

As = 19 mmφ 20 cm c.to c $= 45 \times 2.835 = 127.5$ cm²

$p = \frac{127.5}{900 \times 150} = 0.00095$, $k = 0.87$, $C = 0.45$

$f_c = \frac{N}{bhc} = \frac{666530}{900 \times 150 \times 45} = 11.0$ kg/cm²

$f_s = 15 \times 11.0 \times \frac{0.13}{0.87} = 247$ kg/cm²



基礎

E′ = 0.75 × 1.00 × 1.75 @ 1,600 = 2,100 kg
F′ = 1.25 × 1.00 × 1.75 @ 2400 = 5,250 kg
R′ = 1.00 × 1.75 × 19,650 = 34,400 kg

Y-Y = 於ケル彎曲率

R′	34,400 ×	.92 =	31,650	
E′	− 2,100 ×	.97 =	− 2,040	
F′	− 5,250 ×	.81 =	− 4,250	
	27,050 kg		25,360 kgm	

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上海地下鐵道鐵筋混凝土拱橋

所要有効厚 $d=\sqrt{\frac{25360\times100}{100\times7.13}}=59.6\ cm$

使用有効厚 140 cm 被覆 10 cm 總厚 150 cm

所要鐵筋量 $\frac{25360\times100}{1{,}200\times7/8\times140}=17.2\ cm^2$

鐵筋 19mmφ 15 cm c. to c $A_s=6.66\times2.835=18.7\ cm^2$

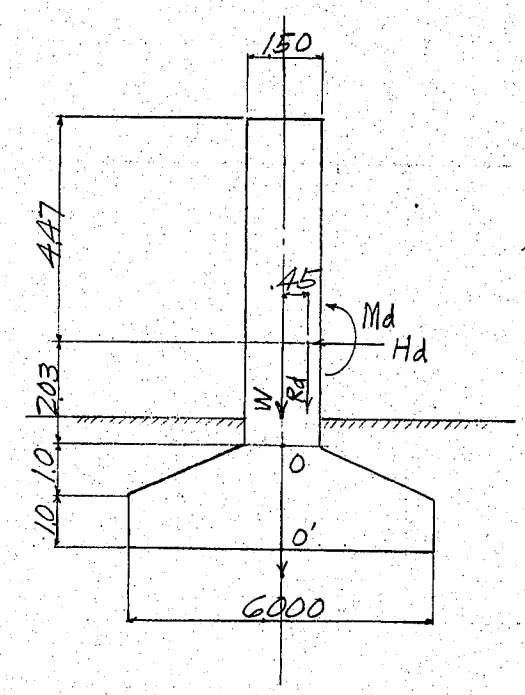
$P=\frac{18.7}{100\times140}=0.0013$ $j=0.94$, $K=0.18$

$f_s=\frac{25360\times100}{18.7\times0.94\times140}=1{,}030\ kg/cm^2$

$f_c=\frac{2\times25360\times100}{0.94\times0.18\times100\times140^2}=15.3\ kg/cm^2$

$S=\frac{27050}{100\times0.94\times140}=2.1\ kg/cm^2$

鎮碇橋脚 (Abutment Pier)



死荷重

反力 $Rd=227{,}830\ kg$
水平推力 $Hd=186{,}230\ kg$
彎曲率 $Md=7{,}782\ kgm$

橋脚上部重量 $W=184{,}920\ kg$

0点=於中心彎曲率

	V	H		M
W	184,920		× 0 =	0
Rd	227,830		× −0.45 =	−102,500
Hd		186,230	× 2.03 =	378,000
Md			=	7782
	412,750 kg	186,230 kg		283,282 kgm

$e=283{,}282\div412{,}750=0.687\ m$

$h=150\ cm$, $d'/h=4.5\div150=0.03$, $e/h=68.7\div150=0.458$

$A_s=19^{mm}\phi$ 20 cm c. to c. $=45\times2.835=127.5\ cm^2$

$P=\frac{127.5}{900\times150}=0.00094$, $K=0.40$, $C=0.192$

$f_s=\frac{N}{bhc}=\frac{412750}{900\times150\times0.192}=15.9\ kg/cm^2$

$f_c=15\times15.9\times\frac{0.60}{0.40}=358\ kg/cm^2$

$S=\frac{186230}{900\times7/8\times140}=1.7\ kg/cm^2$

基礎上ノ土ノ重量

$2@1.00\times2.25\times11.00=49.50$
$1.00\times1.50\times2.00=3.00$
$E=52.50@1{,}600=84{,}000\ kg$

基礎ノ重量

$6.00\times1.00\times11.00=66.00$
$3.75\times1.00\times1.000=37.50$
$B=103.50@2{,}400=248{,}500\ kg$

$W+B=184{,}920+248{,}500=433{,}420\ kg$

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設計	日付	類別	C
照査	日付	第	27頁

上海地下鐵道鐵筋混凝土拱橋

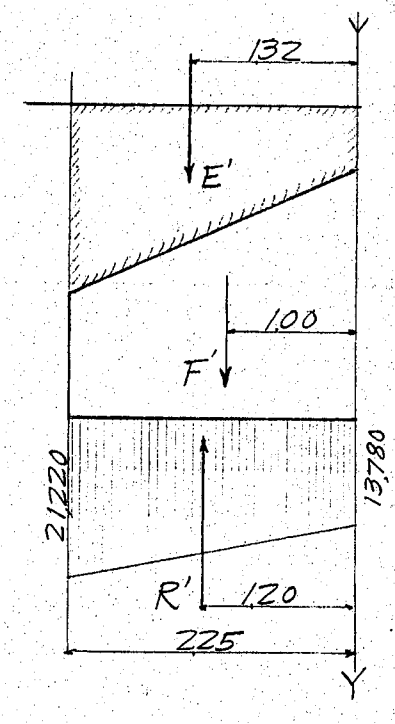
0′ 点 = 於ケル能率

	V	Hd			M
W+B	433,420		×	0 =	0
Rd	227,830		×	−0.45 =	−102,500
Hd		186,230	×	4.03 =	751,000
E	84,000		×	0 =	0
Md				=	7,782
	745,250 kg	186,230 kg			656,282 kgm

$e = 656,282 \div 745,250 = 0.88\ m$

滑動係数 $186,230 \div 745,250 = 0.25$

支圧力 $= \frac{745,250}{6.00 \times 11.00} \times \left(1 \pm \frac{6 \times 0.88}{6.0}\right) = 21,220\ kg/m^2$
$= 1,360\ \text{〃}$



E′ = 1.00 × 1.00 × 2.25 @ 1,600 = 3,600 kg
F′ = 1.50 × 1.00 × 2.25 @ 2,400 = 8,100 kg
R′ = 1.00 × 2.25 @ 17,500 = 39,400 kg

Y-Y = 於ケル弯曲率

R′	39,400	× 1.20 =	47,300
E′	−3,600	× 1.32 =	−4,750
F′	−8,100	× 1.00 =	−8,100
	27,700 kg		34,450 kgm

所要有効厚 $d = \sqrt{\frac{34450 \times 100}{100 \times 7.13}} = 69.5\ cm$

使用有効厚 190 cm 被覆 10 cm 總厚 200 cm

所要鐵筋量 $\frac{34450 \times 100}{1,200 \times 7/8 \times 190} = 17.3\ cm^2$

鐵筋 22mmφ 20 cm c. to c. $A_s = 5 @ 3.801 = 19.0\ cm^2$

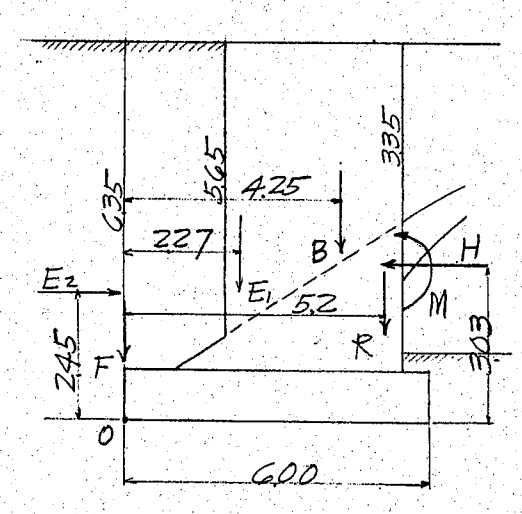
$p = \frac{19.0}{100 \times 190} = 0.001$, $j = 0.946$, $K = 0.151$

$f_s = \frac{34450 \times 100}{19.0 \times 0.946 \times 190} = 1,008\ kg/cm^2$

$f_c = \frac{2 \times 34450 \times 100}{0.151 \times 0.946 \times 100 \times 190^2} = 13.4\ kg/cm^2$

$s = \frac{27,700}{100 \times 0.946 \times 190} = 1.5\ kg/cm^2$

橋臺設計



死荷重

反力	Rd =	227,830 kg
水平推力	Hd =	186,230 kg
弯曲率	Md =	7,782 kgm

躯体重量

2 @	3.50 × 1.05 × 4.65	= 34.18 × 3.61 =		123.3
	1.50 × 4.50 × 9.00	= 60.7 × 4.00 =		242.8
	6.00 × 1.00 × 11.00	= 66.0 × 3.00 =		198.0
		160.88	4.25	684.1

B = 160.88 @ 2,400 = 386,000 kg

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上海地下鐵道鐵筋混凝土拱橋

上部荷重及土砂ノ重量

6.35 × 1.00 × 11.00 @ 1,600	= 111,800	× 0.50	=	55,900
6.00 × 1.00 × 11.00 @ 1,600	= 105,600	× 1.49	=	157,300
3.50 × 4.50 × 6.90 @ 1,600	= 173,800	× 3.60	=	626,000
2.00 × 3.43 × 4.00 @ 1,600	= 43,900	× 3.00	=	131,600
2 @ 6.00 × 5.50	= 6,600	× 2.75	=	18,150
6.90 × 0.40 × 5.50 @ 1,900	= 28,800	× 2.75	=	79,200
	E1 = 470,500 kg	2.27		1068,150

土圧　$\frac{1}{3} \times wh = \frac{1}{3} \times 1{,}600 \times 7.35 = 3{,}920$ kg

$E_2 = \frac{1}{2} \times 3{,}920 \times 7.35 \times 11.00 = 158{,}500$ kg

土ノ摩擦

$\tan\theta = \tan 20° = 0.364$

$F = 158{,}500 \times 0.364 = 57{,}700$ kg

最大正彎曲率ノ起ル場合

衝撃係数 $i = \frac{0.5 \times 14{,}730}{14{,}730 + 227{,}830 + 386{,}000} = 0.012$

活荷重

反力	Rl =	14,730 × 1.012	=	14,900 kg
水平推力	Hl =	51,900 × 1.012	=	52,500 kg
彎曲率	Ml =	82,000 × 1.012	=	83,000 kgm

R = 227,830 + 14,900 = 242,730 kg
H = 186,230 + 52,500 = 238,730 kg
M = 7,782 + 83,000 = 90,782 kgm

O点ニ於ケル能率

	V	H		M
R	242,730	×	5.2	= 1,262,000
E1	470,500	×	2.27	= 1,018,000
B	386,000	×	4.25	= 1,640,000
F	57,700	×	0	= 0
H	-238,730	×	3.03	= -723,000
E2	158,500	×	2.45	= 398,500
M				= -90,782
	1,156,930 kg	-80,230 kg		3,504,718 kgm

3,504,718 ÷ 1,156,930 = 3.03 m
e = 3.03 − 3.0 = .03 m
滑動係数 80,230 ÷ 1156,930 = 0.07
支圧力 $= \frac{1156,930}{6.0 \times 11.0} \times \left(1 \pm \frac{6 \times 0.03}{6.0}\right) = 18,050$ kg/m²
17,000 〃

最大水平推力ノ起ル場合

衝撃係数 $i = \frac{0.5 \times 25,450}{25,450 + 227,830 + 386,000} = 0.02$

活荷重

反力	Rl =	25,450 × 1.02	=	25,950 kg
水平推力	Hl =	68,600 × 1.02	=	70,000 kg
彎曲率	Ml =	85,900 × 1.02	=	87,600 kgm

R = 227,830 + 25,950 = 253,780 kg
H = 186,230 + 70,000 = 256,230 kg
M = 7,782 + 87,600 = 95,382 kgm

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設計	日付	類別	C
照査	日付	第	29 頁

上海地下鐵道鐵筋混凝土拱橋

0点=於ケル能率

	V	H			M
R	227,830		×	5.2	= 1,183,000
E_1	470,500		×	2.27	= 1,067,000
B	386,000		×	4.25	= 1,640,000
F	57,700		×	0	= 0
H		-256,230	×	3.03	= - 776,000
E_2		158,500	×	2.45	= 388,500
M					= - 95,382
	1,142,030 kg	-97,730 kg			3,407,118 kgm

3,407,118 ÷ 1142,030 = 2.98 m

e = 3.0 − 2.98 = 0.02 m

滑動係数 97,730 ÷ 1142,030 = 0.086

支圧力 $\frac{1142030}{6.0 \times 11.0} \times \left(1 \pm \frac{6 \times 0.02}{6}\right) = 17,650$ kg/m²

16,950 〃

最大反力ノ起心場合

衝撃係数 $i = \frac{0.5 \times 55,000}{55,000 + 227,830 + 386,000} = 0.041$

活荷重

反力	R_l = 55,000 × 1.041	= 57,200 kg
水平推力	H_l = 41,100 × 1.041	= 42,800 kg
弯曲率	M_l = -27,550 × 1.041	= -28,700 kgm

R = 227,830 + 57,200 = 285,030 kg

H = 186,230 + 42,800 = 229,030 kg

M = 7,782 − 28,700 = -20,918 kgm

0点=於ケル能率

	V	H			M
R	285030		×	5.2	= 1482,000
E_1	470,500		×	2.27	= 1068,000
B	386,000		×	4.25	= 1640,000
F	57,700		×	0	= 0
H		-229,030	×	3.03	= - 694,000
E_2		158,500	×	2.45	= 388,000
M					= 20,918
	1,199,230 kg	-70,530 kg			3,904,918 kgm

3904,918 ÷ 1199,230 = 3.26 m

e = 3.26 − 3.00 = 0.26 m

滑動係数 70,530 ÷ 1199,230 = 0.059

支圧力 $\frac{1199230}{6.0 \times 11.0} \times \left(1 \pm \frac{6 \times 026}{6.0}\right) = 22,900$ kg/m²

13,450 〃