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
鐵混凝土複線標準隧道
筋応系
應力計算書

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設計 稲葉 日付 16-5-19 類別 S.C.T. 3467

照査 日付 第 1 頁

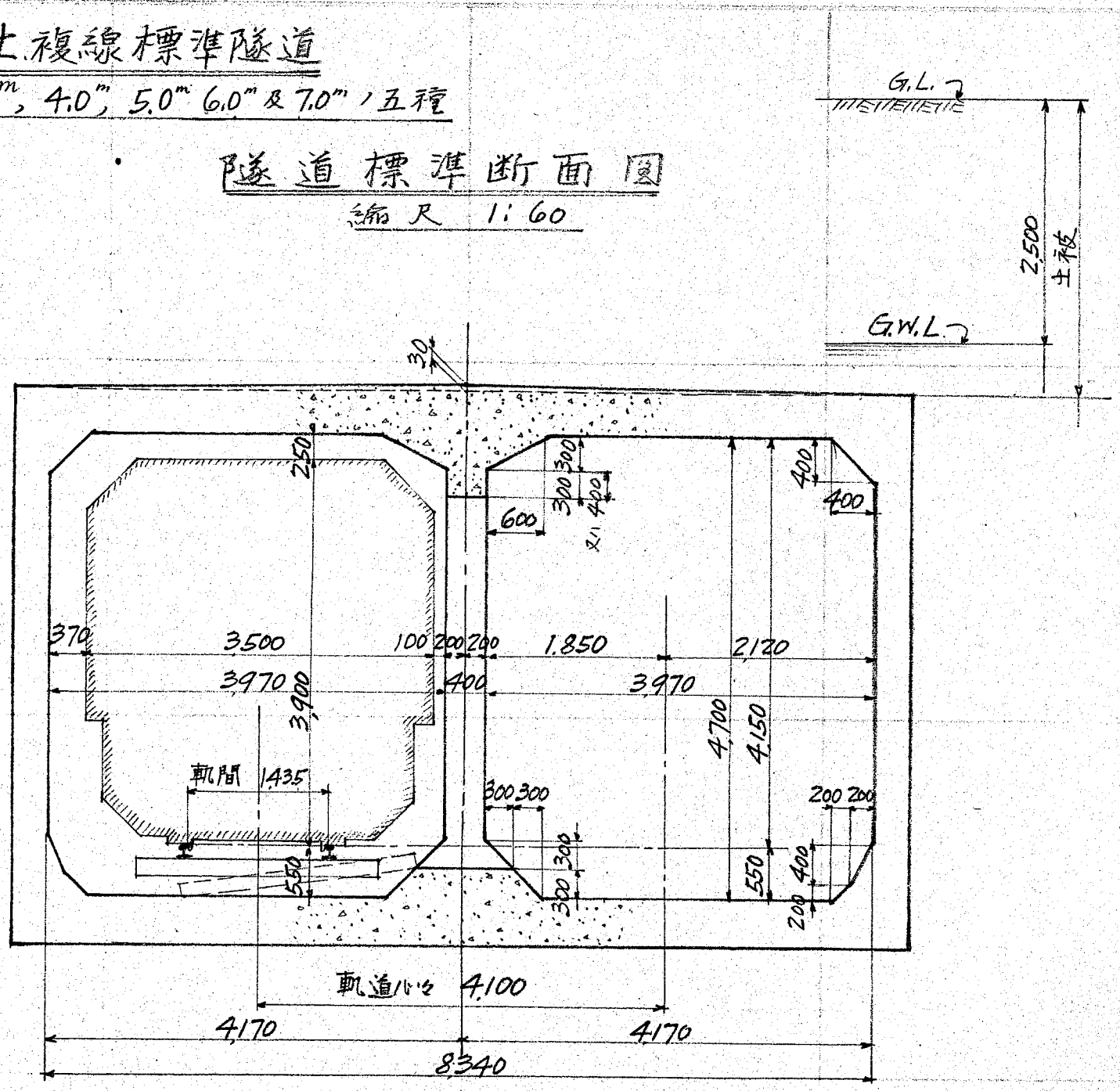
上海高速鐵道鉄筋混凝土標準隧道

鐵筋混凝土複線標準隧道

土被 3.0m, 4.0m, 5.0m 6.0m 及 7.0m ノ五種

隧道標準断面圖

縮尺 1:60



一般設計條件

土被 3.0m; 4.0; 5.0; 6.0 及 7.0m, 五種トス
地下水位 地表面以下 2.5m ト假定ス
土ノ息角 $\phi = 25°$ トス ---------- 土圧係数 $C = \frac{1-\sin\phi}{1+\sin\phi} = \frac{0.5774}{1.4226} = 0.406$
土ノ重量 地下水位以上 1,600 kg/m³
〃 以下 2,000 〃

路面傳布荷重及 被覆混凝土

隧道呼稱	土被	Circharge load. 換算土深	被覆混凝土厚			
SCT3	3.0m	1,000 kg/m² --- 0.6m	上床及側壁上部	50 cm	下床及側壁下部	10 cm (上部ハ防空施設)
SCT4	4.0	900 ---- 0.55	〃	50	〃	10 (〃)
SCT5	5.0	800 ---- 0.50	上床及側壁	10	下床	10
SCT6	6.0	800 ---- 0.50	〃	10	〃	10
SCT7	7.0	800 ---- 0.50	〃	10	〃	10

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設計	日付	類別	
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上海高速鐵道
鐵筋混凝土標準型複線隧道
上被三、〇米 應力計算書

Standard Reinforced Concrete Tunnel.
Double Track
Mark. S.C.T. 3.

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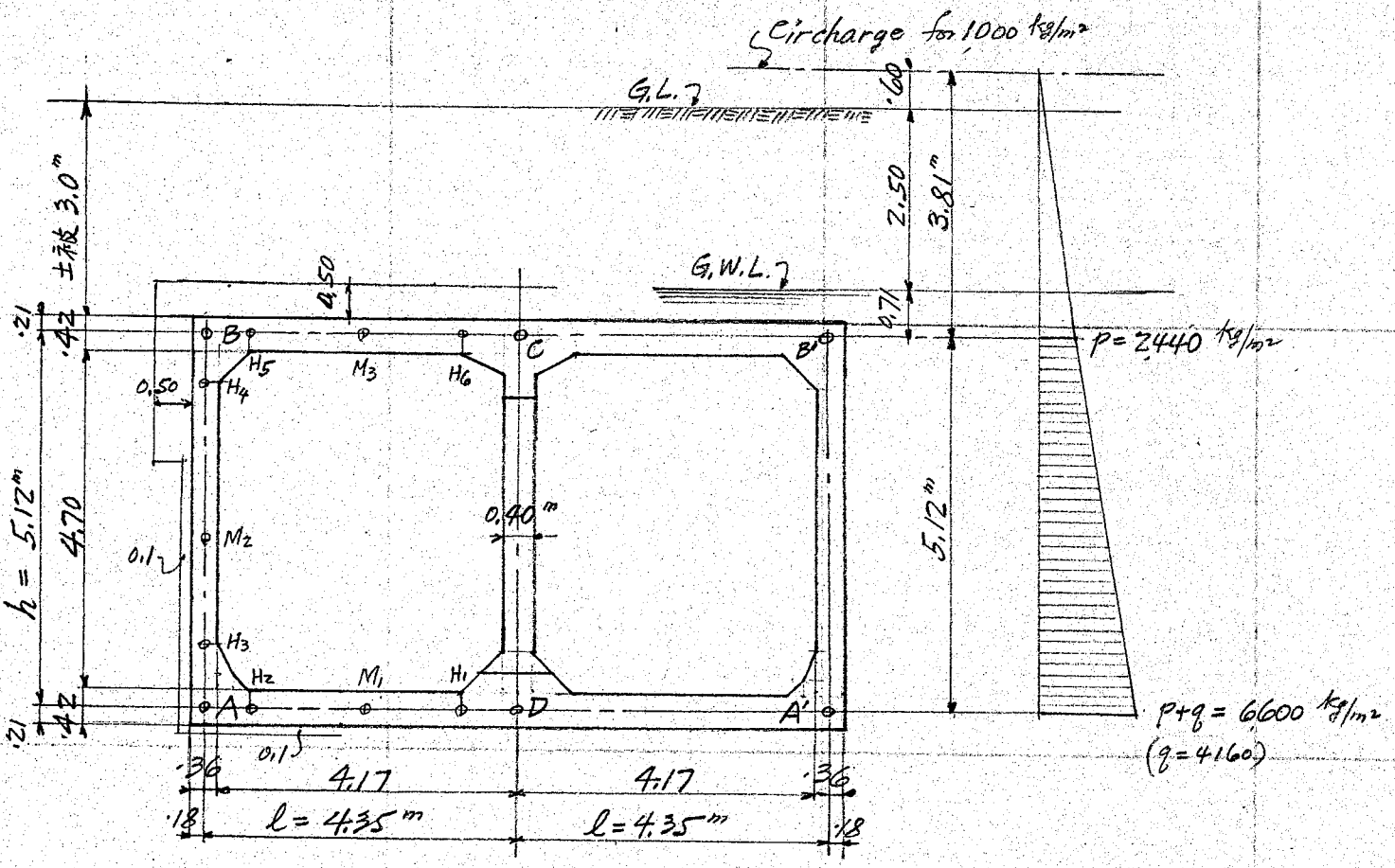
上海標準隧道

土被 3.0m 標準隧道 S.C.T.3



上床荷重 w

土被、地下水位以上	2.50m @ 1,600 =	4,000	
表皮覆泥凝土	0.50m @ 2,200 =	1,100	
上床 〃	0.42m @ 2,400 =	1,010	
		6,110	
路面傳布荷重		1,000	
	w =	7,110 kg/m²	

下床荷重　上床荷重ト全ク同ト假定ス

側壁荷重

B及B'点ニ於ケル荷重

土被	2.50m @ 1,600 =	4,000	
〃	0.50 @ 2,000 =	1,000	
路面荷重		1,000	
		6,000 × 0.406 =	2,440 kg/m² = p

A及A'点ニ於ケル荷重

5.12m @ 2,000 =	10,240 × 0.406 =	4,160	= q
		6,600	= p+q

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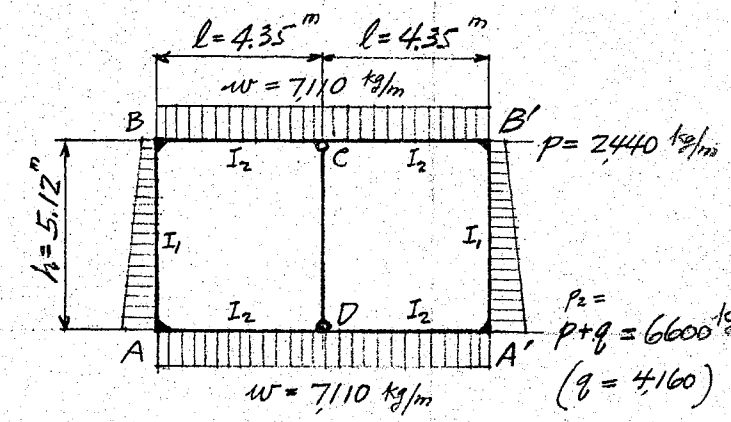
上海標準隧道

荷重狀態



Moment of Inertia

$$I_1 = \frac{1.0\times 0.36^3}{12} = 0.00389\ m^4$$

$$I_2 = \frac{1.0\cdot 0.42^3}{12} = 0.00617\ m^4$$

$$K_1 = \frac{I_1}{h} = \frac{0.00389}{5.12} = 0.00076$$

$$K_2 = \frac{I_2}{l} = \frac{0.00617}{4.35} = 0.00142$$

$$K = \frac{K_2}{K_1} = \left(\frac{I_2}{I_1}\cdot\frac{h}{l}\right) = \frac{0.00142}{0.00076} = 1.868$$

上下床ノ荷重 w = 依ル彎曲率

$$M_A = M_B = -\frac{wl^2}{12(1+2K)} = -\frac{7110\times 4.35^2}{12(1+3.736)} = -2,360\ kgm$$

$$M_C = M_D = -\frac{(1+3K)wl^2}{12(1+2K)} = -\frac{7110\times(1+5.604)\times 4.35^2}{12(1+3.736)} = -15,600\ kgm$$

両側壁荷重 p 及 $p+q$ = 依ル彎曲率

$$M_A = -\frac{K_2h^2\{(61K_1+12K_2)(p+q)+(59K_1+8K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.00142\times 5.12^2\{(0.0464+0.0170)\times 6600+(0.0448+0.0114)2440\}}{120(0.00456+0.00142)(0.00076+0.00284)}$$

$$= -\frac{0.0372(0.0634\times 6600+0.0562\times 2440)}{0.00258} = -8,000\ kgm$$

$$M_B = -\frac{K_2h^2\{(59K_1+8K_2)(p+q)+(61K_1+12K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)}$$

$$= -\frac{0.0372(0.0562\times 6600+0.0634\times 2440)}{0.00258} = -7,570\ kgm$$

$31K_1+7K_2 = 0.0335$ ✓
$29K_1+3K_2 = 0.0263$ ✓

$$M_C = \frac{K_2h^2\{(31K_1+7K_2)(p+q)+(29K_1+3K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)}$$

$$= \frac{0.0372(0.0335\times 6600+0.0263\times 2440)}{0.00258} = 4,110\ kgm$$

$$M_D = \frac{K_2h^2\{(29K_1+3K_2)(p+q)+(31K_1+7K_2)p}{120(6K_1+K_2)(K_1+2K_2)}$$

$$= \frac{0.0372(0.0263\times 6600+0.0335\times 2440)}{0.00258} = 3,680\ kgm$$

上下床及両側壁荷重ニ依ル彎曲率

	床荷重	両側壁荷重	合成彎曲率	
M_A	−2,360	−8,000	−10,360	kgm
M_B	−2,370	−7,570	−9,940	〃
M_C	−15,600	+4,110	−11,490	〃
M_D	−15,600	+3,680	−11,920	〃

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上海標準隧道

剪力.

上床 $S_{BZ} = \frac{wl}{2} + \frac{M_C - M_B}{l} = \frac{7110 \times 4.35}{2} + \frac{-11490 + 9940}{4.35} = 15460 - 360 = 15,100$ kg

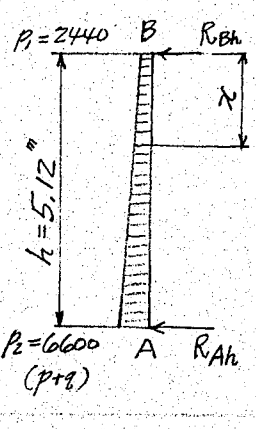
〃 $S_{CZ} = -\frac{wl}{2} + \frac{M_C - M_B}{l} =$ $= -15460 - 360 = -15,820$

下床 $S_{AZ} = -\frac{wl}{2} + \frac{M_A - M_D}{l} = -15460 + \frac{-10360 + 11920}{4.35} = -15460 + 360 = -15,100$

〃 $S_{DZ} = \frac{wl}{2} + \frac{M_A - M_D}{l} =$ $= 15460 + 360 = 15,820$

側壁.

AB ヲ Simple beam トスル反力.



$R_{Ah} = \frac{h}{6}(2p_2 + p_1) = \frac{5.12}{6}(2 \times 6600 + 2440) = 13,330$ kg (15640)

$R_{Bh} = \frac{h}{6}(2p_1 + p_2) = \frac{5.12}{6}(2 \times 2440 + 6600) = 9,780$ 〃 (11480)

剪力

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -9,780 + \frac{-9940 + 10360}{5.12} = -9,860$ kg (80)

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 13,330 - 80 = 13,250$ 〃

中間点ニ於ケル曲率及剪力.

下床 AD.

(M1) 0 Shear $x = -\frac{S_{A2}}{w} = \frac{15100}{7110} = 2.125^m$ from A.

$M_A = -10,630$
$-S_{A2}x = 15,100 \times 2.125 = 32,100$
$-\frac{wx^2}{2} = -\frac{7110 \times 2.125^2}{2} = -16,050$
$M_1 = 5,420$ kgm $S_1 = 0$

(H1) $x = 4.35 - 0.80 = 3.55^m$

$M_A = -10,630$
$-S_{AZ}x = 15,100 \times 3.55 = 53,600$
$-\frac{wx^2}{2} = -\frac{7110 \times 3.55^2}{2} = -44730$
$M_{H1} = -1,760$ kgm

$S_{A2} = -15,100$
$wx = 7110 \times 3.55 = 25200$
$S_{H1} = 10,100$ kg

(H2) $x = 0.58^m$

$M_A = -10,630$
$15100 \times 0.58 = 8,760$
$-\frac{7110 \times 0.58^2}{2} = -1,200$
$M_{H2} = -3,070$ kgm

$-15,100$
$7110 \times 0.58 = 4120$
$S_{H2} = -10,980$ kg

軸力 $N_{AD} = S_{A1} = 13,250$ kg. C.

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上海標準隧道

上床 BC.

(M3) 0 Shear $x = \frac{S_{B2}}{w} = \frac{15100}{7110} = 2.125^m$

M_B		-9940
$S_{B2}x$	15100×2.125	$32,100$
$-\frac{wx^2}{2}$	$-\frac{7110 \times 2.125^2}{2}$	-16050
		$M_2 = 6110$ kgm

$S_3 = 0$

(H5) $x = 0.58^m$

		-9940
15100×0.58	$=$	8760
$-\frac{7110 \times 0.58^2}{2}$	$=$	-1200
		$M_{H5} = -2380$ kgm

$-7110 \times 0.58 = -4120$ (15100)
$S_{H5} = 10980$ kg

(H6) $x = 4.35 - 0.80 = 3.55^m$

		-9940
15100×3.55	$=$	53600
$-\frac{7110 \times 3.55^2}{2}$	$=$	-44730
		$M_{H6} = -1070$ kgm

$-7110 \times 3.55 = -25200$ (15100)
$S_{H6} = -10100$ kg

軸力 $N_{BC} = -S_{B1} = 9860$ kg.C.

側壁 AB.

任意1点に於ける剪力 $S_x = S_{B1} + \frac{qx^2}{2h} + px = -9860 + \frac{4160x^2}{2 \times 5.12} + 2440x$

$= 406x^2 + 2440x - 9860$

0 Shear. $x^2 + 6.01x - 24.3 = 0$

$x = -\frac{6.01}{2} \pm \frac{\sqrt{6.01^2 + 4 \times 24.3}}{2} = 2.77^m$

任意1点に於ける曲率 $M_x = -S_{B1}x - \frac{px^2}{2} - \frac{qx^3}{6h} + M_B$

$= 9860x - 1220x^2 - \frac{4160}{6 \times 5.12}x^3 - 9940$

$= -135.5x^3 - 1220x^2 + 9860x - 9940$

	x	$-135.5x^3 - 1220x^2 + 9860x - 9940 = M$	$406x^2 + 2440x - 9860 = S$
(H4)	0.61^m	$-30 - 450 + 6020 - 9940 = -4400$ kgm	$150 + 1490 - 9860 = -8220$ kg
(M2)	2.77	$-2880 - 9360 + 27300 - 9940 = 5120$	$3110 + 6750 - 9860 = 0$
(H3)	4.31	$-10820 - 22650 + 42500 - 9940 = -910$	$7640 + 10510 - 9860 = 8290$

軸力 $N_{AB} = S_{B2} = 15100$ kg.C.

中央柱 CD.

軸力 $N_{CD} = -2S_{C2} = 2 \times 15820 = 31640$ kg.C.

柱の間隔を 2.5m c to c とスレバ 柱一本当荷重

$= 2.5 @ 31640 = 79100$ kg.C.

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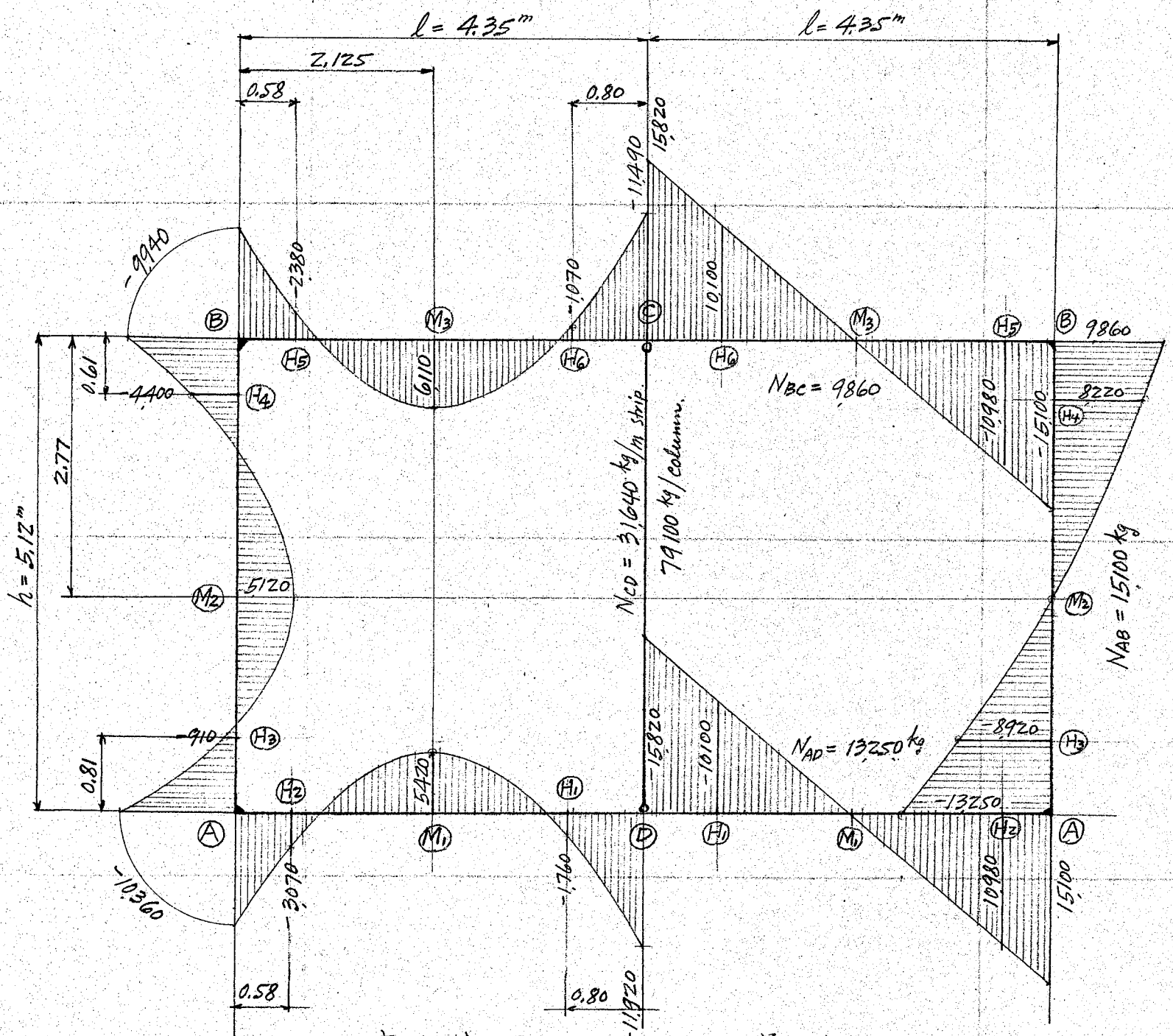
上海標準隧道

彎曲率及剪力圖



彎曲率圖 1/50m = 10,000 kgm
剪力圖 1/50m = 10,000 kg
縮尺 1:60

Note
M1, M2, M3 ---- Points of Max. moment.
H1, H2 ~ H6 ---- End of each haunch.

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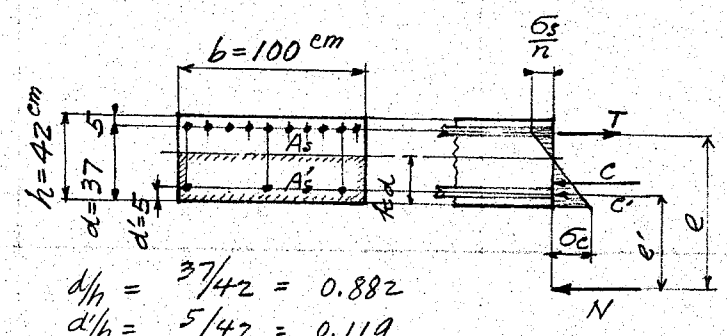
上海標準隧道

断面應力ノ計算

下床 AD.

(M1) M = 5420 kgm , N = 13250 kg.c. , S = 0



$d/h = 37/42 = 0.882$
$d'/h = 5/42 = 0.119$
$p_0 = \frac{As}{bh} = \frac{20.1}{100\times42} = 0.00479$
$p_0' = \frac{As'}{bh} = \frac{5.0}{100\times42} = 0.00119$
$u/h = 0.518$
$u = 21.8$ cm
$d-u = 15.2$ cm

$\frac{M}{N} = \frac{5420\times100}{13250} = 40.9$ cm
$d-u = 15.2$
$e = 56.1$ cm
$e' = e - 32 = 24.1$ "
$e'/e = 24.1/56.1 = 0.430$
$\frac{Ne}{bd^2} = \frac{13250\times56.1}{100\times37^2} = 5.440$
$\frac{Ne}{bd^2\sigma_c} = 0.203$, $k = 0.440$
$\sigma_c = \frac{5.440}{0.203} = 26.8$ kg/cm²
$\sigma_s = n\sigma_c \frac{1-k}{k} = 15\times26.8\frac{1-.44}{.44} = 521$ kg/cm²
$\tau = 0$

$b = 100$ cm, $h = 42$ cm
$d = 37$ cm, $d' = 5$ cm
$As = 10-16\phi = 20.1$ cm²
$As' = 2.5-16\phi = 5.0$ "
$p = \frac{As}{bd} = \frac{20.1}{100\times37} = 0.00544$
$p' = \frac{As'}{bd} = \frac{5.0}{100\times37} = 0.00136$
$d'/d = 5/37 = 0.135$

(D) M = −11920 kgm , N = 13250 kg.c., S = 15820 kg

$d/h = 63/68 = 0.926$
$d'/h = 5/68 = 0.074$
$p_0 = \frac{20.1}{100\times68} = 0.00296$
$p_0' = \frac{5.0}{100\times68} = 0.00074$
$u/h = 0.511$
$u = 34.7$
$d-u = 28.3$

$\frac{M}{N} = \frac{11920\times100}{13250} = 90.0$
$d-u = 28.3$
$e = 118.3$ cm
$e' = e-58 = 60.3$
$e'/e = 60.3/118.3 = 0.510$
$\frac{Ne}{bd^2} = \frac{13250\times118.3}{100\times63^2} = 3.950$
$\frac{Ne}{bd^2\sigma_c} = 0.158$, $k = 0.350$
Concrete stress $\sigma_c = \frac{3.950}{0.158} = 25.0$ kg/cm²
Steel " $\sigma_s = 15\times25.0\times\frac{1-.35}{.35} = 697$ "
shear " $\tau = \frac{15820}{100\times.883\times63} = 2.9$ "
bond " $\tau_0 = \frac{1}{2}\frac{15820}{5.03\times10\times.883\times63} = 2.8$ " (Bent up bar ヲ使用セル場合 Shear ヲ半数ハ採ル次ノ如シ)

$b = 100$, $h = 42+\frac{80}{3} = 68$
$d = 63$, $d' = 5$
$As = 10-16\phi = 20.1$ cm²
$As' = 2.5-16\phi = 5.0$ "
$p = \frac{20.1}{100\times63} = 0.0032$
$p' = \frac{5.0}{100\times63} = 0.0008$
$d'/d = 5/63 = 0.080$

(A) M = −10360 kgm, N = 13250 kg.c. S = −15100 kg

$d/h = 56/61 = 0.918$
$d'/h = 5/61 = 0.082$
$p_0 = \frac{20.1}{100\times61} = 0.00330$
$p_0' = \frac{5.0}{100\times61} = 0.00082$
$u/h = 0.512$
$u = 31.2$ cm
$d-u = 24.8$

$\frac{M}{N} = \frac{10360\times100}{13250} = 78.3$
$d-u = 24.8$
$e = 103.1$ cm
$e' = e-51 = 52.1$
$e'/e = \frac{52.1}{103.1} = 0.505$
$\frac{Ne}{bd^2} = \frac{13250\times103.1}{100\times56^2} = 4.355$
$\frac{Ne}{bd^2\sigma_c} = 0.165$, $k = 0.355$

$b = 100$, $h = 42+\frac{58}{3} = 61$
$d = 56$, $d' = 5$
$As = 10-16\phi = 20.1$
$As' = 2.5-16\phi = 5.0$
$p = \frac{20.1}{100\times56} = 0.00359$
$p' = \frac{5.0}{100\times56} = 0.00089$
$d'/d = 5/56 = 0.089$

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上海標準隧道

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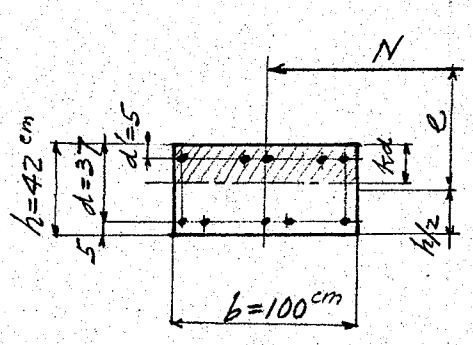
$$\sigma_c = \frac{4.355}{0.165} = 26.4 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 26.4 \times \frac{1-.355}{.355} = 719 \text{ "}$$

$$\tau = \frac{15100}{100 \times .882 \times 56} = 3.0 \text{ "}$$

$$\tau_0 = \frac{1}{2} \frac{15100}{5.03 \times 10 \times .882 \times 56} = 3.0 \text{ "}$$

(H1) $M = -1760$ kgm $N = 13250$ kg.c. $S = 10100$ kg.



$$e = \frac{M}{N} = \frac{1760 \times 100}{13250} = 13.3$$

$$d'/h = 5/42 = 0.119$$

$$e/h = 13.3/42 = 0.318$$

$k = 0.645$, $C = 0.51$

$b = 100$, $h = 42$
$d = 37$, $d' = 5$
$A_s = A_s' = 5-16\phi = 10.1$ cm²
$p_0 = p_0' = \frac{10.1}{100 \times 42} = 0.00241$

$$\sigma_c = \frac{N}{bhC} = \frac{13250}{100 \times 42 \times 0.51} = 6.2 \text{ kg/cm}^2$$

$$\sigma_s = n\sigma_c \frac{1-k-d'/h}{k} = 15 \times 6.2 \frac{1-0.645-0.119}{0.645} = 34 \text{ kg/cm}^2$$

$$\tau \fallingdotseq \frac{10100}{100 \times \frac{7}{8} \times 37} = 3.1 \text{ kg/cm}^2$$

$$\tau_0 = \frac{1}{2} \times \frac{10100}{5.03 \times 7.5 \times \frac{7}{8} \times 37} = 4.1 \text{ "}$$ (下面主鉄筋が 7.5 本ﾄｯﾌﾟ筋と lap ﾌﾗｲｽﾞ)

(H2) $M = -3070$ kgm, $N = 13250$ kg.c. $S = 10,980$ kg

$d/h = 37/42 = 0.880$
$d'/h = 5/42 = 0.119$
$p_0 = \frac{15.1}{100 \times 42} = 0.00359$
$p_0' = \frac{10.1}{100 \times 42} = 0.00240$
$u/h = 0.506$
$u = 21.3$
$d-u = 15.7$

$$\frac{M}{N} = \frac{3070 \times 100}{13250} = 23.2$$

$d-u = 15.7$
$e = 38.9$ cm
$e' = e - 32 = 6.9$
$e'/e = 6.9/38.9 = 0.178$

$$\frac{Ne}{bd^2} = \frac{13250 \times 38.9}{100 \times 37^2} = 3.77$$

$$\frac{Ne}{bd^2\sigma_c} = 0.238 \quad k = 0.510$$

$b = 100$, $h = 42$
$d = 37$, $d' = 5$
$A_s = 7.5-16\phi = 15.1$ cm²
$A_s' = 5-16\phi = 10.1$ "
$p = \frac{15.1}{100 \times 37} = 0.00408$
$p' = \frac{10.1}{100 \times 37} = 0.00273$
$d'/d = 5/37 = 0.135$

$$\sigma_c = \frac{3.77}{0.238} = 15.8 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 15.8 \times \frac{.49}{.51} = 228 \text{ "}$$

$$\tau \fallingdotseq \frac{10980}{100 \times \frac{7}{8} \times 37} = 3.4 \text{ "}$$

$$\tau_0 \fallingdotseq \frac{1}{2} \cdot \frac{10980}{5.03 \times 7.5 \times \frac{7}{8} \times 37} = 4.5 \text{ "}$$

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上海標準隧道

上床 BC.

(M3) $M = 6110$ kgm, $N = 9860$ kg, $S = 0$

$\frac{M}{N} = \frac{6110 \times 100}{9860} = 62.0$

$d-u$ = 15.2

e = 77.2 cm

$e' = e - 32$ = 45.2 〃

e'/e = 0.586

$\frac{Ne}{bd^2} = \frac{9860 \times 77.2}{100 \times 37^2} = 5.560$

$\frac{Ne}{bd^2\sigma_c} = 0.185$, $k = 0.40$

$\sigma_c = \frac{5.560}{0.185}$ = 30.1 kg/cm²

$\sigma_s = 15 \times 30.1 \times \frac{.60}{.40}$ = 677 〃

$\tau = 0$

断面ハ (M1) ニ全ジ
(第7頁参照)

(H5) 及 (H6) ハ夫々 (H3) 及 (H1) ト同一断面ヲ使用スルガ故ニ省略ス

(B) $M = -9940$ kgm, $N = 9860$ kg, c, $S = 15100$ kg

$\frac{M}{N} = \frac{9940 \times 100}{9860} = 100.7$

$d-u$ = 24.8

e = 125.5 cm

$e' = e - 51$ = 74.5 〃

e'/e = 0.594

$\frac{Ne}{bd^2} = \frac{9860 \times 125.5}{100 \times 56^2} = 3.950$

$\frac{Ne}{bd^2\sigma_c} = 0.159$, $k = 0.335$

$\sigma_c = \frac{3.950}{0.159}$ = 24.9 kg/cm²

$\sigma_s = 15 \times 24.9 \times \frac{.665}{.335}$ = 742 〃

$\tau = \frac{15100}{100 \times .888 \times 56}$ = 3.0 〃

$\tau_0 = \frac{1}{2} \cdot \frac{15100}{5.03 \times 10 \times .888 \times 56}$ = 3.0 〃

断面ハ (A) ニ全ジ
(第7頁参照)

(C) $M = -11490$ kgm, $N = 9860$ kg, c, $S = -15820$ kg

$\frac{M}{N} = \frac{11490 \times 100}{9860} = 116.5$

$d-u$ = 28.3

e = 144.8 cm

$e' = e - 58$ = 86.8 〃

$e'/e = 86.8/144.8$ = 0.60

$\frac{Ne}{bd^2} = \frac{9860 \times 144.8}{100 \times 63^2} = 3.600$

$\frac{Ne}{bd^2\sigma_c} = 0.153$ $k = 0.320$

断面ハ (D) ニ全ジ
(第7頁参照)

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上海標準隧道

$\sigma_c = \frac{3.600}{0.153} = 23.5$ kg/cm²

$\sigma_s = 15 \times 23.5 \times \frac{.68}{.32} = 751$ "

$\tau = \frac{15820}{100 \times .893 \times 63} = 2.8$ "

$\tau_0 = \frac{1}{2} \times \frac{15820}{5.03 \times 10 \times .893 \times 63} = 2.8$ "

側壁 AB.

(M2) $M = 5120$ kgm. $N = 15100$ kg. $S = 0$.

$d/h = 31/36 = 0.861$
$d'/h = 5/36 = 0.139$
$p_0 = \frac{20.1}{100 \times 36} = 0.00558$
$p_0' = 0.00279$
$u/h = 0.518$
$u = 18.70$
$d-u = 12.3$ cm

$\frac{M}{N} = \frac{5120 \times 100}{15100} = 33.9$
$d-u = 12.3$
$e = 46.2$ cm
$e' = e - 26 = 20.2$
$e'/e = 0.438$
$\frac{Ne}{bd^2} = \frac{15100 \times 46.2}{100 \times 31^2} = 7.260$
$\frac{Ne}{bd^2\sigma_c} = 0.225$, $k = 0.465$

$\sigma_c = \frac{7.260}{0.225} = 32.3$ kg/cm²
$\sigma_s = 15 \times 32.3 \times \frac{.535}{.465} = 555$ "
$\tau = 0$

$b = 100$. $h = 36$
$d = 31$, $d' = 5$
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 5-16\phi = 10.1$ "
$p = \frac{20.1}{100 \times 31} = 0.00648$
$p' = \frac{10.1}{100 \times 31} = 0.00324$
$d'/d = 5/31 = 0.161$

(A) $M = -10360$ kgm, $N = 15100$ kg. $S = 13250$ kg

$d/h = 58/63 = 0.920$
$d'/h = 5/63 = 0.0793$
$p_0 = \frac{20.1}{100 \times 63} = 0.00319$
$p_0' = 0.00080$
$u/h = 0.512$
$u = 32.2$ cm
$d-u = 25.8$ cm

$\frac{M}{N} = \frac{10360 \times 100}{15100} = 68.6$
$d-u = 25.8$
$e = 94.4$ cm
$e' = e - 53 = 41.4$
$e'/e = 0.439$
$\frac{Ne}{bd^2} = \frac{15100 \times 94.4}{100 \times 58^2} = 4240$
$\frac{Ne}{bd^2\sigma_c} = 0.174$ $k = 0.370$

$\sigma_c = \frac{4.240}{0.174} = 24.4$ kg/cm²
$\sigma_s = 15 \times 24.4 \times \frac{.630}{.370} = 623$ "
$\tau = \frac{13250}{100 \times .877 \times 58} = 2.6$ "
$\tau_0 = \frac{1}{2} \times \frac{13250}{5.03 \times 10 \times .877 \times 58} = 2.6$ "

$b = 100$, $h = 36 + \frac{81}{3} = 63$ cm
$d = 58$, $d' = 5$
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 2.5-16\phi = 5.0$ "
$p = \frac{20.1}{100 \times 58} = 0.00347$
$p' = 0.00087$
$d'/d = 5/58 = 0.0862$

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上海標準隧道

Ⓑ $M = -9940$ kgm, $N = 15100$ kg.c. $S = -9860$ kg.

$d/h = 51/56 = 0.910$
$d'/h = 5/56 = 0.089$
$p_0 = \frac{20.1}{100\times56} = 0.00359$
$p_0' = 0.00090$
$u/h = 0.515$
$u = 28.8$ cm
$d-u = 22.2$ cm

$\frac{M}{N} = \frac{9940\times100}{15100} = 65.8$
$d-u = 22.2$
$e = 88.0$ cm
$e' = e-46 = 42.0$ 〃
$e'/e = 0.477$
$\frac{Ne}{bd^2} = \frac{15100\times88.0}{100\times51^2} = 5.110$
$\frac{Ne}{bd^2\sigma_c} = 0.178$, $k = 0.380$

$\sigma_c = \frac{5.110}{0.178} = 28.7$ kg/cm²
$\sigma_s = 15\times28.7\times\frac{.620}{.380} = 703$ 〃
$\tau = \frac{9860}{100\times.873\times51} = 2.2$ 〃
$\tau_0 = \frac{1}{2}\frac{9860}{5.03\times10\times.873\times51} = 2.2$ 〃

$b=100$, $h = 36+\frac{6}{3} = 56$ cm
$d=51$, $d'=5$
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 2.5-16\phi = 5.0$ 〃
$p = \frac{20.1}{100\times51} = 0.00394$
$p' = 0.00098$
$d'/d = 5/51 = 0.098$

Ⓗ4 $M = -4400$ kgm, $N = 15100$ kg.c. $S = -8220$ kg.

$e = \frac{M}{N} = \frac{4400\times100}{15100} = 29.1$ cm
$e/h = 29.1/36 = 0.810$
$d'/h = 5/36 = 0.139$
$k = 0.370$, $C = 0.141$
$\sigma_c = \frac{15100}{100\times36\times0.141} = 29.8$ kg/cm²
$\sigma_s = 15\times29.8\times\frac{1-0.370-0.139}{0.370} = 593$ 〃
$\tau = \frac{8220}{100\times.877\times31} = 3.0$ 〃
$\tau_0 = \frac{1}{2}\times\frac{8220}{5.03\times7.5\times.877\times31} = 4.0$ 〃

$b=100$, $h=36$
$d=31$, $d'=5$
$A_s = A_s' = 7.5-16\phi = 15.07$
$p_0 = p_0' = \frac{15.07}{100\times36} = 0.00419$

Ⓗ3 $M = -910$ kgm, $N = 15100$ kg.c $S = 8920$ kg.

$\tau = \frac{8920}{100\times7/8\times31} = 3.3$ kg/cm²
$\tau_0 = \frac{1}{2}\times\frac{8920}{5.03\times7.5\times.877\times31} = 4.4$ 〃

断面 Ⓗ4 = 含む

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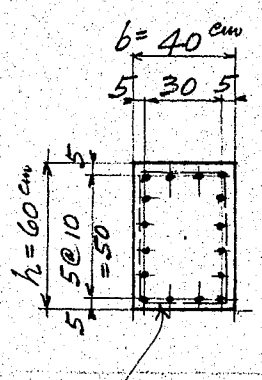
上海標準隧道

中央柱 C D. (間隔 2.5m c to c)



中央柱 最大荷重 79,100
柱自重 0.40×0.60×4.7 @2400= 2700
N= 81800 kg.c.

As = 16-16φ = 32.2 cm²
Ac = 40×60 = 2400 cm²
Ai = 32.2×15 + 2400 = 2883 cm²

σc = 81800/2883 = 28.4 kg/cm²c
σs' = 15×28.4 = 426 〃 .c
τ = 0

中央部上下縦桁

支間 2.5m, continuous beam. トス

荷重 w = 3,640 kg/m (第6頁参照)
最大正曲率 $M_c = \frac{wl^2}{14} = \frac{3640\times2.50^2}{14} = +1410$ kgm 中央
最大負 〃 $M_s = -\frac{wl^2}{10} = -\frac{3640\times2.50^2}{10} = -1975$ 〃 両側支点
剪力 $S = \frac{wl}{2} = \frac{3640\times2.50}{2} = 3960$ kg 〃

柱両側面に於ける縦桁の曲率.

$\frac{wl}{2}\times0.30 = 3960\times0.30 = 1188$
$-\frac{w\times0.30^2}{2} = -\frac{3640\times0.30^2}{2} = -164$
$M_s = -1975$
$M_{CF} = -930$ kgm

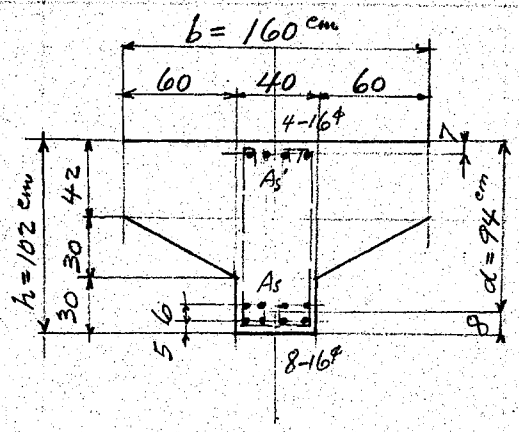
仍上 剪力.

$S_{CF} = S - 0.30w = 3960 - 0.30\times3640 = 3010$ kg

上部縦桁.

中央 断面.

$M_c = 1411$ kgm, $S = 0$



b = 160cm(假定), h = 102, d = 94, d' = 7
As = 8-16φ = 16.10 cm² p = 16.10/160×94 = 0.00107
A's = 4-16φ = 8.05 〃 p' = 8.05/ 〃 〃 = 0.00053
d'/d = 7/94 = 0.075
k = 0.180, Lc = 0.091, Ls = 0.0010

$\sigma_c = \frac{M}{bd^2L_c} = \frac{1411\times100}{160\times94^2\times0.091} = 1.10$ kg/cm²c
$\sigma_s = \frac{M}{bd^2L_s} = \frac{1411\times100}{160\times94^2\times0.0010} = 100$ 〃 T.
τ = 0

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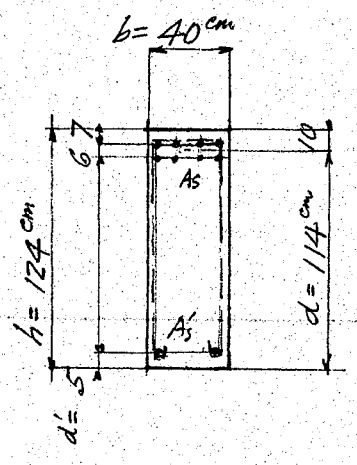
上海標準隧道

支点断面

$M_S = -19,750\ kgm$, $S = 39,600\ kg$

$b = 40\ cm$, $h = 102 + \frac{35+30}{3} = 124\ cm$, $d = 114\ cm$, $d' = 5\ cm$.



$A_s = 8-16\phi = 16.10\ cm^2$ $p = 16.10/40\times114 = 0.00353$
$A_s' = 2-16\phi = 4.00\ "$ $p' = 4.0/\ "\ = 0.00088$
$d'/d = 5/114 = 0.044$

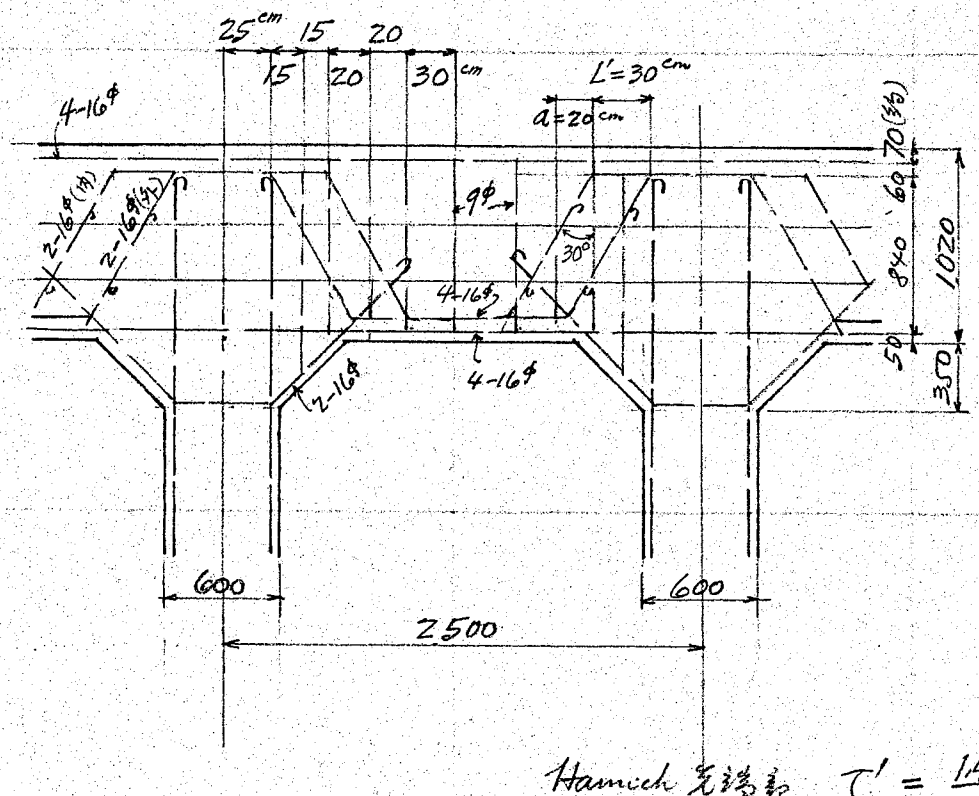
$k = 0.270$, $L_c = 0.135$, $L_s = 0.00327$

$\sigma_c = \frac{19750\times100}{40\times114^2\times0.135} = 28.1\ kg/cm^2$

$\sigma_s = \frac{19750\times100}{40\times114^2\times0.00327} = 1163\ "$

$\tau = \frac{39600}{40\times0.910\times114} = 9.5\ "$

$\tau_0 = \frac{39600}{5.03\times8\times0.910\times114}\times\frac{1}{2} = 4.7\ "$



腹鉄筋ノ抵抗劣力.

$\theta = 45° - 30° = 15°$

$V = 1.41\cos15°A_6\sigma_s + A_s\sigma_s$

腹鉄筋ノ抵抗ヲ除ク剪應力

$\tau' = \frac{1.41\cos15°A_6\sigma_s}{L'b_0} + \frac{A_s\sigma_s}{ab_0}$

茲ニ

$\cos15° = 0.966$
$A_6 = 2-16\phi = 4.02\ cm^2$
$A_s = 2-9\phi = 1.27\ "$
$a = 20\ cm$ (垂直肋筋間隔)
$L' = 30\ cm$ (曲鉄筋ノ水平間隔)
$b_0 = 40\ cm$ (桁ノ巾員)

Hamiech 先端部 $\tau' = \frac{1.41\times0.966\times4.02\times1200}{30\times40} + \frac{1.27\times1200}{20\times40}$

$= 5.47 + 1.91 = 7.38\ kg/cm^2$

ハウンチ先端ニ於ケル剪力.

$S_h = S - 0.65w = 39600 - 0.65\times31640 = 18000\ kg$

剪應力 $\tau = \frac{18000}{40\times\frac{7}{8}\times94} = 5.5\ kg/cm^2 < 7.38$

柱側面

$\tau' = 5.47 + \frac{1.27\times1200}{15\times40} = 5.47 + 2.54 = 8.01\ kg/cm^2$

$h_0 = 102 + \frac{35}{3} = 114\ cm$
$d = 114 - 10 = 104$

剪力 $S_{cf} = 30100$

剪應力 $\tau = \frac{30100}{40\times0.9\times104} = 8.0 \fallingdotseq \tau'$

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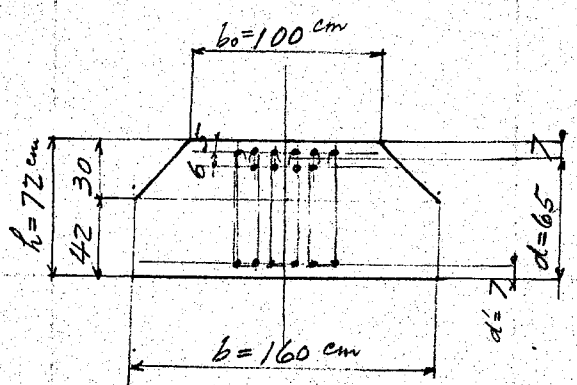
上海標準隧道

下部経桁 中央断面



$M = 14110$ kgm , $S = 0$

$b = 160$ cm, $b_0 = 100$ cm

$h = 72$ cm, $d = 65$ cm $d' = 7$ cm

$A_s = 10 - 16\phi = 20.1$ cm² $p = 20.1/160 \times 65 = 0.00193$

$A_s' = 6 - 16\phi = 12.1$ 〃 $p' = 12.1/〃 = 0.00116$

$d'/d = 7/65 = 0.108$

$k = 0.210$, $L_c = 0.104$, $L_s = 0.0018$

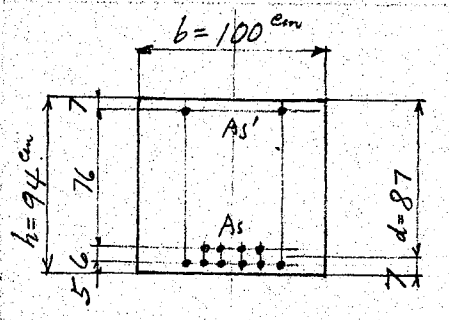
$$\sigma_c = \frac{14110 \times 100}{160 \times 65^2 \times 0.104} = 20.1 \text{ kg/cm}^2$$

$$\sigma_s = \frac{14110 \times 100}{160 \times 65^2 \times 0.0018} = 1160 \text{ 〃}$$

$\tau = 0$

支点断面

$M = -19,750$ kgm $S = 39,600$ kg



$b = 100$, $h = 72 + \frac{35+30}{3} = 94$ cm

$d = 87$ cm , $d' = 7$ cm

$A_s = 10 - 16\phi = 20.1$ cm² $p = 20.1/100 \times 87 = 0.00231$

$A_s' = 2 - 16\phi = 4.0$ 〃 $p' = 4.0/〃 = 0.00046$

$d'/d = 7/87 = 0.081$

$k = 0.230$, $L_c = 0.111$, $L_s = 0.0022$

$$\sigma_c = \frac{19750 \times 100}{100 \times 87^2 \times 0.111} = 23.5 \text{ kg/cm}^2$$

$$\sigma_s = \frac{19750 \times 100}{100 \times 87^2 \times 0.0022} = 1185 \text{ 〃}$$

$$\tau = \frac{39600}{100 \times 0.923 \times 87} = 4.9 \text{ 〃}$$

$$\tau_0 = \frac{39600}{5.03 \times 10 \times .923 \times 87} \times \frac{1}{2} = 4.9 \text{ 〃}$$

腹鉄筋ノ抵抗劈裂力

$$\tau' = \frac{1.41 A_b \sigma_s}{L' b_0} + \frac{A_s \sigma_s}{a b_0} = \frac{1.41 \times \overset{2-16\phi}{4.02} \times 1200}{30 \times 100} + \frac{\overset{3-12\phi\ (2本+4本ノ平均)}{3.39} \times 1200}{20 \times 100}$$

$$= 2.27 + 2.03 = 4.30 \text{ kg/cm}^2$$

ハウンチ先端ニ於ケル劈力 $S_h = 18,000$ kg

劈裂力 $\tau = \frac{18000}{100 \times 7/8 \times 65} = 3.2 \text{ kg/cm}^2 < 4.30$

柱側面 $\tau' = 2.27 + \frac{3.39 \times 1200}{15 \times 100} = 2.27 + 2.71 = 4.98$ kg/cm²

劈裂力 $\tau = \frac{30100}{100 \times 7/8 \times 77} = 4.5 \text{ kg/cm}^2 < 4.98$ $h = 72 + \frac{35}{3} = 84$ $d = 77$

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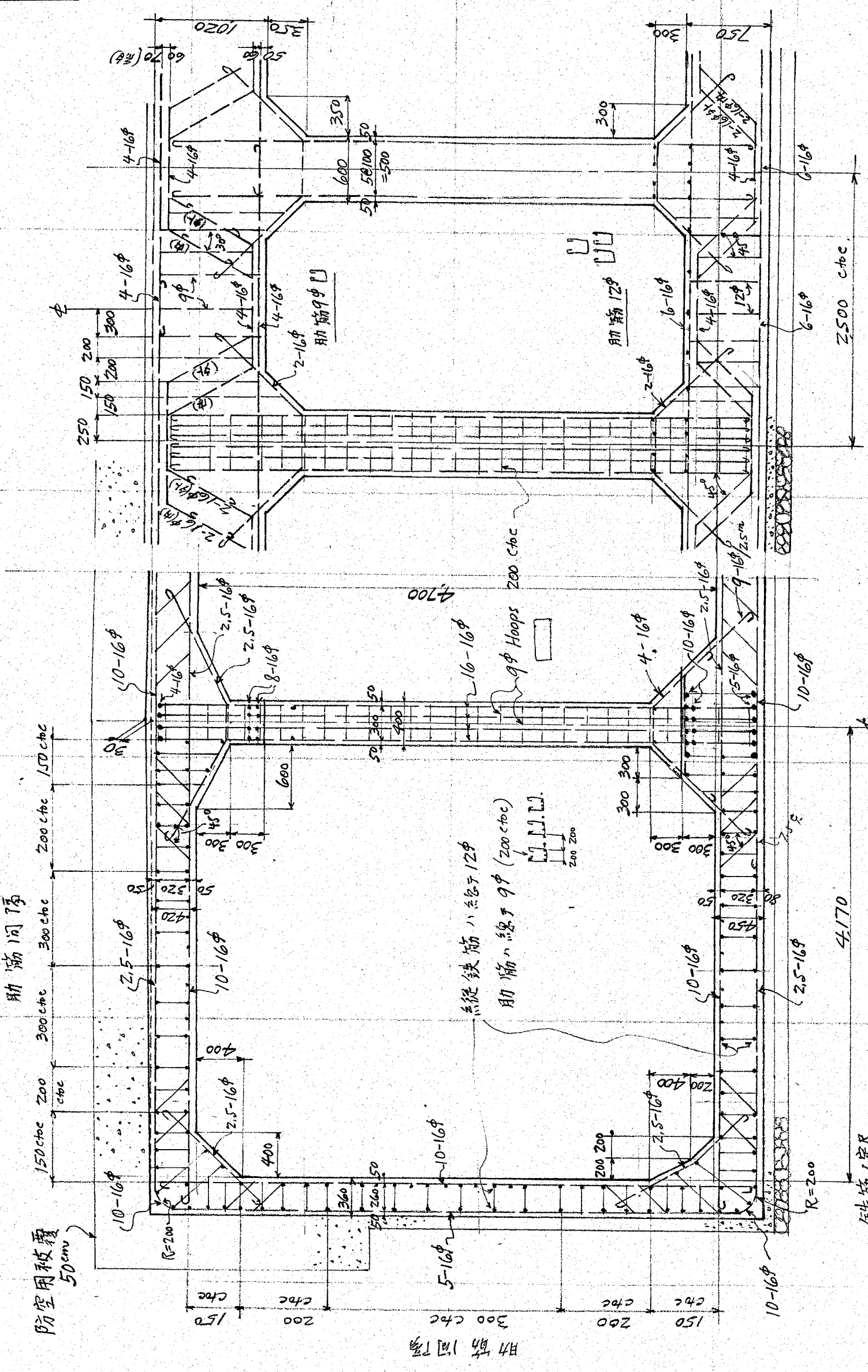
上海標準隧道

配筋圖



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設計　日付　類別

照査　日付　第　頁

上海高速鐵道
鐵筋混凝土標準型複線隧道
土被四米 應力計算書

Standard Reinforced Concrete Tunnel.
Double Track
Mark S.C.T. 4.

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設計 稲葉 日付 16-5-23 類別 S.C.T.4
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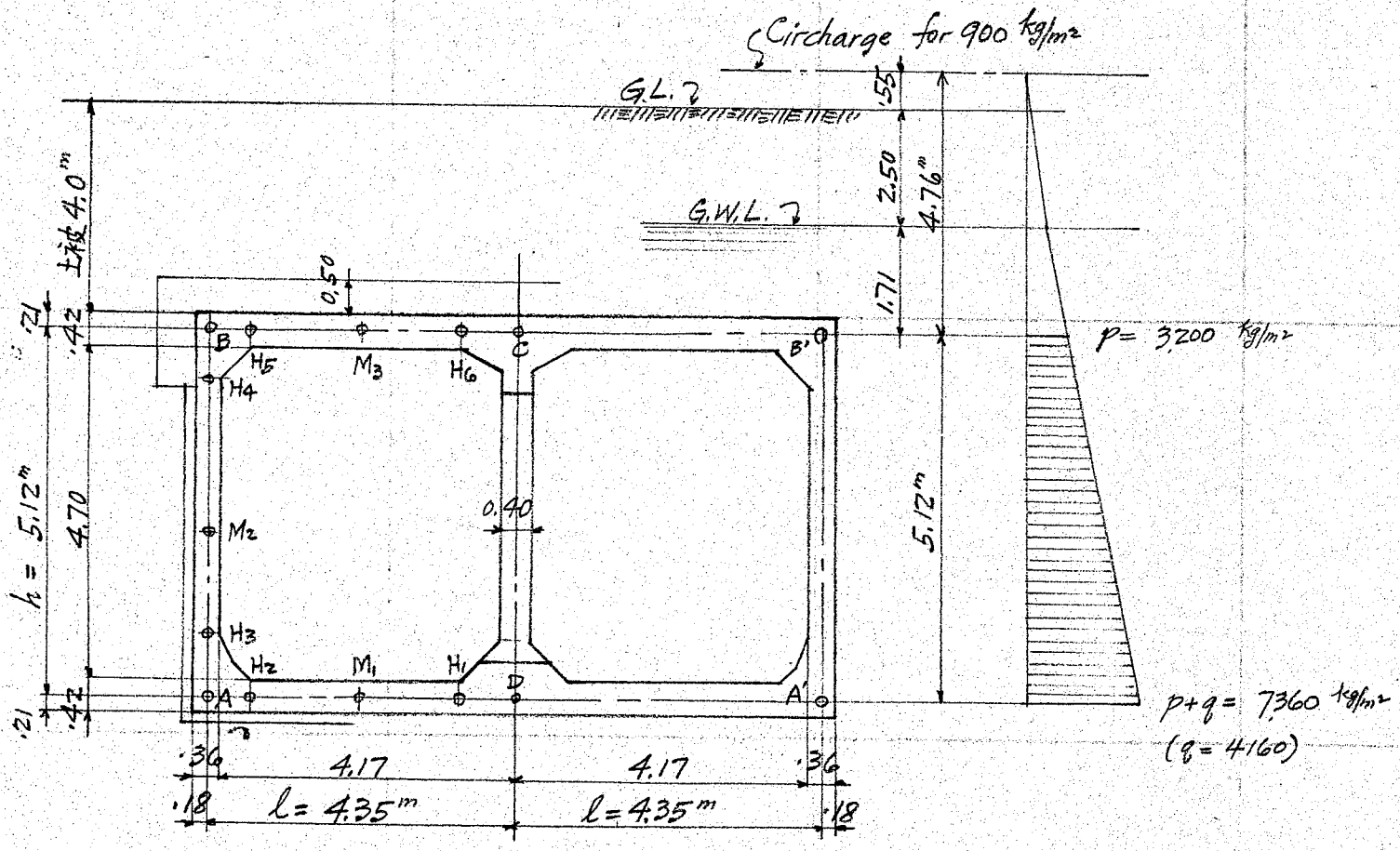
上海高速鉄道 鉄筋混凝土標準隧道

土被 4.0m 標準隧道 S.C.T.4



上床荷重 w

土被	地下水位以上	2.50m @ 1600	=	4000
〃	〃 以下	1.00 @ 2000	=	2000
被覆混凝土		0.50 @ 2200	=	1100
上床		0.42 @ 2400	=	1010
				8110
路面傳布荷重				900
			w =	9010 kg/m²

下床荷重　上床荷重ト同一ト假定ス

側壁荷重

B, B'点ニ於ケル荷重

土被	2.50m @ 1600	=	4000
〃	1.50 @ 2000	=	3000
路面荷重			900
	7900 × 0.406	=	3200 kg/m² = p

A, A'点ニ於ケル荷重

5.12 @ 2000	= 10240 × 0.406	=	4160 〃 = q
			7360 kg/m² = p+q

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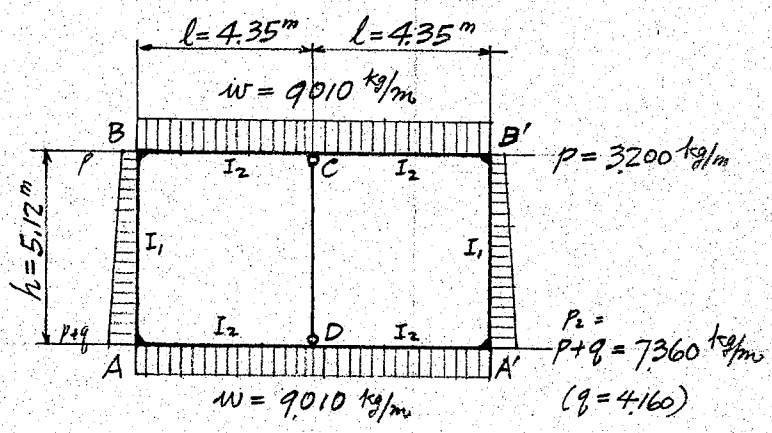
上海標準隧道

荷重狀態



第3頁參照.

$I_1 = 0.00389\ m^4$ $k_1 = 0.00076$

$I_2 = 0.00617\ m^4$ $k_2 = 0.00142$

$k = 1.868$

$12(1+2k) = 12(1+3.736) = 56.832$

$1+3k = 1+5.604 = 6.604$

$wl^2 = 9010 \times 4.35^2 = 170,500$

$61k_1 + 12k_2 = 0.0464 + 0.0170 = 0.0634$

$59k_1 + 8k_2 = 0.0448 + 0.0114 = 0.0562$

$31k_1 + 7k_2 = 0.0236 + 0.0099 = 0.0335$

$29k_1 + 3k_2 = 0.0220 + 0.0043 = 0.0263$

$120(6k_1+k_2)(k_1+2k_2) = 120 \times 0.00598 \times 0.00360 = 0.00258$

$k_2h^2 = 0.00142 \times 5.12^2 = 0.0372$

上下床ノ荷重 w = 依ル 彎曲率

$$M_A = M_B = -\frac{wl^2}{12(1+2k)} = -\frac{170,500}{56.832} = -3,000\ kgm$$

$$M_C = M_D = -\frac{(1+3k)wl^2}{12(1+2k)} = -\frac{6.604 \times 170500}{56.832} = -19,800\ "$$

兩側壁ノ荷重 p 及ビ p+q = 依ル 彎曲率

$$M_A = -\frac{k_2h^2\{(61k_1+12k_2)(p+q)+(59k_1+8k_2)p\}}{120(6k_1+k_2)(k_1+2k_2)} = -\frac{0.0372\,(0.0634 \times 7360^{646.7} + 0.0562 \times 3200)}{0.00258} = -9,330\ kgm$$

$$M_B = -\frac{k_2h^2\{(59k_1+8k_2)(p+q)+(61k_1+12k_2)p\}}{120(6k_1+k_2)(k_1+2k_2)} = -\frac{0.0372\,(0.0562 \times 7360^{616.3} + 0.0634 \times 3200)}{0.00258} = -8,890\ kgm$$

$$M_C = \frac{k_2h^2\{(31k_1+7k_2')(p+q)+(29k_1+3k_2)p\}}{120(6k_1+k_2)(k_1+2k_2)} = \frac{0.0372\,(0.0335 \times 7360^{330.7} + 0.0263 \times 3200)}{0.00258} = 4,770\ kgm$$

$$M_D = \frac{k_2h^2\{(29k_1+3k_2)(p+q)+(31k_1+7k_2)p\}}{120(6k_1+k_2)(k_1+2k_2)} = \frac{0.0372\,(0.0263 \times 7360^{300.7} + 0.0335 \times 3200)}{0.00258} = 4,340\ kgm$$

上下床及左右側壁荷重=依ル合成彎曲率

	床荷重=依ル彎曲率	側壁荷重=依ル彎曲率	合成彎曲率
M_A	− 3,000 kgm	− 9330 kgm	− 12,330 kgm
M_B	− 3,000	− 8,890	− 11,890
M_C	− 19,800	+ 4,770	− 15,030
M_D	− 19,800	+ 4,340	− 15,460

剪力

上床 $S_{B2} = \frac{wl}{2} + \frac{M_C - M_B}{l} = \frac{9010 \times 4.35}{2} + \frac{-15030 + 11,890}{4.35} = 19570 - 720 = 18,850\ kg$

〃 $S_{C2} = -\frac{wl}{2} + \frac{M_C - M_B}{l} = -19570 - 720 = -20,290$

下床 $S_{A2} = -\frac{wl}{2} + \frac{M_A - M_D}{l} = -19570 + \frac{-12330 + 15460}{4.35} = -19570 + 720 = -18,850$

〃 $S_{D2} = \frac{wl}{2} + \frac{M_A - M_D}{l} = 19570 + 720 = 20,290$

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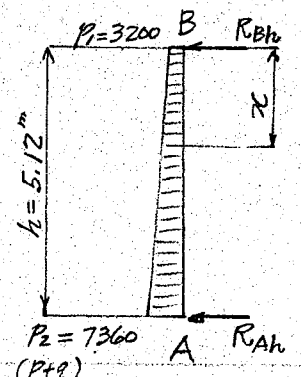
上海標準隧道

側壁



AB ヲ Simple Beam トスル支力.

$$R_{Ah} = \frac{h}{6}(2p_2 + p_1) = \frac{5.12}{6}(14720 + 3200) = 15280 \text{ kg}$$

$$R_{Bh} = \frac{h}{6}(2p_1 + p_2) = \frac{5.12}{6}(6400 + 7360) = 11740 \text{ "}$$

剪力.

$$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -11740 + \frac{-11890 + 12330}{5.12} = -11650 \text{ kg}$$

$$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 15280 + 90 = 15370 \text{ "}$$

中間点ニ於ケル彎曲率及剪力.

下床 AD.

(M1) 0 Shear ノ点 $x = -\frac{S_{A2}}{w} = \frac{18850}{9010} = 2.09 \text{ m}$ (A ヨリノ距離)

$$M_A = -12330$$
$$-S_{A2}x = 18850 \times 2.09 = 39400$$
$$-\frac{wx^2}{2} = -\frac{9010 \times 2.09^2}{2} = -19660$$
$$M_1 = 7410 \text{ kgm} \qquad S_1 = 0$$

(H1) $x = 4.35 - 0.80 = 3.55 \text{ m}$

$$M_A = -12330$$
$$-S_{A2}x = 18850 \times 3.55 = 66900 \qquad S_{A2} = -18850$$
$$-\frac{wx^2}{2} = -\frac{9010 \times 3.55^2}{2} = -56770 \qquad wx = 9010 \times 3.55 = 31950$$
$$M_{H1} = -2200 \text{ kgm} \qquad S_{H1} = 13100 \text{ kg}$$

(H2) $x = 0.58 \text{ m}$

$$-12330$$
$$18850 \times 0.58 = 10930$$
$$-\frac{9010 \times 0.58^2}{2} = -1510$$
$$M_{H2} = -2910 \text{ kgm}$$

$$-18850$$
$$9010 \times 0.58 = 5220$$
$$S_{H2} = -13630 \text{ kg}$$

軸力. $N_{AD} = S_{A1} = 15370 \text{ kg. C.}$

上床 BC

(M3) 0 Sheau ノ点 $x = \frac{S_{B2}}{w} = \frac{18850}{9010} = 2.09 \text{ m}$ (B ヨリノ距離)

$$M_B = -11890$$
$$S_{B2}x = 18850 \times 2.09 = 39400$$
$$-\frac{wx^2}{2} = -\frac{9010 \times 2.09^2}{2} = -19660$$
$$M_3 = 7850 \text{ kgm} \qquad S_3 = 0$$

(H5) $x = 0.58 \text{ m}$

$$-11890$$
$$18850 \times 0.58 = 10930$$
$$-\frac{9010 \times 0.58^2}{2} = -1510$$
$$M_{H5} = -2470 \text{ kgm}$$

$$18850$$
$$-9010 \times 0.58 = -5220$$
$$S_{H5} = 13630 \text{ kg}$$

上海標準隧道

(H6) $x = 4.35 - 0.80 = 3.55^m$

$$18850 \times 3.55 = 66900$$
$$-\frac{9010 \times 3.55^2}{2} = -56770$$
$$-11890$$
$$M_{H6} = -1760 \text{ kgm.}$$

$$-9010 \times 3.55 = -31950$$
$$18850$$
$$S_{H6} = -13100 \text{ kg}$$

軸力 $N_{BC} = -S_{B1} = 11650$ kg.C

側壁 AB.

任意ノ1点ニ於ケル剪力.

$$S_x = S_{B1} + \frac{qx^2}{2h} + px = -11650 + \frac{4160x^2}{2 \times 5.12} + 3200x$$
$$= 406x^2 + 3200x - 11650$$

O Shear ノ点.

$$x^2 + 7.88x - 28.70 = 0$$
$$x = -\frac{7.88}{2} \pm \frac{\sqrt{7.88^2 + 28.70 \times 4}}{2} = 2.71^m$$

任意ノ1点ニ於ケル彎曲率

$$M_x = -S_{B1}x - \frac{px^2}{2} - \frac{qx^3}{6h} + M_B$$
$$= 11650x - 1600x^2 - \frac{4160}{6 \times 5.12}x^3 - 11890$$
$$= -135.5x^3 - 1600x^2 + 11650x - 11890$$

	x	$-135.5x^3$	$-1600x^2$	$+11650x$	-11890		M_x
(H4)	0.61m	− 30	− 600	+ 7110	− 11890	=	−5410 kgm
(M2)	2.71	− 2700	− 11750	+ 31580	− 11890	=	5240
(H3)	4.31	−10820	− 29700	+ 50220	− 11890	=	−2190

	x	$406x^2$	$+3200x$	-11650		S_x
(H4)	0.61m	150	+ 1950	− 11650	=	−9550 kg
(M2)	2.71	2980	+ 8670	− 11650	=	0
(H3)	4.31	7530	+ 13790	− 11650	=	9670

軸力 $N_{AB} = S_{B2} = 18850$ kg.C

中央柱 CD.

軸力 $N_{CD} = -2S_{C2} = 20290 \times 2 = 40580$ kg.C/m. strip of tunnel

柱ノ間隔ヲ 2.5m C to C トスレバ

柱一本当荷重 = 2.5 @ 40580 = 101450 kg.C.

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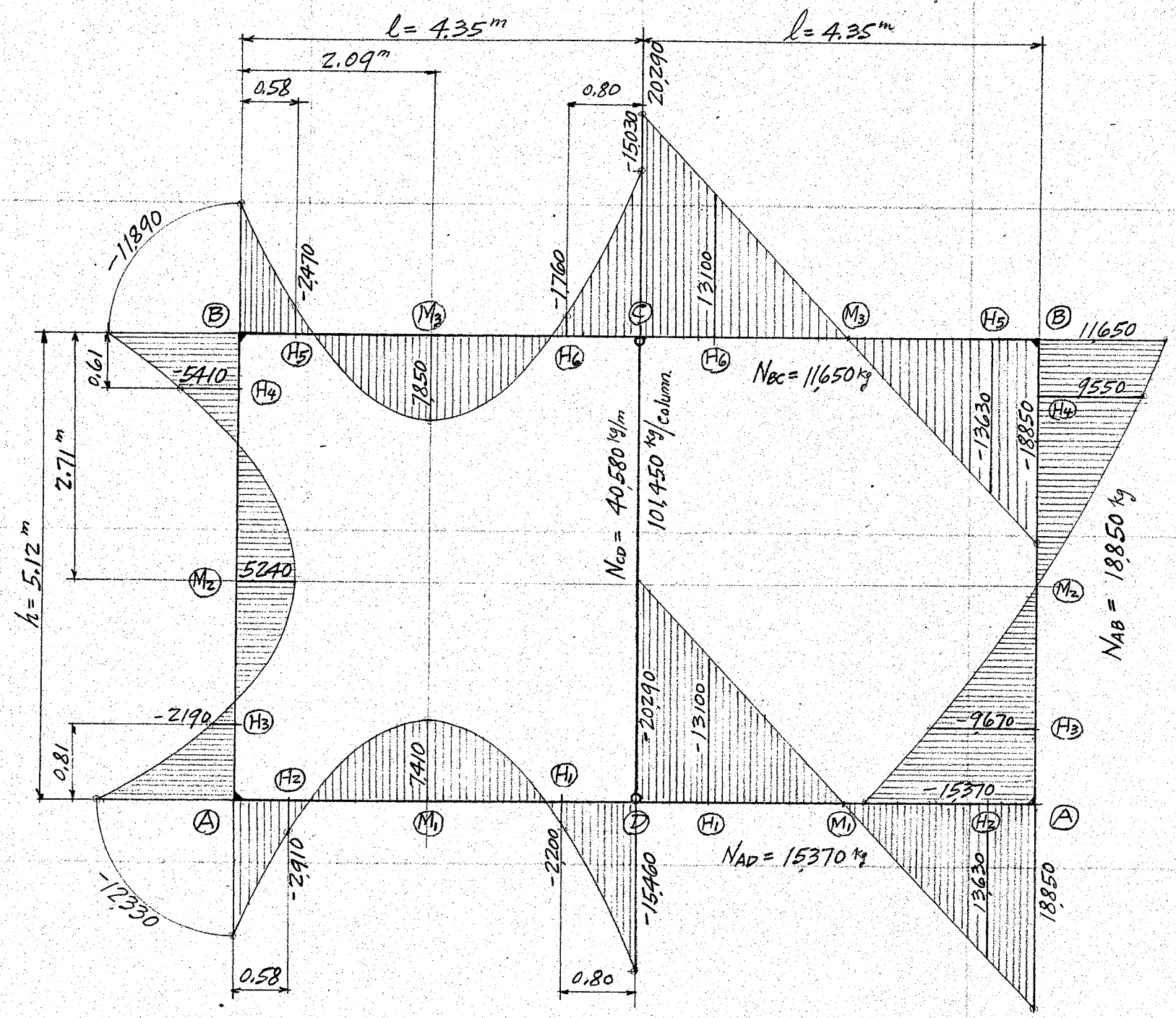
彎曲率及剪力圖



彎曲率圖　　剪力圖

$\frac{1}{50}$ m = 10,000 kgm　　$\frac{1}{50}$ m = 10,000 kg

縮尺 1:60

Note.

M_1, M_2, M_3. ---- Points of Max. moment.

H_1, H_2 ~ H_6 ---- End of each haunch.

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上海標準隧道

断面應力ノ計算

断面ハ特記セカル限リ総テ S.C.T3 型ニ合ス

下床 AD

Ⓜ $M = 7{,}410$ kgm, $N = 15{,}370$ kg, $S = 0$

断面ハ第7頁参照
$b = 100$, $h = 42$
$d = 37$, $d' = 5$
$A_s = 10 - 16\phi$
$A_s' = 2.5 - 16\phi$

$$\frac{M}{N} = \frac{7410 \times 100}{15370} = 48.2$$
$$d - u = 15.2$$
$$e = 63.4 \text{ cm}$$
$$e' = e - 32 = 31.4$$
$$e'/e = 0.496$$
$$\frac{Ne}{bd^2} = \frac{15370 \times 63.4}{100 \times 37^2} = 7.120$$
$$\frac{Ne}{bd^2\sigma_c} = 0.195, \quad k = 0.42$$
$$\sigma_c = \frac{7.120}{0.195} = 36.6 \text{ kg/cm}^2$$
$$\sigma_s = 15 \times 36.6 \times \frac{.58}{.42} = 758 \text{ "}$$
$$\tau = 0.$$

Ⓓ $M = -15{,}460$ kgm, $N = 15{,}370$ kg, $S = 20{,}290$ kg

$b = 100$, $h = 68$
$d = 63$, $d' = 5$
$A_s = 10 - 16\phi$
$A_s' = 2.5 - 16\phi$

$$\frac{M}{N} = \frac{15460 \times 100}{15370} = 100.6$$
$$d - u = 28.3$$
$$e = 128.9 \text{ cm}$$
$$e' = e - 58 = 70.9$$
$$e'/e = 0.550$$
$$\frac{Ne}{bd^2} = \frac{15370 \times 128.9}{100 \times 63^2} = 4.995$$
$$\frac{Ne}{bd^2\sigma_c} = 0.157, \quad k = 0.330$$
$$\sigma_c = \frac{4.995}{0.157} = 31.8 \text{ kg/cm}^2$$
$$\sigma_s = 15 \times 31.8 \times \frac{0.67}{0.33} = 970 \text{ "}$$
$$\tau = \frac{20290}{100 \times 0.890 \times 63} = 3.6 \text{ "}$$

Ⓐ $M = -12{,}330$ kgm, $N = 15{,}370$ kg, $S = -18850$ kg.

$b = 100$, $h = 61$
$d = 56$, $d' = 5$
$A_s = 10 - 16\phi$
$A_s' = 2.5 - 16\phi$

$$\frac{M}{N} = \frac{12330 \times 100}{15370} = 86.9$$
$$d - u = 24.8$$
$$e = 111.7 \text{ cm}$$
$$e' = e - 51 = 60.7$$
$$e'/e = 0.543$$
$$\frac{Ne}{bd^2} = \frac{15370 \times 111.7}{100 \times 56^2} = 5.475$$
$$\frac{Ne}{bd^2\sigma_c} = 0.164, \quad k = 0.345$$
$$\sigma_c = \frac{5.475}{0.164} = 33.4 \text{ kg/cm}^2$$
$$\sigma_s = 15 \times 33.4 \times \frac{.655}{.345} = 950 \text{ "}$$
$$\tau = \frac{18850}{100 \times 0.885 \times 56} = 3.8 \text{ "}$$

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上海標準隧道

(H1)　$M = -2200$ kgm, $N = 15370$ kg, $S = 13100$ kg

$\tau = \dfrac{13100}{100 \times 7/8 \times 37} = 4.1$ kg/cm²

$\tau_0 = \dfrac{13100}{5.03 \times 7.5 \times \frac{7}{8} \times 37} \times \frac{1}{2} = 5.4$ 〃

下面主鉄筋ガ7.5本トナル
故 lap ヲ長クシテ bond
Stress ヲ軽減スルコト

(H2)　$M = -2910$ kgm, $N = 15370$ kg, $S = -13630$ kg

$\tau = \dfrac{13630}{100 \times 7/8 \times 37} = 4.2$ kg/cm²

$\tau_0 = \dfrac{13630}{5.03 \times 7.5 \times \frac{7}{8} \times 37} \times \frac{1}{2} = 5.5$ 〃

$b = 100$, $h = 42$
$d = 37$, $d' = 5$
$A_s = 7.5 - 16\phi$
$A_s' = 5 - 16\phi$

上床 BC.

(M3)　$M = 7850$ kgm, $N = 11650$ kg, $S = 0$

断面ハ(M1)ニ全ジ
(第21頁参照)

$\dfrac{M}{N} = \dfrac{7850 \times 100}{11650} = 67.4$

$d - u = 15.2$

$e = 82.6$ cm

$e' = e - 32 = 50.6$

$e'/e = 0.613$

$\dfrac{Ne}{bd^2} = \dfrac{11650 \times 82.6}{100 \times 37^2} = 7.030$

$\dfrac{Ne}{bd^2\sigma_c} = 0.184$, $k = 0.390$

$\sigma_c = \dfrac{7.030}{0.184} = 38.2$ kg/cm²

$\sigma_s = 15 \times 38.2 \times \dfrac{0.61}{0.39} = 897$ 〃

$\tau = 0$

(H5)及(H6)ハ夫々(H2)及(H1)ト同一断面ヲ使用スレバ安全ナリ.

(B)　$M = 11890$ kgm, $N = 11650$ kg, $S = 18850$ kg

断面ハ(A)ニ全ジ
(第21頁参照)

$\dfrac{M}{N} = \dfrac{11890 \times 100}{11650} = 102.0$

$d - u = 24.8$

$e = 126.8$ cm

$e' = e - 51 = 75.8$ 〃

$e'/e = 0.597$

$\dfrac{Ne}{bd^2} = \dfrac{11650 \times 126.8}{100 \times 56^2} = 4.71$

$\dfrac{Ne}{bd^2\sigma_c} = 0.159$, $k = 0.335$

$\sigma_c = \dfrac{4.710}{0.159} = 29.6$ kg/cm²

$\sigma_s = 15 \times 29.6 \times \dfrac{0.665}{0.335} = 882$ 〃

$\tau = \dfrac{18850}{100 \times 0.888 \times 56} = 3.8$ 〃

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上海標準隧道

Ⓒ $M = 15030$ kgm, $N = 11650$ kg, $S = -20290$ kg　　断面 Ⓓ = 全

$\frac{M}{N} = \frac{15030 \times 100}{11650} = 129.0$
$d - u = 28.3$
$e = 157.3$ cm
$e' = e - 58 = 99.3$
$e'/e = 0.631$
$\frac{Ne}{bd^2} = \frac{11650 \times 157.3}{100 \times 63^2} = 4.620$
$\frac{Ne}{bd^2\sigma_c} = 0.150$, $k = 0.310$

$\sigma_c = \frac{4.620}{0.150} = 30.8$ kg/cm²
$\sigma_s = 15 \times 30.8 \times \frac{0.690}{0.310} = 1027$ 〃
$\tau = \frac{20290}{100 \times 0.897 \times 63} = 3.5$ 〃

側壁 AB

Ⓜ₂　$M = 5240$ kgm, $N = 18850$ kg, $S = 0$

$\frac{M}{N} = \frac{5240 \times 100}{18850} = 27.8$
$d - u = 12.3$
$e = 40.1$ cm
$e' = e - 26 = 14.1$
$e'/e = 0.353$
$\frac{Ne}{bd^2} = \frac{18850 \times 40.1}{100 \times 31^2} = 7.870$
$\frac{Ne}{bd^2\sigma_c} = 0.234$, $k = 0.495$

$\sigma_c = \frac{7.870}{0.234} = 33.6$ kg/cm²
$\sigma_s = 15 \times 33.6 \times \frac{0.505}{0.495} = 515$ 〃
$\tau = 0$

第10頁参照
$b = 100$, $h = 36$
$d = 31$, $d' = 5$
$A_s = 10 - 16\phi$
$A_s' = 5 - 16\phi$

Ⓐ　$M = -12330$ kgm, $N = 18850$ kg, $S = 15370$ kg

$\frac{M}{N} = \frac{12330 \times 100}{18850} = 70.8$
$d - u = 25.8$
$e = 96.6$ cm
$e' = e - 53 = 43.6$
$e'/e = 0.452$
$\frac{Ne}{bd^2} = \frac{18850 \times 96.6}{100 \times 58^2} = 5.420$
$\frac{Ne}{bd^2\sigma_c} = 0.170$, $k = 0.370$
$\sigma_c = \frac{5.420}{0.170} = 31.9$ kg/cm²
$\sigma_s = 15 \times 31.9 \times \frac{0.63}{0.37} = 815$ 〃
$\tau = \frac{15370}{100 \times 0.877 \times 58} = 3.0$ 〃

$b = 100$, $h = 63$
$d = 58$, $d' = 5$
$A_s = 10 - 16\phi$
$A_s' = 2.5 - 16\phi$

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上海標準隧道

Ⓑ $M = -11890$ kgm, $N = 18850$ kg, $S = -11650$ kg

第11頁参照
$b=100$, $h=56$
$d=51$, $d'=5$
$A_s = 10-16\phi$
$A_s' = 2.5-16\phi$

$\frac{M}{N} = \frac{11890\times100}{18850} = 63.1$

$e = \frac{d-u}{} = \frac{22.2}{85.3}$ cm

$e' = e - 46 = 39.3$ 〃

$e'/e = 0.461$

$\frac{Ne}{bd^2} = \frac{18850\times85.3}{100\times51^2} = 6.180$

$\frac{Ne}{bd^2\sigma_c} = 0.178$, $k = 0.380$

$\sigma_c = \frac{6180}{0.178} = 34.7$ kg/cm²

$\sigma_s = 15\times34.7\times\frac{0.62}{0.38} = 850$ 〃

$\tau = \frac{11650}{100\times.873\times51} = 2.6$ 〃

Ⓗ4 $M = -5410$ kgm, $N = 18850$ kg, $S = -9550$ kg

$b=100$, $h=36$
$d=31$, $d'=5$
$A_s = A_s' = 7.5-16\phi$

$e = \frac{M}{N} = \frac{5410\times100}{18850} = 28.7$ cm

$e/h = 28.7/36 = 0.798$

$d'/h = 5/36 = 0.139$

$k_0 = 0.372$, $C = 0.155$

$\sigma_c = \frac{18850}{100\times36-0.155} = 33.8$ kg/cm²

$\sigma_s = 15\times33.8\times\frac{1-0.372-0.139}{0.372} = 667$ 〃 (.489)

$\tau = \frac{9550}{100\times.876\times31} = 3.5$ 〃

Ⓗ3 $M = -2190$ kgm, $N = 18850$ kg, $S = 9670$ kg

第70頁 Ⓗ4 = ½ L'

$\tau = \frac{9670}{100\times\frac{7}{8}\times31} = 3.6$ kg/cm².

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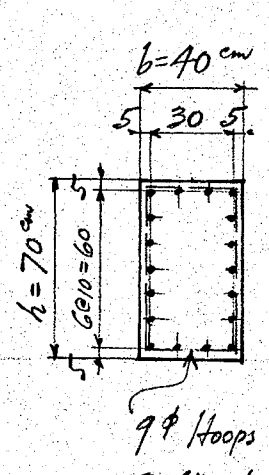
設計 神谷 泰 日付 16-5-24 類別 S.C.T.4
照査 日付 第 25 頁

上海標準隧道

中央柱 CD. (間隔 2.5m c to c)



中央柱最大荷重

柱自重 0.40×0.70×4.70 2400 = 101,450
3150
N= 104,600 kg c

A_s = 18−16φ = 36.2 cm²
A_c = 40×70 = 2800 〃
A_i = 2800 + 36.2×15 = 3343 cm²

$\sigma_c = \frac{104600}{3343} = 31.3$ kg/cm² c

$\sigma_s' = 15 \times 31.3 = 470$ 〃 c

$\tau = 0$

中央部上下縦桁

支間 2.5m / Continuous beam と.

荷重 $w = 40{,}580$ kg/m (第20頁応力図参照)

最大正曲率 $M_c = \frac{wl^2}{14} = \frac{40580 \times 2.5^2}{14} = +18120$ kgm 中央

最大負 〃 $M_s = -\frac{wl^2}{10} = -\frac{40580 \times 2.5^2}{10} = -25350$ 〃 両側支点

剪力 $S = \frac{wl}{2} = \frac{40580 \times 2.5}{2} = 50{,}700$ kg 〃

柱ノ側面ニ於ケル縦桁ノ曲率

$\frac{wl}{2} \times 0.35 = 50{,}700 \times 0.35 = 17{,}730$

$-\frac{w \times 0.35^2}{2} = -\frac{40580 \times 0.35^2}{2} = -2490$

$M_S = -25{,}350$

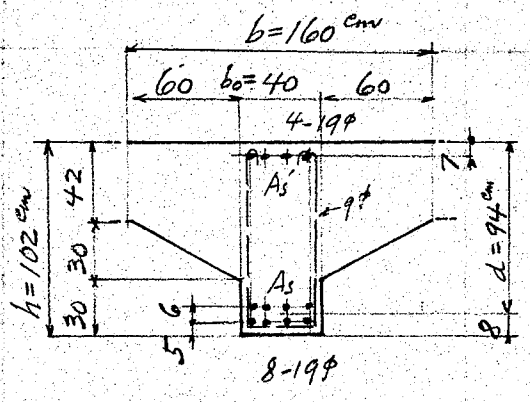
$M_{CF} = -10{,}110$ kgm

左上剪力.

$S_{CF} = S - 0.35w = 50700 - 0.35 \times 40580 = 36{,}500$ kg

上部縦桁

中央断面 $M_c = 18{,}120$ kgm , $S = 0$



b = 160 cm (假定) , h = 102 , d = 94 , d' = 7

A_s = 8−19φ = 22.68 cm² $p = 22.68/160 \times 94 = 0.00151$

A_s' = 4−19φ = 11.34 〃 $p' = 11.34/\ 〃 = 0.00076$

$d'/d = 7/94 = 0.075$

$k = 0.190$, $L_c = 0.098$, $L_s = 0.00135$

$\sigma_c = \frac{18120 \times 100}{160 \times 94^2 \times 0.098} = 13.1$ kg/cm²

$\sigma_s = \frac{18120 \times 100}{160 \times 94^2 \times 0.00135} = 950$ 〃

$\tau = 0$

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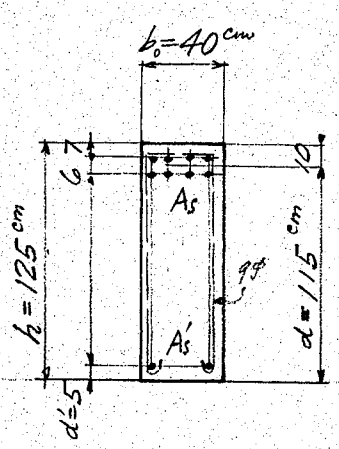
上海標準隧道

支点断面



$M_s = -25350$ kgm , $S = 50700$ kg

$b = 40$ cm, $h = 102 + \frac{35+35}{3} = 125$ cm, $d = 115$ cm $d' = 5$ cm

$A_s = 8-19\phi = 22.68$ cm² $p = 22.68/40\times115 = 0.00493$
$A'_s = 2-19\phi = 5.67$ 〃 $p' = 5.67/$ 〃 $= 0.00123$
$d'/d = 5/115 = 0.0435$

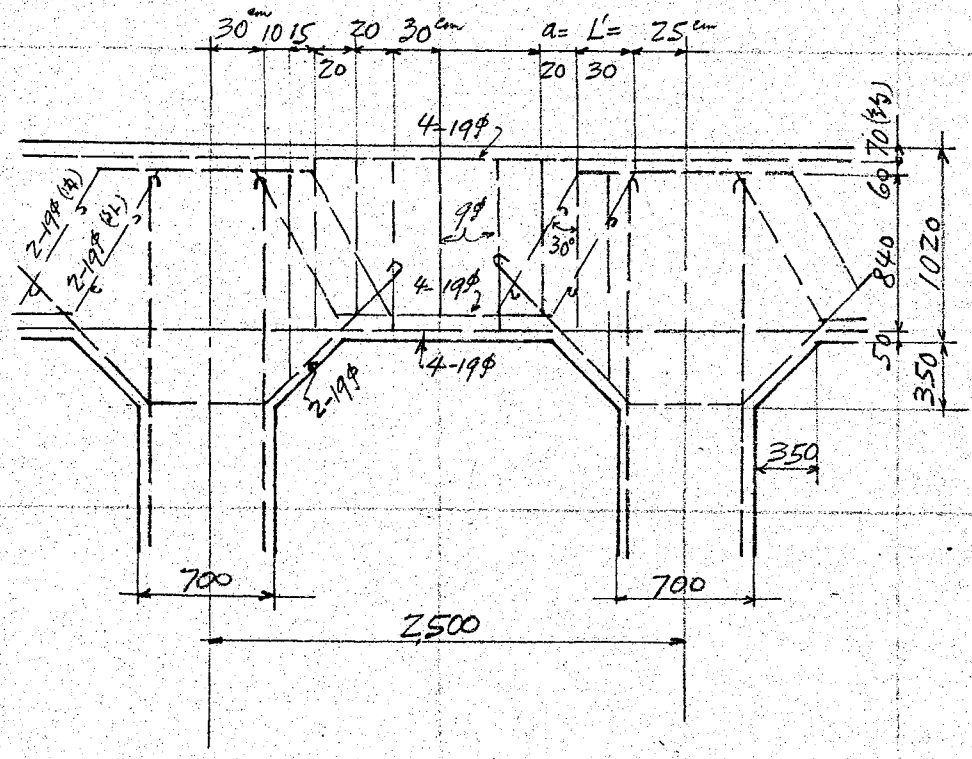
$K = 0.307$, $L_c = 0.152$, $L_s = 0.00445$

$$\sigma_c = \frac{25350\times100}{40\times115^2\times0.152} = 31.6 \text{ kg/cm}^2$$

$$\sigma_s = \frac{25350\times100}{40\times115^2\times0.00445} = 1077 \text{ 〃}$$

$$\tau = \frac{50700}{40\times1898\times115} = 12.3 \text{ 〃}$$

$$\tau_0 = \frac{50700}{5.97\times8\times1898\times115}\times\frac{1}{2} = 5.1 \text{ 〃}$$



腹鉄筋ノ抵抗剪力

$\theta = 45° - 30° = 15°$

$V = 1.41\cos15°A_6\sigma_s + A_s\sigma_s$

腹鉄筋ノ抵抗ニ得ル剪応力

$$\tau' = \frac{1.41\cos15°A_6\sigma_s}{L'b_0} + \frac{A_s\sigma_s}{ab_0} \quad \text{(第13頁参照)}$$

$$= \frac{1.41\times0.966\times1200A_6}{L'b_0} + \frac{1200A_s}{ab_0}$$

$$= 1630\frac{A_6}{L'b_0} + 1200\frac{A_s}{ab_0}$$

$A_6 = 2-19\phi = 5.67$ cm²
$A_s = 2-9\phi = 1.27$ 〃
$a = 20$ cm (haunch 先端部)
$L' = 30$ 〃
$b_0 = 40$ 〃

Haunch 先端部 $\tau' = 1630\times\frac{5.67}{30\times40} + 1200\times\frac{1.27}{20\times40} = 7.70 + 1.91 = 9.61$ kg/cm²

Haunch 先端ニ於ケル剪力

$S_h = S - 0.70w = 50700 - 0.70\times40580 = 22300$ kg

剪応力 $\tau = \frac{22300}{40\times\frac{7}{8}\times94} = 6.8$ kg/cm² < 9.61

柱側面

$\tau' = 1630\times\frac{5.67}{30\times40} + 1200\times\frac{1.27}{15\times40} = 7.70 + 2.54 = 10.24$ kg/cm²

$S_{cf} = S - 0.35w = 50700 - 0.35\times40580 = 36500$ kg

$h = 102 + \frac{35}{3} = 114$ cm
$d = 114 - 10 = 104$ 〃

剪応力 $\tau = \frac{36500}{40\times\frac{7}{8}\times104} = 10.0$ kg/cm² < 10.24

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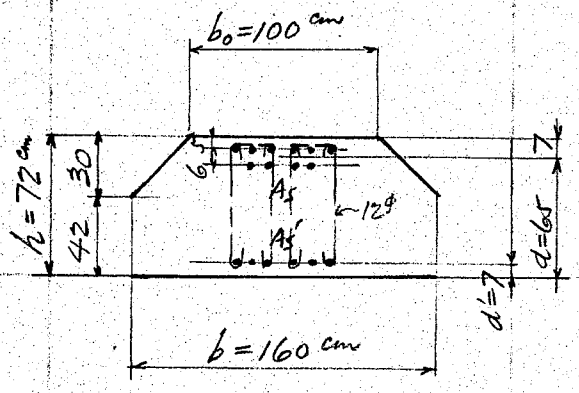
上海標準隧道

下部縦桁

中央断面



$M_c = 18120\ kgm$, $S = 0$

$b = 160^{cm}$, $b_0 = 100\ cm$,
$h = 72$, $d = 65$, $d' = 7$

$A_s = 10-19\phi = 28.35\ cm^2$ $\quad p = 28.35/160\times65 = 0.00273$
$A_s' = 6-19\phi = 17.01$ 〃 $\quad p' = 17.01/$ 〃 $= 0.00164$
$d'/d = 7/65 = 0.108$

$k = 0.239$ $\quad L_c = 0.121$ $\quad L_s = 0.00245$

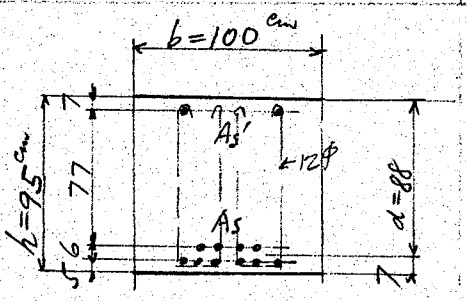
$$\sigma_c = \frac{18120\times100}{160\times65^2\times0.121} = 22.2\ kg/cm^2$$

$$\sigma_s = \frac{18120\times100}{160\times65^2\times0.00245} = 1094\ 〃$$

$\tau = 0$

支点断面

$M_s = -25350\ kgm$, $\quad S = 50700\ kg$



$b = 100^{cm}$, $\quad h = 72 + \frac{35+35}{3} = 95\ cm$
$d = 88\ cm$ $\quad d' = 7\ cm$
$A_s = 10-19\phi = 28.35\ cm^2$ $\quad p = 28.35/100\times88 = 0.00322$
$A_s' = 2-19\phi = 5.67$ 〃 $\quad p' = 5.67/$ 〃 $= 0.00064$
$d'/d = 7/88 = 0.080$

$k = 0.262$, $\quad L_c = 0.127$ $\quad L_s = 0.00291$

$$\sigma_c = \frac{25350\times100}{100\times88^2\times0.127} = 25.8\ kg/cm^2$$

$$\sigma_s = \frac{25350\times100}{100\times88^2\times0.00291} = 1125\ 〃$$

$$\tau = \frac{50700}{100\times0.913\times88} = 6.3\ 〃$$

$$\tau_0 = \frac{50700}{5.97\times10\times0.913\times88}\times\frac{1}{2} = 5.3\ 〃$$

腹鉄筋ノ抵抗剪力.

Hannch先端 $\quad \tau' = \frac{1.41 A_b \sigma_s}{L' b_0} + \frac{A_s \sigma_s}{a b_0} = 12\left\{\frac{1.41 A_b}{L'} + \frac{A_s}{a}\right)$

$$= 12\left\{\frac{1.41\times5.67}{30} + \frac{3.39}{20}\right\} = 3.20 + 2.03 = 5.23\ kg/cm^2$$

(2-19φ, 3-12φ)

Haunch先端ニ於ケル剪力 $S_h = 22300\ kg$

剪応力 $\quad \tau = \frac{22300}{100\times7/8\times65} = 3.9\ kg/cm^2 < 5.23$

柱側面 $\quad \tau' = 12\left\{\frac{1.41\times5.67}{30} + \frac{3.39}{15}\right\} = 3.20 + 2.71 = 5.90\ kg/cm^2$

$\tau = \frac{36500}{100\times7/8\times77} = 5.4\ kg/cm^2 < 5.90$ $\quad h = 72 + \frac{35}{3} = 84$ $\quad d = 77$

配筋ハ上下縦桁及ビ柱ヲ除ク外全部 S.C.T. 3 ニ合ヒ (第15頁参照)

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設計　日付　類別

照査　日付　第　頁

上海高速鐵道

鐵筋混凝土標準型複線隧道

土被五〇米　應力計算書

Standard Reinforced Concrete Tunnel,
Double Track
Mark S. C. T. 5.

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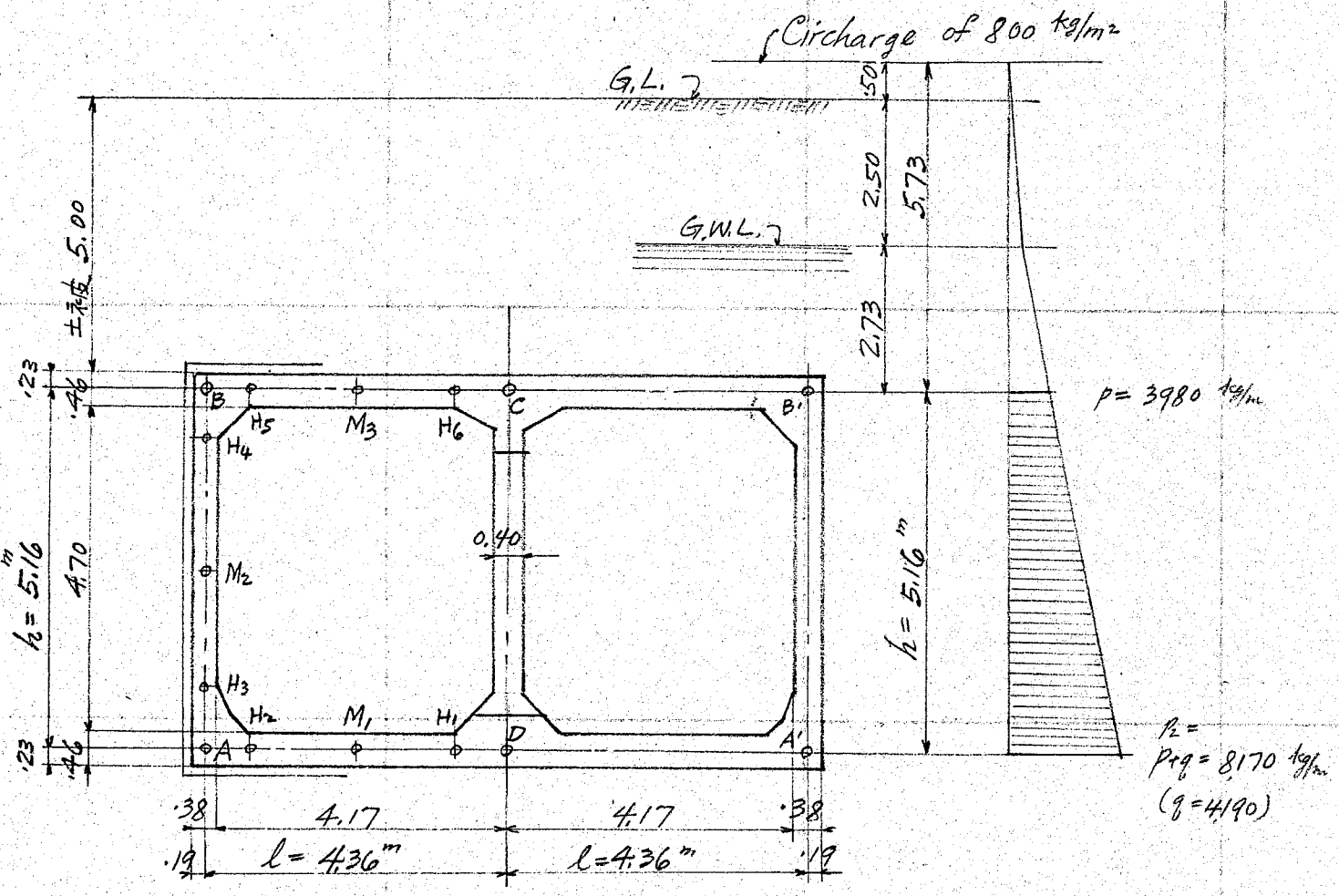
上海高速鉄道鉄筋混凝土標準隧道

土被 5.0m 標準隧道 S.C.T.5



上床荷重 w.

土被	地下水位以上	2.50 @ 1600	=	4,000
〃	〃 以下	2.40 @ 2000	=	4,800
被覆混凝土		0.10 @ 2200	=	220
上床		0.46 @ 2400	=	1,100
				10120
路面傳布荷重				800
			w =	10,920 kg/m²

下床荷重 上床荷重ト同一ト假定ス.

側壁荷重

B, B' 点ニ於ケル荷重

土被	2.50 @ 1600	=	4,000
〃	2.50 @ 2000	=	5,000
路面荷重			800
	9,800 × 0.406	=	3,980 kg/m² = p

A, A' 点ニ於ケル荷重

	5.16 @ 2000 = 10320 × 0.406	=	4,190 〃 = q
			8,170 kg/m² = p+q

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上海標準隧道

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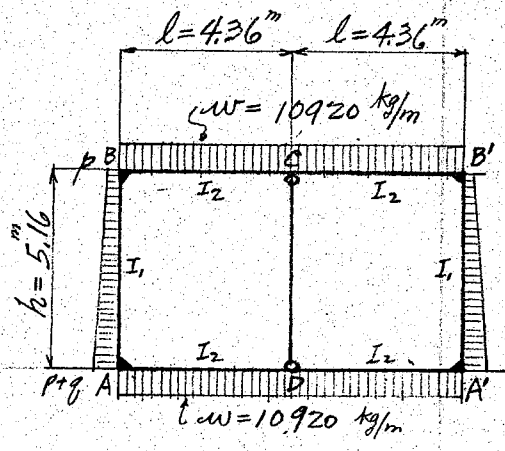
荷重狀態



Moments of Inertia.

$I_1 = \frac{1.0 \times 0.38^3}{12} = 0.00457\ m^4$

$I_2 = \frac{1.0 \times 0.46^3}{12} = 0.00811$ "

$K_1 = \frac{I_1}{h} = \frac{0.00457}{5.16} = 0.00089$

$K_2 = \frac{I_2}{l} = \frac{0.00811}{4.36} = 0.00186$

$K = \frac{K_2}{K_1} = \left(\frac{I_2}{I_1}\cdot\frac{h}{l}\right) = \frac{0.00186}{0.00089} = 2.090$

$12(1+2K) = 12(1+4.180) = 62.160$
$1+3K = 1+6.270 = 7.270$
$wl^2 = 10920 \times 4.36^2 = 207{,}500$

$61K_1+12K_2 = 0.0543 + 0.0223 = 0.0766$
$59K_1+8K_2 = 0.0525 + 0.0149 = 0.0674$
$31K_1+7K_2 = 0.0276 + 0.0130 = 0.0406$
$29K_1+3K_2 = 0.0258 + 0.0056 = 0.0314$
$120(6K_1+K_2)(K_1+2K_2) = 120 \times 0.0072 \times 0.00461 = 0.00398$
$K_2h^2 = 0.00186 \times 5.16^2 = 0.0495$

上下床，荷重 w = 依ル彎曲率

$M_A = M_B = -\frac{wl^2}{12(1+2K)} = -\frac{207{,}500}{62.160} = -3340$ kgm

$M_C = M_D = -\frac{(1+3K)wl^2}{12(1+2K)} = -\frac{7.270 \times 207500}{62.16} = -24{,}270$ "

兩側壁，荷重 p 及 p+q = 依ル彎曲率

$M_A = -\frac{K_2h^2\{(61K_1+12K_2)(p+q)+(59K_1+8K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.0495(0.0766\times8170 + 0.0674\times3980)}{0.00398} = -11{,}100$ kgm
(893.6)

$M_B = -\frac{K_2h^2\{(59K_1+8K_2)(p+q)+(61K_1+12K_2)p\}}{120(61K_1+K_2)(K_1+2K_2)} = -\frac{0.0495(0.0674\times8170 + 0.0766\times3980)}{0.00398} = -10{,}630$ "
(853.2)

$M_C = +\frac{K_2h^2\{(31K_1+7K_2)(p+q)+(29K_1+3K_2)p\}}{120(61K_1+K_2)(K_1+2K_2)} = +\frac{0.0495(0.0406\times8170 + 0.0314\times3980)}{0.00398} = +5{,}680$ "
(456.4)

$M_D = +\frac{K_2h^2\{(29K_1+3K_2)(p+q)+(31K_1+7K_2)p\}}{120(61K_1+K_2)(K_1+2K_2)} = +\frac{0.0495(0.0314\times8170 + 0.0406\times3980)}{0.00398} = +5{,}200$ "
(418.4)

上下床及ビ左右側壁荷重＝依ル合成彎曲率

	床荷重＝依ル彎曲率	側壁荷重＝依ル彎曲率	合成彎曲率
M_A	− 3,340 kgm	− 11,100 kgm	−14,440 kgm
M_B	− 3340	− 10,630	−13,970 "
M_C	− 24270	+ 5,680	−18,590 "
M_D	− 24270	+ 5,200	−19,070 "

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上海標準隧道

剪力

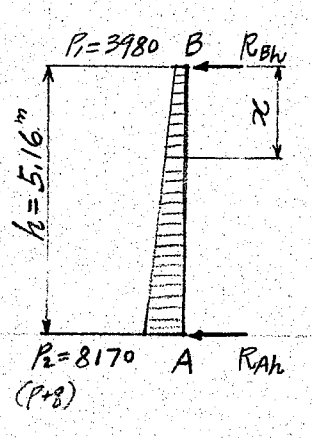
上床 $S_{BZ} = \frac{wl}{2} + \frac{M_C - M_B}{l} = \frac{10920 \times 4.36}{2} + \frac{-18590+13970}{4.36} = 23,800 - 1060 = 22,740$ kg

〃 $S_{CZ} = -\frac{wl}{2} + \frac{M_C - M_B}{l} = -23,800 - 1060 = -24,860$ 〃

下床 $S_{AZ} = -\frac{wl}{2} + \frac{M_A - M_D}{l} = -23,800 + \frac{-14440+19070}{4.36} = -23,800 + 1060 = -22,740$ 〃

〃 $S_{DZ} = \frac{wl}{2} + \frac{M_A - M_D}{l} = 23,800 + 1060 = 24,860$ 〃

側壁.



AB ヲ Simple beam トスル支力.

$R_{Ah} = \frac{h}{6}(2P_2 + P_1) = \frac{5.16}{6}(16340 + 3980) = 17,480$ kg (20320)

$R_{Bh} = \frac{h}{6}(2P_1 + P_2) = \frac{5.16}{6}(7960 + 8170) = 13,870$ 〃 (16130)

剪力.

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -13,870 + \frac{-13970+14440}{5.16} = -13,780$ kg (90)

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = +17,480 + 90 = 17,570$ kg

中間点ニ於ケル彎曲率及剪力.

下床 AD

Ⓜ₁ 0 Shear ノ点 $x = -\frac{S_{A2}}{w} = \frac{22740}{10920} = 2.082$ m (A点ヨリノ距離)

$M_A = -14,440$

$-S_{A2}x = 22,740 \times 2.082 = 47,350$

$-\frac{wx^2}{2} = -\frac{10920 \times 2.082^2}{2} = -23,680$

$M_1 = 9,230$ kgm $S_1 = 0$

Ⓗ₁ $x = 4.36 - 0.80 = 3.56$ m

$M_A = -14,440$

$-S_{A2}x = 22740 \times 3.56 = 81,000$

$-\frac{wx^2}{2} = -\frac{10920 \times 3.56^2}{2} = -69,180$

$M_{H1} = -2,620$ kgm

$S_{A2} = -22,740$

$wx = 10920 \times 3.56 = 38,850$

$S_{H1} = 16,110$ kg

Ⓗ₂ $x = 0.19 + 0.40 = 0.59$ m

$M_A = -14,440$

$-S_{A2}x = 22740 \times 0.59 = 13,420$

$-\frac{wx^2}{2} = -\frac{10920 \times 0.59^2}{2} = -1,900$

$M_{H2} = -2,920$ kgm

$S_{A2} = -22,740$

$wx = 10920 \times 0.59 = 6,440$

$S_{H2} = -16,300$ kg

軸由力 $N_{AD} = S_{A1} = 17,570$ kg.c.

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上海標準隧道

上床 BC

(M3) 0 Shear 1点 $x = \frac{S_{B2}}{w} = \frac{22740}{10920} = 2.082\,m$ (B点より距離)

$M_B = -13,970$

$S_{B2}x = 22740 \times 2.082 = 47,350$

$-\frac{wx^2}{2} = -\frac{10920 \times 2.082^2}{2} = -23,680$

$M_3 = 9,700\ kgm$ $S_3 = 0$

(H5) $x = 0.59^m$

$-13,970$

$22740 \times 0.59 = 13,420$

$-\frac{10920 \times 0.59^2}{2} = -1,900$

$M_{H5} = -2,450\ kgm$

$22740 - 10920 \times 0.59 = -6440$

$S_{H5} = 16,300\ kg$

(H6) $x = 4.36 - 0.80 = 3.56^m$

$-13,970$

$22740 \times 3.56 = 81,000$

$-\frac{10920 \times 3.56^2}{2} = -69,180$

$M_{H6} = -2,150\ kgm$

$22,740 - 10920 \times 3.56 = -38,850$

$S_{H6} = -16,110\ kg$

軸力 $N_{BC} = -S_{B1} = 13,780\ kg.c.$

側壁 AB

任意1点=於ケル剪力.

$S_x = S_{B1} + \frac{gx^2}{2h} + px = -13,780 + \frac{4190x^2}{2 \times 5.16} + 3980x$

$= 406x^2 + 3,980x - 13,780$

0 Shear 1点. $x^2 + 9.81x - 33.95 = 0$, $x = -\frac{9.81}{2} \pm \frac{\sqrt{9.81^2 + 33.95 \times 4}}{2} = 2.71^m$

任意1点=於ケル彎曲率

$M_x = -S_{B1}x - \frac{px^2}{2} - \frac{gx^3}{6h} + M_B = 13780x - \frac{3980x^2}{2} - \frac{4190x^3}{6 \times 5.16} - 13970$

$= -135.5x^3 - 1990x^2 + 13780x - 13970$

	x	$-135.5x^3$	$-1,990x^2$	$+13,780x$	$-13,970$		M_x
(H4)	0.63^m	− 30	− 790	+ 8690	− 13,970	=	− 6,100 kgm
(M2)	2.71	− 2,700	− 14,620	+ 37,350	− 13,970	=	6,060 〃
(H3)	4.33	− 11,000	− 37,300	+ 59,700	− 13,970	=	− 2,570 〃

	x	$406x^2$	$+3,980x$	$-13,780$		S_x
(H4)	0.63^m	160	+ 2510	− 13,780	=	− 11,110 kg
(M2)	2.71	2980	+ 10,800	− 13,780	=	0 〃
(H3)	4.33	7,610	+ 17230	− 13,780	=	11,060 〃

軸力. $N_{AB} = S_{B2} = 22,740\ kg.c.$

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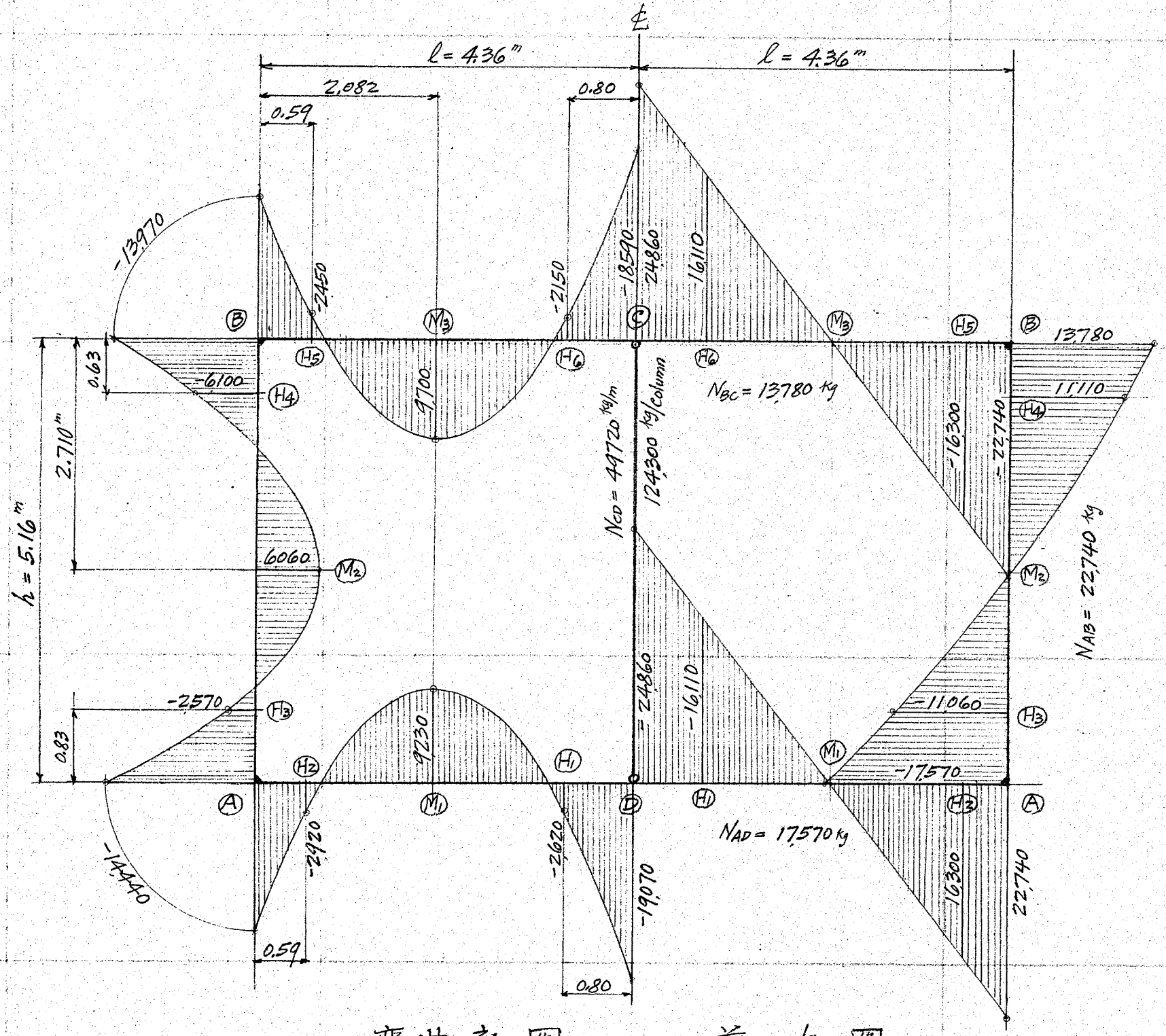
中央柱 C.D.
軸力 $N_{CD} = -2S_{c2} = 24860 \times 2 = 49{,}720$ kg. C/meter strip of tunnel.
柱ノ間隔ヲ2.5m c to c トスレバ
柱一本当リ荷重 $= 2.5 @ 49720 = 124{,}300$ kg.C.

彎曲率及剪力圖



彎曲率圖　　剪力圖

$\frac{1}{50}$m = 10,000 kgm　　$\frac{1}{50}$m = 10,000 kg

縮尺 1:60

注意　M_1, M_2 及 M_3 ハ最大正彎曲率ノ点
H_1, H_2 乃至 H_6 ハ各 haunch ノ先端

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断面應力ノ計算

下床 AD

⑯ M = 9230 kgm , N = 17570 kg.c. S = 0

$d/h = 41/46 = 0.891$
$d'/h = 5/46 = 0.108$
$p_0 = 20.1/100\times46 = 0.00437$
$p_0' = 5.0/\ \ \ = 0.00108$
$u/h = 0.517$
$u = 23.8$ cm
$d-u = 17.2$ cm

$\frac{M}{N} = \frac{9230\times100}{17570} = 52.5$
$d-u = 17.2$
$e = 69.7$ cm
$e' = e-36 = 33.7$ 〃
$e'/e = 0.484$
$\frac{Ne}{bd^2} = \frac{17570\times69.7}{100\times41^2} = 7.290$
$\frac{Ne}{bd^2\sigma_c} = 0.190$ $k = 0.410$
$\sigma_c = \frac{7.290}{0.190} = 38.4$ kg/cm²
$\sigma_s = 15\times38.4\times\frac{0.590}{0.410} = 829$ 〃
$\tau = 0$

$b=100$ cm, $h=46$ cm
$d=41$ cm, $d'=5$ cm
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 2.5-16\phi = 5.0$ 〃
$p = 20.1/100\times41 = 0.00491$
$p' = 5.0/\ \ \ = 0.00122$
$d'/d = 5/41 = 0.122$

Ⓓ M = −19070 kgm , N = 17570 kg.c. S = 24860 kg

$d/h = 67/72 = 0.792$
$d'/h = 5/72 = 0.069$
$p_0 = 20.1/100\times72 = 0.00279$
$p_0' = 5.0/\ \ \ = 0.00069$
$u/h = 0.507$
$u = 36.5$
$d-u = 30.5$

$\frac{M}{N} = \frac{19070\times100}{17570} = 108.5$
$d-u = 30.5$
$e = 139.0$ cm
$e' = e-62 = 77.0$ 〃
$e'/e = 0.554$
$\frac{Ne}{bd^2} = \frac{17570\times139.0}{100\times67^2} = 5.445$
$\frac{Ne}{bd^2\sigma_c} = 0.152$ $k = 0.320$
$\sigma_c = \frac{5.445}{0.152} = 35.8$ kg/cm²
$\sigma_s = 15\times35.8\times\frac{0.680}{0.320} = 1140$ 〃
$\tau = \frac{24860}{100\times0.893\times67} = 4.2$ 〃
$\tau_0 = \frac{24860}{5.03\times10\times0.893\times67}\times\frac{1}{2} = 4.1$ 〃

$b=100$, $h = 46+\frac{80}{3} = 72$ cm
$d=67$ cm, $d'=5$ cm
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 2.5-16\phi = 5.0$ 〃
$p = 20.1/100\times67 = 0.00300$
$p' = 5.0/\ \ \ = 0.00075$
$d'/d = 5/67 = 0.075$

Ⓐ M = −14440 kgm , N = 17570 kg.c. S = −22740 kg

$d/h = 61/66 = 0.935$
$d'/h = 5/66 = 0.076$
$p_0 = 20.1/100\times66 = 0.00305$
$p_0' = 5.0/\ \ \ = 0.00076$
$u/h = 0.512$
$u = 33.8$ cm
$d-u = 27.2$ 〃

$\frac{M}{N} = \frac{14440\times100}{17570} = 82.2$
$d-u = 27.2$
$e = 109.4$ cm
$e' = e-56 = 53.4$ 〃
$e'/e = 0.489$
$\frac{Ne}{bd^2} = \frac{17570\times109.4}{100\times61^2} = 5.170$
$\frac{Ne}{bd^2\sigma_c} = 0.160$ $k = 0.335$

$b=100$, $h = 46+\frac{59}{3} = 66$
$d=61$, $d'=5$
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 2.5-16\phi = 5.0$ 〃
$p = 20.1/100\times61 = 0.00330$
$p' = 5.0/\ \ \ = 0.00082$
$d'/d = 5/61 = 0.082$

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$\sigma_c = \frac{5,170}{0.160} = 32.3$ kg/cm²

$\sigma_s = 15 \times 32.3 \times \frac{0.665}{0.335} = 962$ "

$\tau = \frac{22740}{100 \times 0.888 \times 61} = 4.2$ "

$\tau_0 = \frac{22740}{5.03 \times 10 \times .888 \times 61} \times \frac{1}{2} = 4.2$ "

(H1) $M = -2620$ kgm, $N = 17570$ kg.c. $S = 16110$ kg

$\tau = \frac{16110}{100 \times \frac{7}{8} \times 41} = 4.5$ kg/cm²

$\tau_0 = \frac{16110}{5.03 \times 7.5 \times \frac{7}{8} \times 41} \times \frac{1}{2} = 6.0$ "

下面主鉄筋ハ 7.5本トナル様 lap ヲ長クシテ bond stress ヲ軽減スルコト

(H2) $M = -2920$ kgm, $N = 17570$ kg.c. $S = -16300$ kg

$\tau = \frac{16300}{100 \times \frac{7}{8} \times 41} = 4.5$ kg/cm²

$\tau_0 = \frac{16300}{5.03 \times 7.5 \times \frac{7}{8} \times 41} \times \frac{1}{2} = 6.0$ "

上床 BC.

$M_3 = 9700$ kgm, $N = 13780$ kg.c. $S = 0$.

$\frac{M}{N} = \frac{9700 \times 100}{13780} = 70.4$

$d - u = 17.2$

$e = 87.6$ cm

$e' = e - 36 = 51.6$ "

$e'/e = 0.589$

$\frac{Ne}{bd^2} = \frac{13780 \times 87.6}{100 \times 41^2} = 7.180$

$\frac{Ne}{bd^2\sigma_c} = 0.181$, $k = 0.385$

$\sigma_c = \frac{7.180}{0.181} = 39.7$ kg/cm²

$\sigma_s = 15 \times 39.7 \times \frac{0.615}{0.385} = 951$ "

$\tau = 0$

断面ハ (M1) ニ同ジ (第32頁参照)

(H5) 及 (H6) ハ夫々 (H2) 及 (H1) ト同一断面ヲ使用スル安全ナリ.

(B) $M = -13970$ kgm, $N = 13780$ kg.c. $S = 22,740$ kg

$\frac{M}{N} = \frac{13970 \times 100}{13780} = 101.3$

$d - u = 27.2$

$e = 128.5$ cm

$e' = e - 56 = 72.5$ "

$e'/e = 5.640$

$\frac{Ne}{bd^2} = \frac{13780 \times 128.5}{100 \times 61^2} = 4.765$

断面ハ (A) ニ同ジ (第32頁参照)

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上海標準隧道

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$\frac{Ne}{bd^2\sigma_c} = 0.157$, $k = 0.335$

$\sigma_c = \frac{4.765}{0.157} = 30.4$ kg/cm²

$\sigma_s = 15 \times 30.4 \times \frac{0.665}{0.335} = 905$ "

$\tau = \frac{22740}{100 \times 0.888 \times 61} = 4.2$ "

$\tau_0 = \frac{22740}{5.03 \times 10 \times .888 \times 61} \times \frac{1}{2} = 4.2$ "

Ⓒ $M = -18.590$ kgm , $N = 13780$ kg.c. , $S = -24860$ kg 断面ハⒹ＝同ジ

$\frac{M}{N} = \frac{18590 \times 100}{13780} = 135.0$

$d-u = \frac{30.5}{165.5}$ cm

$e =$

$e' = e - 62 = 103.5$

$e'/e = 0.626$

$\frac{Ne}{bd^2} = \frac{13780 \times 165.5}{100 \times 67^2} = 5.080$

$\frac{Ne}{bd^2\sigma_c} = 0.148$, $k = 0.305$

$\sigma_c = \frac{5.080}{0.148} = 34.3$ kg/cm²

$\sigma_s = 15 \times 34.3 \times \frac{0.695}{0.305} = 1173$ "

$\tau = \frac{24860}{100 \times 0.898 \times 67} = 4.1$ "

$\tau_0 = \frac{24860}{5.03 \times 10 \times .898 \times 67} \times \frac{1}{2} = 4.1$ "

側壁 AB

(M₂) $M = 6060$ kgm , $N = 22740$ kg.c , $S = 0$

$d/h = 33/38 = 0.868$
$d'/h = 5/38 = 0.132$
$p_0 = 20.1/100 \times 38 = 0.00529$
$p_0' = 10.1/ \; " \; " = 0.00265$

$u/h = 0.512$
$u = 19.5$
$d-u = 13.5$

$\frac{M}{N} = \frac{6060 \times 100}{22740} = 26.7$

$d-u = 13.5$

$e = \frac{}{40.2}$ cm

$e' = e - 28 = 12.2$ "

$e'/e = 0.304$

$\frac{Ne}{bd^2} = \frac{22740 \times 40.2}{100 \times 33^2} = 8.400$

$\frac{Ne}{bd^2\sigma_c} = 0.238$, $k = 0.505$

$\sigma_c = \frac{8.400}{0.238} = 35.3$ kg/cm²

$\sigma_s = 15 \times 35.3 \times \frac{.495}{.505} = 519$ "

$\tau = 0$

$b = 100$ cm , $h = 38$ cm
$d = 33$, $d' = 5$
$A_s = 10 - 16\phi = 20.1$ cm²
$A_s' = 5.0 - 16\phi = 10.1$ "
$p = 20.1/100 \times 33 = 0.00609$
$p' = 10.1/ \; " \; " = 0.00305$
$d'/d = 5/33 = 0.152$

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照査 日付 第 36 頁

上海標準隧道

Ⓐ M = -14,440 kgm, N = 22,740 kg, S = 17,570 kg

$d/h = 61/66 = 0.924$
$d'/h = 5/66 = 0.076$
$p_0 = 20.1/100\times66 = 0.00304$
$p_0' = 5.0/\,\,\,\,\,\,\,\, = 0.00076$
$u/h = 0.514$
$u = 33.9$
$d-u = 27.1$

$\frac{M}{N} = \frac{14440\times100}{22740} = 63.5$
$d-u = 27.1$
$e = 90.6$ cm
$e' = e-d/6 = 34.6$
$e'/e = 0.382$
$\frac{Ne}{bd^2} = \frac{22740\cdot90.6}{100\times61^2} = 5.540$
$\frac{Ne}{bd^2\sigma_c} = 0.1755$, $k = 0.380$
$\sigma_c = \frac{5.540}{0.1775} = 31.2$ kg/cm²
$\sigma_s = 15\times31.2\times\frac{0.63}{0.37} = 798$ "
$\tau = \frac{17570}{100\times0.873\times61} = 3.3$ "
$\tau_0 = \frac{17570}{5.03\times10\times.873\times61}\times\frac{1}{2} = 3.3$ "

$b=100$, $h = 38+\frac{83}{3} = 66$
$d=61$, $d'=5$
$A_s = 10-16\phi = 20.1$
$A_s' = 2.5-16\phi = 5.0$
$p = 20.1/100\cdot61 = 0.00329$
$p' = 5.0/\,\,\,\,\,\,\,\, = 0.00082$
$d'/d = 5/61 = 0.082$

Ⓑ M = -13,970 kgm, N = 22740 kg.c, S = -13780 kg

$d/h = 54/59 = 0.915$
$d'/h = 5/59 = 0.085$
$p_0 = 20.1/100\times59 = 0.00341$
$p_0' = 0.00085$
$u/h = 0.513$
$u = 30.3$
$d-u =$

$\frac{M}{N} = \frac{13970\times100}{22740} = 61.5$
$d-u = 23.7$
$e = 85.2$ cm
$e' = e-49 = 36.2$
$e'/e = 0.425$
$\frac{Ne}{bd^2} = \frac{22740\times85.2}{100\times54^2} = 6.640$
$\frac{Ne}{bd^2\sigma_c} = 0.179$, $k = 0.385$
$\sigma_c = \frac{6.640}{0.179} = 37.1$ kg/cm²
$\sigma_s = 15\times37.1\times\frac{0.615}{0.385} = 890$ "
$\tau = \frac{13780}{100\times0.872\times54} = 2.9$ "
$\tau_0 = \frac{13780}{5.03\times10\times.872\times54}\times\frac{1}{2} = 2.9$ "

$b=100$, $h = 38+\frac{63}{3} = 59$
$d=54$, $d'=5$
$A_s = 10-16\phi = 20.1$
$A_s' = 2.5-16\phi = 5.0$
$p = 20.1/100\times54 = 0.00372$
$p' = 0.00093$
$d'/d = 5/54 = 0.093$

(H4) M = -6,100 kgm, N = 22740 kg.c, S = 11,110 kg

$e = \frac{M}{N} = \frac{6100\times100}{22740} = 26.8$ cm
$e/h = 26.8/38 = 0.705$
$d'/h = 5/38 = 0.132$
$k = 0.385$ $C = 0.157$
$\sigma_c = \frac{22740}{100\times38\cdot0.157} = 38.1$ kg/cm²
$\sigma_s = 15\times38.1\times\frac{1-0.385-0.132}{0.385}$ (483) $= 718$ "
$\tau = \frac{11110}{100\times0.872\times33} = 3.9$ "
$\tau_0 = \frac{11110}{5.03\times7.5\times0.872\times33}\times\frac{1}{2} = 5.1$ "

$b=100$, $h=38$
$d=33$, $d'=5$
$A_s = A_s' = 7.5-16\phi = 15.07$
$p_0 = p_0' = 15.07/100\times38 = 0.00397$

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上海標準隧道

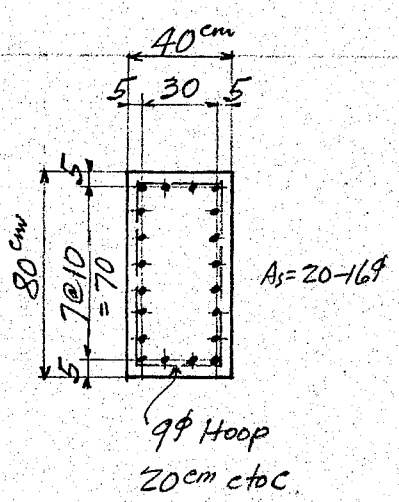
(H3) M = −2570 kgm, N = 22,740 kg.c. S = 11,060 kg

$\tau = \frac{11060}{100 \times 0.872 \times 33} = 3.8$ kg/cm²

$\tau_0 = \frac{11060}{5.03 \times 7.5 \times 0.872 \times 33} \times \frac{1}{2} = 5.1$ 〃

断面ハ(H4)ニ同ジ

中央柱 C.D. (間隔 2.5m c to c)



中央柱最大荷重 124,300
柱自重 0.40×0.80×4.7@2400 = 3,600
127,900 kg.c

As = 20−16φ = 40.2
Ac = 40×80 = 3200
Ai = 3200 + 40.2×15 = 3803 cm²
$\sigma_c = \frac{127900}{3803} = 33.6$ kg/cm² c
$\sigma_s' = 15 \times 33.6 = 505$ 〃 c
τ = 0

中央部上下縦桁

支間 2.50m ノ連続桁トス.

荷重 w = 49,720 kg/m (第32頁ノ応力図参照)
最大正曲率 $M_c = \frac{wl^2}{14} = \frac{49720 \times 2.5^2}{14} = 22,200$ kgm 中央
最大負曲率 $M_s = -\frac{wl^2}{10} = -\frac{49720 \times 2.5^2}{10} = -31,100$ 〃 支点
剪力 $S = \frac{wl}{2} = \frac{49720 \times 2.5}{2} = 62,100$ kg 〃

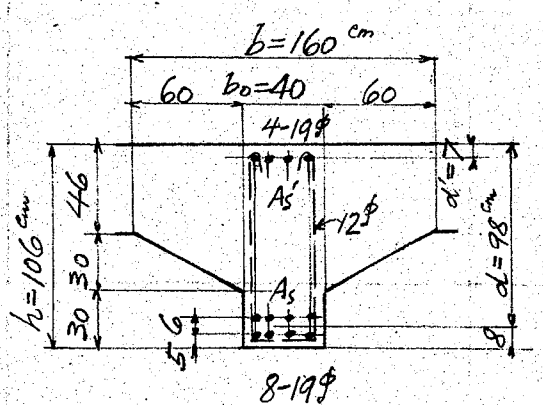
柱ノ側面ニ於ケル曲率

0.40S = 0.40×62100 = 24,850
$-\frac{w \times 0.4^2}{2}$ = −0.08×49720 = −3,980
M_s = −31,100
M_{cf} = −10,230 kgm

仝上剪力 $S_{cf} = S - 0.4w = 62100 - 0.4 \times 49720 = 42,200$ kg

上部縦桁 中央断面

M_c = 22,200 kgm, S = 0
b = 160 cm (假定), h = 106 cm, d = 98 cm, d' = 7
As = 8−19φ = 22.68 cm² $p = 22.68/160 \times 98 = 0.00145$
As' = 4−19φ = 11.34 〃 $p' = 11.34/$ 〃 〃 $= 0.00072$ $d'/d = 7/98 = 0.072$



k = 0.190, L_c = 0.097, L_s = 0.00133

$\sigma_c = \frac{22200 \times 100}{160 \times 98^2 \times 0.097} = 14.9$ kg/cm²

$\sigma_s = \frac{22200 \times 100}{160 \times 98^2 \times 0.00133} = 1087$

τ = 0

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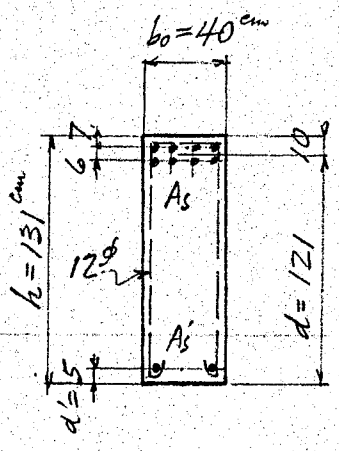
上海標準隧道

支点断面

$M_S = -31{,}100$ kgm , $S = 62{,}100$ kg

$b_0 = 40^{cm}$, $h = 106 + \frac{35+40}{3} = 131^{cm}$, $d = 121^{cm}$, $d' = 5^{cm}$



$A_s = 8-19\phi = 22.68\ cm^2$ $\quad p = 22.68/40\times121 = 0.00468$

$A_s' = 2-19\phi = 5.67\ "$ $\quad p' = 5.67/\ " = 0.00117$

$d'/d = 5/121 = 0.0413$

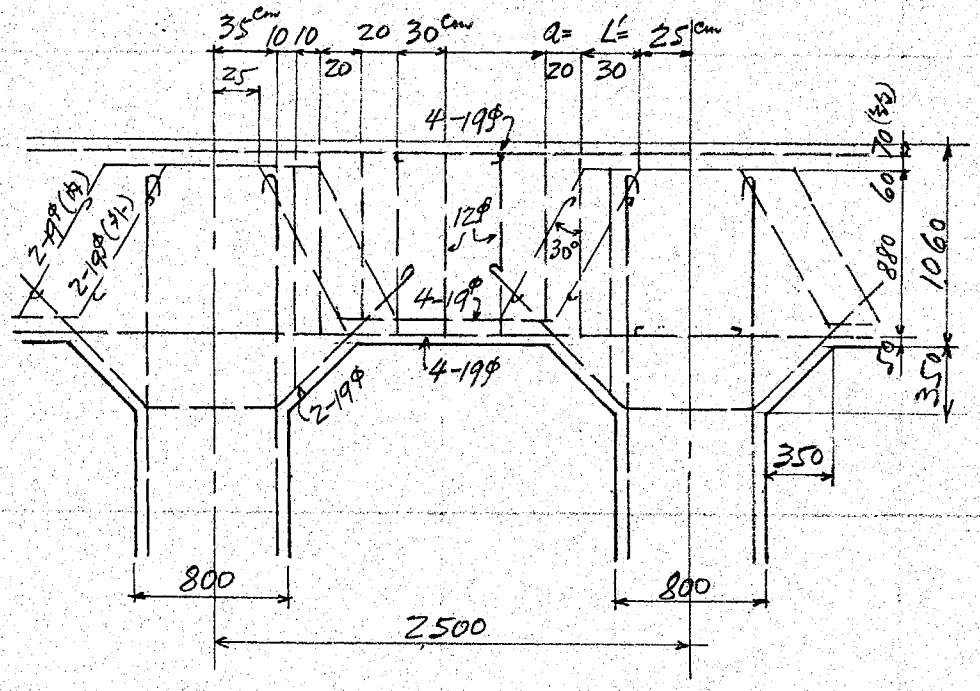
$k = 0.300$, $L_c = 0.150$, $L_s = 0.00432$

$$\sigma_c = \frac{31100\times100}{40\times121^2\times0.150} = 35.3\ kg/cm^2$$

$$\sigma_s = \frac{31100\times100}{40\times121^2\times0.00432} = 1225\ "$$

$$\tau = \frac{62100}{40\times0.900\times121} = 14.2\ "$$

$$\tau_0 = \frac{62100}{5.97\times8\times0.900\times121}\times\frac{1}{2} = 5.9\ "$$



腹鉄筋ノ抵抗劈應力

$\theta = 45° - 30° = 15°$

$$\tau' = 1630\frac{A_b}{L'b_0} + 1200\frac{A_s}{a\,b_0}$$ (第26頁參照)

$A_b = 2-19\phi = 5.67\ cm^2$

$A_s = 2-12\phi = 2.262\ "$

$a = 20^{cm}$ (haunch 先端部)

$L' = 30^{cm}$

$b_0 = 40^{cm}$

Haunch ノ先端部ニ於ケル抵抗劈應力.

$$\tau' = 1630\times\frac{5.67}{30\times40} + 1200\times\frac{2.262}{20\times40} = 7.70 + 3.40 = 11.10\ kg/cm^2$$

Haunch 先端ニ於ケル劈力

$S_h = S - 0.75w = 62100 - 0.75\times49720 = 24{,}800$ kg

劈應力 $\tau = \frac{24800}{40\times\frac{7}{8}\times98} = 7.2\ kg/cm^2 < 11.10$

柱側面

$$\tau' = 1630\times\frac{5.67}{30\times40} + 1200\times\frac{2.262}{10\times40} = 7.70 + 6.79 = 14.49\ kg/cm^2$$

$S_{cf} = 42{,}200$ kg $\quad h = 106 + \frac{35}{3} = 118^{cm}$, $d = 118 - 10 = 108^{cm}$

劈應力 $\tau = \frac{42200}{40\times\frac{7}{8}\times108} = 11.15\ kg/cm^2 < 14.49$

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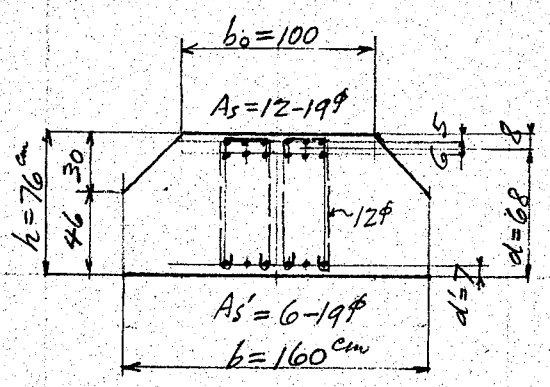
上海標準隧道

下部縦桁

中央断面



M_c= 22200 kgm, S=0

b=160cm, b_0=100cm
h=76cm, d=68cm, d'=7

A_s=12-19φ= 34.02 cm² p=34.02/160×68 = 0.00313
A_s'=6-19φ= 17.01 〃 p'=17.01/〃〃 = 0.00156
d'/d = 7/68 = 0.103

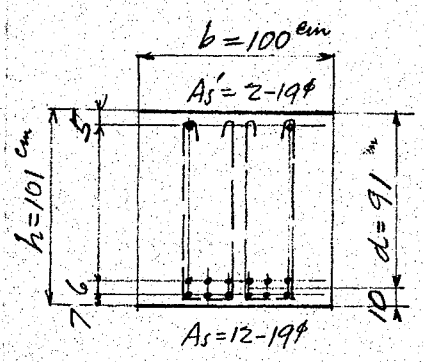
k=0.255, L_c=0.131, L_s=0.00285

$\sigma_c = \frac{22200\times100}{160\times68^2\times0.131}$ = 22.9 kg/cm²

$\sigma_s = \frac{22200\times100}{160\times68^2\times0.00285}$ = 1053 〃

τ = 0

支点断面



M_s= −31100 kgm, S=62100 kg

b=100cm, $h = 76 + \frac{40+35}{3}$ = 101cm, d=91cm, d'=5cm
A_s= 12-19φ= 34.02 cm² p= 34.02/100×91 = 0.00374
A_s'= 2-19φ= 5.67 〃 p'= 5.67/〃〃 = 0.00062
d'/d = 5/91 = 0.055

k=0.278, L_c=0.132, L_s=0.00336

$\sigma_c = \frac{31100\times100}{100\times91^2\times0.132}$ = 28.5 kg/cm²

$\sigma_s = \frac{31100\times100}{100\times91^2\times0.00336}$ = 1118 〃

$\tau = \frac{62100}{100\times0.907\times91}$ = 7.5 〃

$\tau_0 = \frac{62100}{5.97\times12\times1.907\times91}\times\frac{1}{2}$ = 5.3 〃

腹鉄筋ノ抵抗ニ得ル勞應力、
Haunch ノ先端 $\tau' = 12\left\{\frac{1.41A_b}{L'} + \frac{A_s}{a}\right\} = 12\left(\frac{1.41\times5.67}{30} + \frac{3.39}{20}\right)$
(2-19φ, 3-12φ (2本ト4本ノ平均))
= 3.20 + 2.03 = 5.23 kg/cm²

Haunch 先端ニ於ケル勞力 S_h = 24,800 kg
勞應力 $\tau = \frac{24800}{100\times\frac{7}{8}\times68}$ = 4.2 kg/cm² < 5.23

柱側面 $\tau' = 12\left(\frac{1.41\times5.67}{30} + \frac{3.39}{10}\right)$ = 3.20 + 4.06 = 7.26 〃

$\tau = \frac{42200}{100\times\frac{7}{8}\times81}$ = 5.95 < 7.26, $h = 76 + \frac{35}{3}$ = 88, d = 81

注意 配筋ハ S.C.T.3 ニ準ズ (第15頁參照)

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上海高速鐵道
鐵筋混凝土標準型複線隧道
土被六。米 應力計算書

Standard Reinforced Concrete Tunnel.
Double Track.
Mark. S. C. T. 6.

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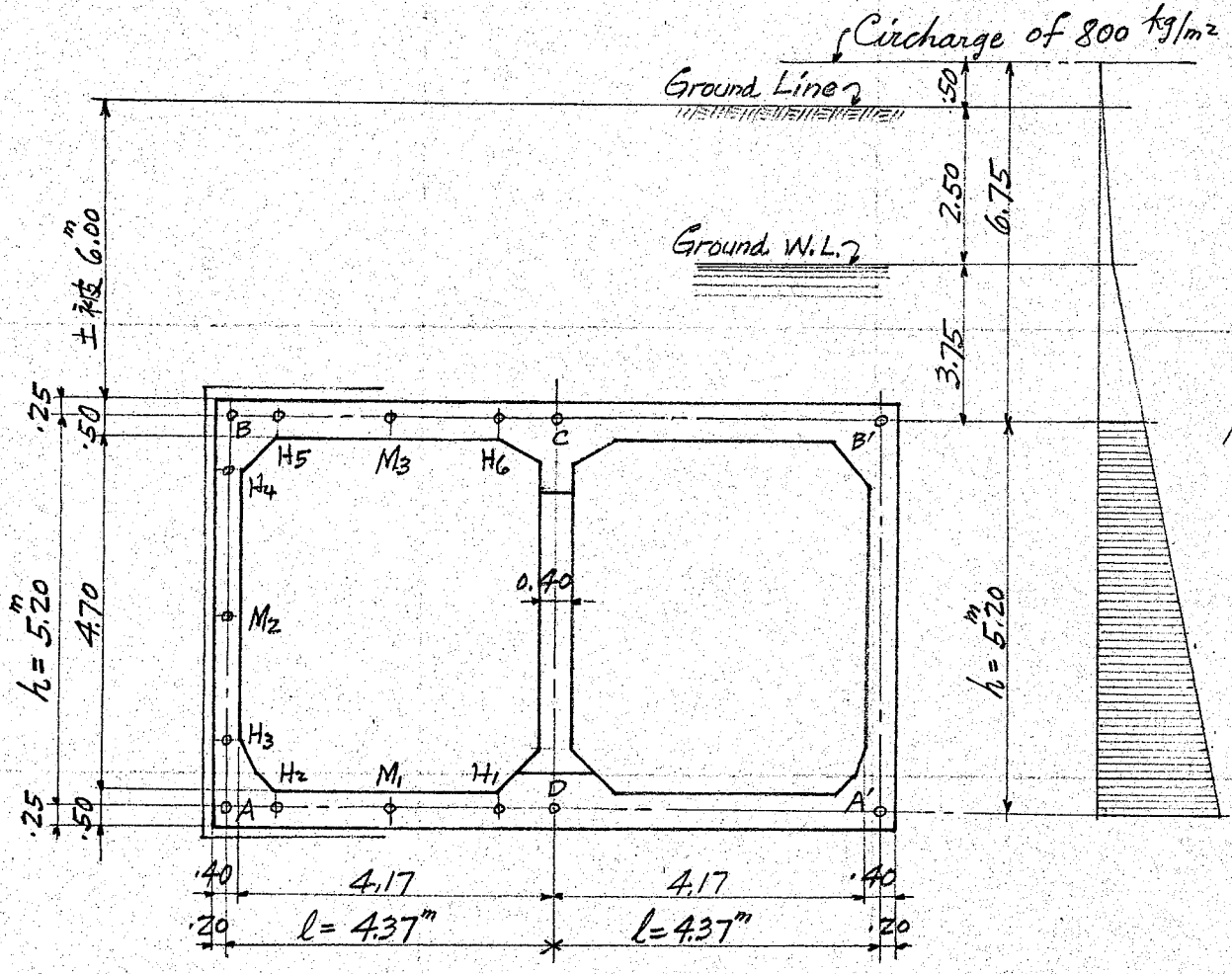
上海高速鐵道鐵筋混凝土標準隧道

土被 6.0m 標準隧道 S.C.T.6.



上床荷重 w.

土被	地下水位以上	2.50m	@ 1,600	= 4,000
〃	〃 以下	3.40	@ 2,000	= 6,800
被覆混凝土		0.10	@ 2,200	= 220
上床		0.50	@ 2,400	= 1,200
				12,220
路面傳布荷重				800
				w = 13,020 kg/m²

下床荷重 上床荷重ト同一ナリト假定ス

側壁荷重

B及B'点ニ於ケル荷重 p.

土被	2.50m @ 1600	= 4,000
〃	3.75 @ 2000	= 7,500
路面荷重		= 800
	12,300 × 0.406	= 5,000 kg/m² = p.

A及A'点ニ於ケル荷重 p+q

5.20 @ 2000	= 10,400 × 0.406	4220 〃 = q
		9,220 kg/m² = p+q.

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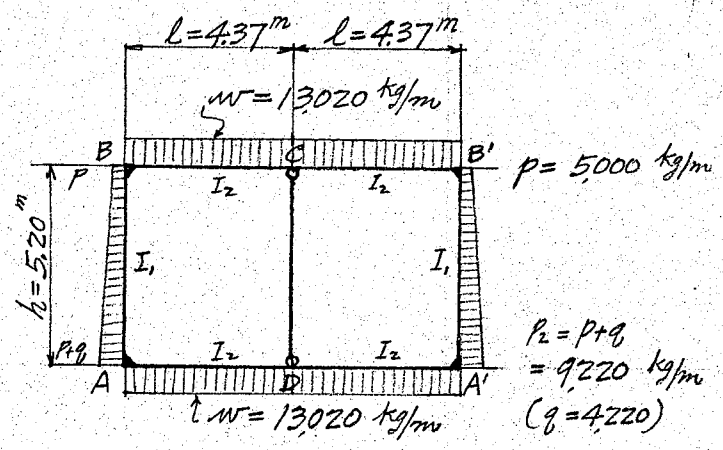
上海標準隧道

荷重狀態



Moments of Inertia.

$$I_1 = \frac{1.0 \times 0.40^3}{12} = 0.00533 \ m^4$$

$$I_2 = \frac{1.0 \times 0.50^3}{12} = 0.01042$$

$$K_1 = \frac{I_1}{h} = \frac{0.00533}{5.20} = 0.00102$$

$$K_2 = \frac{I_2}{l} = \frac{0.01042}{4.37} = 0.00238$$

$$K = \frac{K_2}{K_1} = \frac{0.00238}{0.00102} = 2.3333$$

$12(1+2K) = 12(1+4.6667) = 68.000$
$1+3K = 1+7.000 = 8.000$
$wl^2 = 13020 \times 437^2 = 248600$

$61K_1 + 12K_2 = 0.0622 + 0.0286 = 0.0908$
$59K_1 + 8K_2 = 0.0602 + 0.0190 = 0.0792$
$31K_1 + 7K_2 = 0.0316 + 0.0167 = 0.0483$
$29K_1 + 3K_2 = 0.0296 + 0.0071 = 0.0367$
$120(6K_1+K_2)(K_1+2K_2) = 120 \times 0.0085 \times 0.0058 = 0.00592$
$K_2h^2 = 0.00238 \times 5.20^2 = 0.0644$

上下床ノ荷重 w = 依ル彎曲率

$$M_A = M_B = -\frac{wl^2}{12(1+2K)} = -\frac{248600}{68.00} = -3660 \ kgm$$

$$M_C = M_D = -\frac{(1+3K)wl^2}{12(1+2K)} = -\frac{8.00 \times 248600}{68.00} = -29250$$

兩側壁ノ荷重 p 及ビ p+q = 依ル彎曲率

$$M_A = -\frac{K_2h^2\{(61K_1+12K_2)(p+q)+(59K_1+8K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.0644(0.0908 \times 9220 + 0.0792 \times 5000)}{0.00592} = -13410 \ kgm$$
[123]

$$M_B = -\frac{K_2h^2\{(59K_1+8K_2)(p+q)+(61K_1+12K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.0644(0.0792 \times 9220 + 0.0908 \times 5000)}{0.00592} = -12870$$
1184

$$M_C = \frac{K_2h^2\{(31K_1+7K_2)(p+q)+(29K_1+3K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = \frac{0.0644(0.0483 \times 9220 + 0.0367 \times 5000)}{0.00592} = +6840$$
628.7

$$M_D = \frac{K_2h^2\{(29K_1+3K_2)(p+q)+(31K_1+7K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = \frac{0.0644(0.0367 \times 9220 + 0.0483 \times 5000)}{0.00592} = +6310$$
579.8

上下床及ビ左右側壁荷重ニ依ル合成彎曲率

	床荷重ニ依ル彎曲率	側壁荷重ニ依ル彎曲率	合成彎曲率
M_A	−3,660 kgm	−13,410 kgm	−17,070 kgm
M_B	−3,660	−12,870	−16,530 〃
M_C	−29,250	6,840	−22,410 〃
M_D	−29,250	6,310	−22,940 〃

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上海標準隧道

剪力

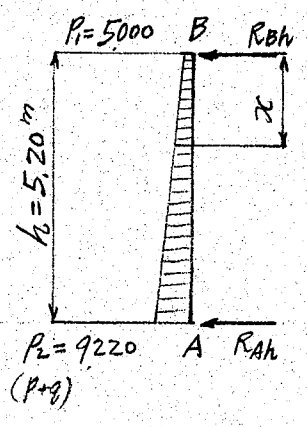
上床 $S_{BZ} = \frac{wl}{2} + \frac{M_C - M_B}{l} = \frac{13020 \times 4.37}{2} + \frac{-22410+16530}{4.37} = 28450 - 1350 = 27,100$ kg

〃 $S_{CZ} = -\frac{wl}{2} + \frac{M_C - M_B}{l} = -28450 - 1350 = -29800$ 〃

下床 $S_{AZ} = -\frac{wl}{2} + \frac{M_A - M_D}{l} = -28450 + \frac{-17070+22940}{4.37} = -28450 + 1350 = -27100$ 〃

〃 $S_{DZ} = \frac{wl}{2} + \frac{M_A - M_D}{l} = 28450 + 1350 = 29800$ 〃

側壁



AB ヲ Simple Beam トシテ 支力

$R_{Ah} = \frac{h}{6}(2p_2 + p_1) = \frac{5.20}{6}(18440 + 5000) = 20,300$ kg (23440)

$R_{Bh} = \frac{h}{6}(2p_1 + p_2) = \frac{5.20}{6}(10,000 + 9220) = 16,650$ 〃 (19220)

剪力

$S_{BI} = -R_{Bh} + \frac{M_B - M_A}{h} = -16,650 + \frac{-16530+17070}{5.20} = -16,550$ kg (100)

$S_{AI} = R_{Ah} + \frac{M_B - M_A}{h} = 20,300 + 100 = 20,400$ 〃

中間点ニ於ケル彎曲率及ビ剪力

下床 AD

Ⓜ₁ 0 Shear ノ点 $x = -\frac{S_{AZ}}{w} = \frac{27100}{13020} = 2.082$ m (A点ヨリノ距離)

$M_A = -17,070$

$-S_{AZ}x = 27100 \times 2.082 = 56,420$

$-\frac{wx^2}{2} = -\frac{13020 \times 2.082^2}{2} = -28250$

$M_1 = 11,100$ kgm $S_1 = 0$

Ⓗ₁ $x = 4.37 - 0.80 = 3.57$ m

$M_A = -17,070$

$-S_{A2}x = 27,100 \times 3.57 = 96,900$

$-\frac{wx^2}{2} = -\frac{13020 \times 3.57^2}{2} = -83,000$

$M_{H1} = -3,170$ kgm

$S_{AZ} = -27,100$

$wx = 13020 \times 3.57 = 46,500$

$S_{H1} = 19,400$ kg

Ⓗ₂ $x = 0.20 + 0.40 = 0.60$ m

$M_A = -17,070$

$-S_{A2}x = 27100 \times 0.60 = 16250$

$-\frac{wx^2}{2} = -\frac{13020 \times 0.60^2}{2} = -2350$

$M_{H2} = -3,170$ kgm

$S_{A2} = -27,100$

$wx = 13020 \times 0.60 = 7800$

$S_{H2} = -19,300$ kg

軸力 $N_{AD} = S_{AI} = 20,400$ kg. C

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上海標準隧道

上床 BC

(M3) $x = 2.082^m$ (M1 ト同一)

$M_B = -16530$
$S_{B2}x = 27100 \times 2.082 = 56420$
$-\frac{wx^2}{2} = -\frac{13020 \times 2.082^2}{2} = -28250$
$M_3 = 11640\ kgm \quad S_3 = 0$

(H5) $x = 0.20 + 0.40 = 0.60^m$

-16530
$27100 \times 0.60 = 16250$
$\frac{13020 \times 0.60^2}{2} = -2350$
$M_{H5} = -2630\ kgm$

$-13020 \times 0.60 = -7800$
$S_{H5} = 19300\ kg$

(H6) $x = 4.37 - 0.80 = 3.57^m$

-16530
$27100 \times 3.57 = 96900$
$-\frac{13020 \times 3.57^2}{2} = -83000$
$M_{H6} = -2630\ kgm$

$S_{H6} = -19400\ kg$

軸力 $N_{BC} = -S_{B1} = 16550\ kg.C.$

側壁 AB

任意ノ1点ニ於ケル剪力

$S_x = S_{B1} + \frac{qx^2}{2h} + px = -16550 + \frac{4220x^2}{2 \times 5.20} + 5000x$
$= 406x^2 + 5000x - 16550$

0 Shear ノ点 $x^2 + 12.31x - 40.75 = 0$, $x = -\frac{12.31}{2} \pm \frac{\sqrt{12.31^2 + 40.75 \times 4}}{2} = 2.715^m$

任意ノ1点ニ於ケル湾曲率

$M_x = -S_{B1}x - \frac{px^2}{2} - \frac{qx^3}{6h} + M_B = 16550x - 2500x^2 - \frac{4220x^3}{6 \times 5.20} - 16530$
$= -135.5x^3 - 2500x^2 + 16550x - 16530$

	x	$-135.5x^3$	$-2500x^2$	$+16550x$	-16530		M_x
(H4)	0.65^m	-40	-1060	$+10750$	-16530	$=$	$-6880\ kgm$
(M2)	2.715	-2710	-18440	$+44950$	-16530	$=$	7270
(H3)	4.35	-11140	-47260	$+72000$	-16530	$=$	-2930

	x		$406x^2$	$+5000x$	-16550		S_x
(H4)	0.65^m		170	$+3250$	-16550	$=$	$-13130\ kg$
(M2)	2.715		2990	$+13560$	-16550	$=$	0 〃
(H3)	4.35		7680	$+21750$	-16550	$=$	12880 〃

軸力 $N_{AB} = S_{B2} = 27100\ kg.C.$

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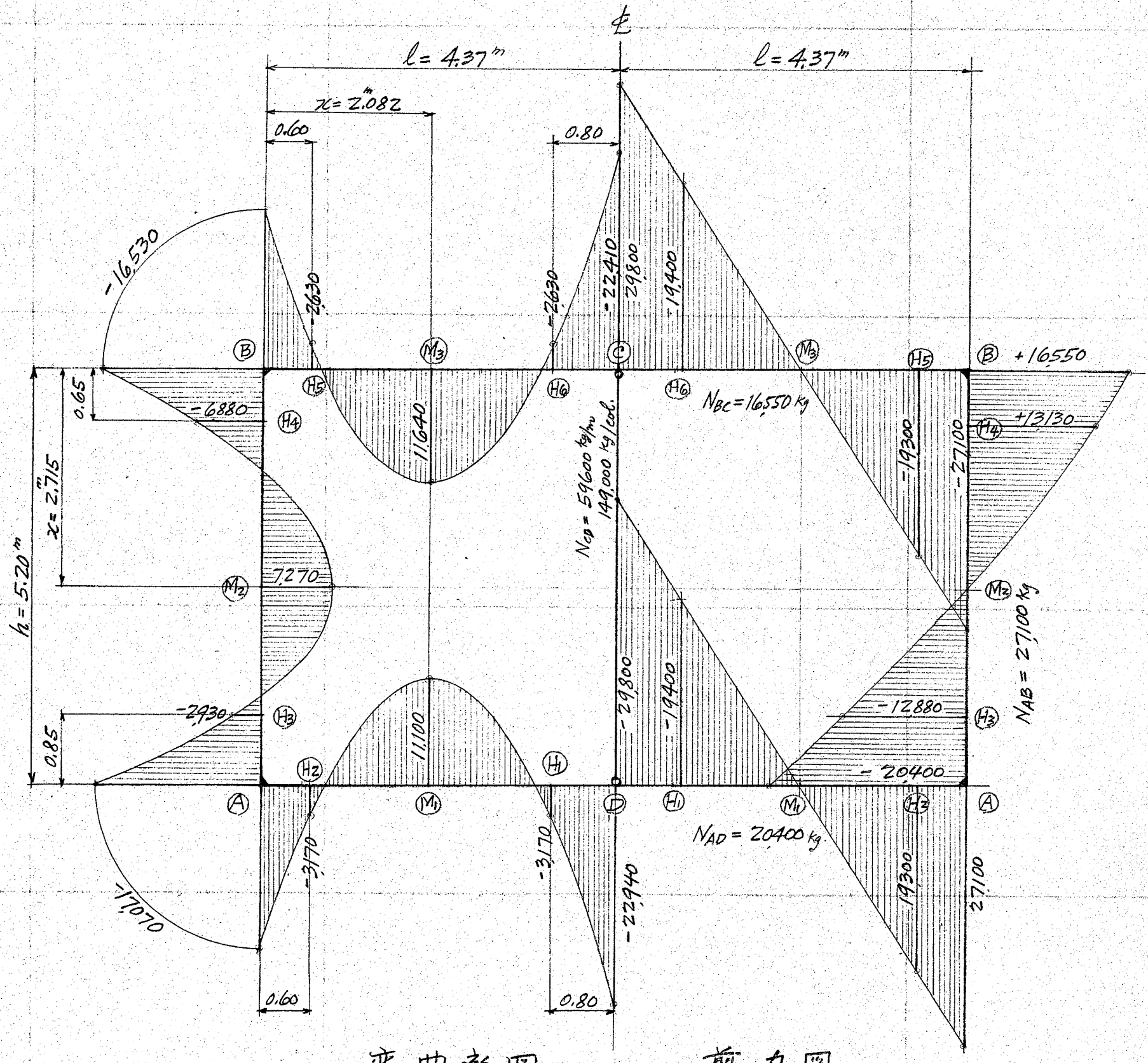
上海標準隧道

中央柱 C.D.

軸力 $N_{CD} = -2S_{cz} = 29800 \times 2 = 59{,}600$ kg.c./m strip of tunnel.
柱ノ間隔ヲ 2.5m c to c トスレバ
柱一本当リ荷重 $= 2.5 \text{m} \times 59600 = 149{,}000$ kg.c.

彎曲率及ビ剪力圖



彎曲率圖 剪力圖

$\frac{1}{50}$m = 10,000 kgm $\frac{1}{50}$m = 10,000 kg

Scale 1:60

注意
M_1, M_2 及 M_3 ハ最大正彎曲率ノ点
H_1 乃至 H_6 ハ各 haunch ノ先端

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上海標準隧道

断面應力ノ計算

下床 AD.

(M1) M = 11,100 kgm, N = 20400 kg, C, S = 0.

$d/h = 45/50 = 0.900$
$d'/h = 5/50 = 0.100$
$p_0 = 28.35/100\times50 = 0.00567$
$p_0' = 7.09/\,\,\,\, = 0.00142$
$u/h = 0.524$
$u = 26.2$ cm
$d-u = 18.8$ "

$\frac{M}{N} = \frac{11100\times100}{20400} = 54.5$
$d-u = 18.8$
$e = 73.3$ cm
$e' = e-40 = 33.3$ "
$e'/e = 0.455$
$\frac{Ne}{bd^2} = \frac{20400\times73.3}{100\times45^2} = 7.380$
$\frac{Ne}{bd^2\sigma_c} = 0.208$, $k = 0.450$
$\sigma_c = \frac{7.380}{0.208} = 35.5$ kg/cm²
$\sigma_s = 15\times35.5\times\frac{1.350}{1.450} = 650$ "
$\tau = 0$

$b = 100$ cm, $h = 50$ cm
$d = 45$ cm, $d' = 5$ cm
$A_s = 10-19\phi = 28.35$ cm²
$A_s' = 2.5-19\phi = 7.09$ "
$p = 28.35/100\times45 = 0.00630$
$p' = 7.09/\,\,\,\, = 0.00157$
$d'/d = 5/45 = 0.111$

(D) M = −22940 kgm, N = 20,400 kg, C. S = 29800 kg

$d/h = 71/76 = 0.935$
$d'/h = 5/76 = 0.066$
$p_0 = 28.35/100\times76 = 0.00373$
$p_0' = 7.09/\,\,\,\, = 0.00093$
$u/h = 0.515$
$u = 39.1$ cm
$d-u = 31.9$

$\frac{M}{N} = \frac{22940\times100}{20400} = 112.5$
$d-u = 31.9$
$e = 144.4$ cm
$e' = e-66 = 78.4$ "
$e'/e = 0.545$
$\frac{Ne}{bd^2} = \frac{20400\times144.4}{100\times71^2} = 5.840$
$\frac{Ne}{bd^2\sigma_c} = 0.170$, $k = 0.360$
$\sigma_c = \frac{5.840}{0.170} = 34.4$ kg/cm²
$\sigma_s = 15\times34.4\times\frac{0.640}{0.360} = 918$ "

$b = 100$, $h = 50+\frac{80}{3} = 76$ cm
$d = 71$, $d' = 5$
$A_s = 10-19\phi = 28.35$
$A_s' = 2.5-19\phi = 7.09$
$p = 28.35/100\times71 = 0.00399$
$p' = 7.09/\,\,\,\, = 0.00100$
$d'/d = 5/71 = 0.070$

$\tau = \frac{29800}{100\times0.880\times71} = 4.8$ kg/cm²
$\tau_0 = \frac{29800}{5.97\times10\times.88\times71}\times\frac{1}{2} = 4.0$ "

(A) M = −17,070 kgm, N = 20400 kg, C. S = −27,100 kg

$d/h = 65/70 = 0.928$
$d'/h = 5/70 = 0.072$
$p_0 = 20.1/100\times70 = 0.00287$
$p_0' = 7.09/\,\,\,\, = 0.00101$
$u/h = 0.509$
$u = 35.7$
$d-u = 29.4$ cm

$\frac{M}{N} = \frac{17070\times100}{20400} = 83.7$
$d-u = 29.4$
$e = 113.0$ cm
$e' = e-60 = 53.0$ "
$e'/e = 0.469$
$\frac{Ne}{bd^2} = \frac{20400\times113.0}{100\times65^2} = 5.460$
$\frac{Ne}{bd^2\sigma_c} = 0.167$, $k = 0.345$
$\sigma_c = \frac{5.460}{0.167} = 32.7$ kg/cm²
$\sigma_s = 15\times32.7\times\frac{0.655}{0.345} = 933$ "

$b = 100$, $h = 50+\frac{60}{3} = 70$
$d = 65$, $d' = 5$
$A_s = 10-16\phi = 20.10$ cm²
$A_s' = 2.5-19\phi = 7.09$ "
$p = 20.10/100\times65 = 0.00309$
$p' = 7.09/\,\,\,\, = 0.00109$
$d'/d = 5/65 = 0.077$

$\tau = \frac{27100}{100\times0.885\times65} = 4.7$ kg/cm²
$\tau_0 = \frac{27100}{5.03\times10\times0.885\times65}\times\frac{1}{2} = 4.7$ "

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上海標準隧道

(H1) $M = -3170$ kgm, $N = 20,400$ kg.c. $S = -19400$ kg

$$\tau = \frac{19400}{100 \times 7/8 \times 45} = 4.9 \text{ kg/cm}^2$$

$$\tau_0 = \frac{19400}{7.5 \times 5.97 \times 7/8 \times 45} \times \frac{1}{2} = 5.5 \text{ 〃}$$

下面ノ主鉄筋ハ 7.5 本トシテ
様. lap ヲ長クシテ bond
Stress ヲ軽減スルコト

(H2) $M = -3170$ kgm, $N = 20400$ kg.c. $S = -19,300$ kg

$$\tau = \frac{19300}{100 \times \frac{7}{8} \times 45} = 4.9 \text{ kg/cm}^2$$

$$\tau_0 = \frac{19300}{7.5 \times 5.97 \times 7/8 \times 45} \times \frac{1}{2} = 5.5 \text{ 〃}$$

〃

上床 BC.

(M3) $M = 11,640$ kgm, $N = 16550$ kg.c. $S = 0$.

$$\frac{M}{N} = \frac{11640 \times 100}{16550} = 70.4$$

$$d - u = 18.8$$

$$e = 89.2 \text{ cm}$$

$$e' = e - 40 = 49.2 \text{ 〃}$$

$$e'/e = 0.552$$

$$\frac{Ne}{bd^2} = \frac{16550 \times 89.2}{100 \times 45^2} = 7,290$$

$$\frac{Ne}{bd^2\sigma_c} = 0.196, \quad k = 0.425$$

$$\sigma_c = \frac{7,290}{0.196} = 37.2 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 37.2 \times \frac{0.575}{0.425} = 755 \text{ 〃}$$

$$\tau = 0$$

断面ハ (M1) ニ同ジ
(第 45 頁参照)

(H5) 及ビ (H6) ハ夫々 (H2) 及 (H1) ト同一断面ヲ使用スレバ安全ナリ.

(B) $M = -16,530$ kgm, $N = 16550$ kg.c. $S = 27,100$ kg

$$\frac{M}{N} = \frac{16530 \times 100}{16550} = 99.9$$

$$d - u = 29.4$$

$$e = 129.3 \text{ cm}$$

$$e' = e - 60 = 69.3 \text{ 〃}$$

$$e'/e = 0.536$$

$$\frac{Ne}{bd^2} = \frac{16550 \times 129.3}{100 \times 65^2} = 5,070$$

$$\frac{Ne}{bd^2\sigma_c} = 0.159, \quad k = 0.330$$

$$\sigma_c = \frac{5070}{0.159} = 31.9 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 31.9 \times \frac{0.670}{0.330} = 973 \text{ 〃}$$

$$\tau = \frac{27100}{100 \times 0.890 \times 65} = 4.7 \text{ 〃}$$

$$\tau_0 = \frac{27100}{5.03 \times 10 \times .890 \times 65} \times \frac{1}{2} = 4.7 \text{ 〃}$$

断面ハ (A) ニ同ジ
(第 45 頁参照)

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上海標準隧道

Ⓒ　M= −22,410 kgm,　N= 16,550 kg.c.　S= −29,800 kg.

$\frac{M}{N} = \frac{22410 \times 100}{16550} = 135.5$
$d-u = 31.9$
$e = 167.4$ cm
$e' = e - 66 = 101.4$ 〃
$e'/e = 0.606$
$\frac{Ne}{bd^2} = \frac{16550 \times 167.4}{100 \times 71^2} = 5.495$
$\frac{Ne}{bd^2\sigma_c} = 0.163$, $k = 0.350$
$\sigma_c = \frac{5.495}{0.163} = 33.7$ kg/cm²
$\sigma_s = 15 \times 33.7 \times \frac{0.650}{0.350} = 940$ 〃
$\tau = \frac{29800}{100 \times 0.883 \times 71} = 4.8$ 〃
$\tau_0 = \frac{29800}{5.97 \times 10 \times 0.883 \times 71} \times \frac{1}{2} = 4.0$ 〃

断面ハⒹ＝同上
(第45頁参照)

側壁 AB.

Ⓜ₂　M= 7270 kgm,　N= 27,100 kg.c.　S=0.

$d/h = 35/40 = 0.875$
$d'/h = 5/40 = 0.125$
$p_0 = 20.1/100 \times 40 = 0.00503$
$p_0' = 10.1/〃 = 0.00252$
$u/h = 0.513$
$u = 20.5$ cm
$d-u = 14.5$ 〃

$\frac{M}{N} = \frac{7270 \times 100}{27100} = 26.8$
$d-u = 14.5$
$e = 41.3$ cm
$e' = e - 30 = 11.3$ 〃
$e'/e = 0.274$
$\frac{Ne}{bd^2} = \frac{27100 \times 41.3}{100 \times 35^2} = 9.14$
$\frac{Ne}{bd^2\sigma_c} = 0.235$, $k = 0.500$
$\sigma_c = \frac{9.140}{0.235} = 38.9$ kg/cm²
$\sigma_s = 15 \times 38.9 \times \frac{0.50}{0.50} = 584$ 〃
$\tau = 0$

$b = 100$ cm, $h = 40$ cm
$d = 35$ cm, $d' = 5$ 〃
$A_s = 10-16\phi = 20.1$ cm²
$A_s' = 5-16\phi = 10.1$ 〃
$p = 20.1/100 \times 35 = 0.00575$
$p' = 10.1/〃 = 0.00288$
$d'/d = 5/35 = 0.143$

Ⓐ　M= −17,070 kgm,　N= 27,100 kg.c.　S= 20,400 kg

$d/h = 63/68 = 0.927$
$d'/h = 5/68 = 0.074$
$p_0 = 20.1/100 \times 68 = 0.00296$
$p_0' = 7.09/〃 = 0.00104$
$u/h = 0.511$
$u = 34.8$
$d-u = 28.2$ cm

$\frac{M}{N} = \frac{17070 \times 100}{27100} = 63.0$
$d-u = 28.2$
$e = 91.2$ cm
$e' = e - 58 = 33.2$ 〃
$e'/e = 0.364$
$\frac{Ne}{bd^2} = \frac{27100 \times 91.2}{100 \times 63^2} = 6.230$
$\frac{Ne}{bd^2\sigma_c} = 0.180$, $k = 0.385$
$\sigma_c = \frac{6.230}{0.180} = 34.6$ kg/cm²
$\sigma_s = 15 \times 34.6 \times \frac{0.615}{0.385} = 830$ 〃
$\tau = \frac{20400}{100 \times 0.872 \times 63} = 3.7$ 〃
$\tau_0 = \frac{20400}{5.03 \times 10 \times .872 \times 63} \times \frac{1}{2} = 3.7$ kg/cm²

$b = 100$, $h = 40 + \frac{85}{3} = 68$
$d = 63$, $d' = 5$
$A_s = 10-16\phi = 20.1$
$A_s' = 2.5-19\phi = 7.09$
$p = 20.1/100 \times 63 = 0.00319$
$p' = 7.09/〃 = 0.00113$
$d'/d = 5/63 = 0.080$

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上海標準隧道

Ⓑ M = −16530 kgm , N = 27,100 kg.c. S = −16550 kg

$d/h = 57/62 = 0.920$
$d'/h = 5/62 = 0.081$
$p_0 = 20.1/100\times62 = 0.00324$
$p_0' = 7.09/\,,\,, = 0.00114$
$u/h = 0.510$
$u = 31.6\,cm$
$d-u = 25.4$

$\frac{M}{N} = \frac{16530\times100}{27100} = 61.0$
$d-u = 25.4$
$e = 86.4\,cm$
$e' = e-52 = 34.4$
$e'/e = 0.398$
$\frac{Ne}{bd^2} = \frac{27100\times86.4}{100\times57^2} = 7.205$
$\frac{Ne}{bd^2\sigma_c} = 0.180$, $k_0 = 0.380$
$\sigma_c = \frac{7.205}{0.180} = 40.0\ kg/cm^2$
$\sigma_s = 15\times40.0\times\frac{0.620}{0.380} = 980\ kg/cm^2$
$\tau = \frac{16550}{100\times0.873\times57} = 3.3\ kg/cm^2$
$\tau_0 = \frac{16550}{5.03\times10\times873\times57}\times\frac{1}{2} = 3.3$,

$b=100$, $h = 40+\frac{65}{3} = 62$
$d=57$, $d'=5$
$A_s = 10-16\phi = 20.1$
$A_s' = 2.5-19\phi = 7.09$
$p = 20.1/100\times57 = 0.00352$
$p' = 7.09/\,,\,, = 0.00124$
$d'/d = 5/57 = 0.088$

Ⓗ4 M = −6880 kgm , N = 27,100 kg.c. S = −13130 kg

$e = \frac{M}{N} = \frac{6880\times100}{27100} = 25.4\ cm$
$e/h = 25.4/40 = 0.635$
$d'/h = 5/40 = 0.125$
$k_0 = 0.460$ $c = 0.220$
$\sigma_c = \frac{27100}{100\times40\times0.220} = 30.8\ kg/cm^2$
$\sigma_s = 15\times30.8\times\frac{1-0.46-0.125}{0.460} = 418$,
$\tau = \frac{13130}{100\times0.847\times35} = 4.4$,
$\tau_0 = \frac{13130}{5.03\times7.5\times.847\times35}\times\frac{1}{2} = 5.9$,

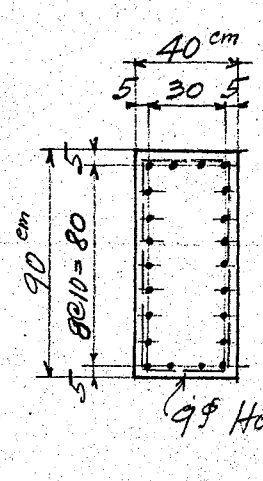
$b=100$, $h=40$
$d=35$, $d'=5$
$A_s = A_s' = 7.5-16\phi = 15.07$
$p_0 = p_0' = 15.07/100\times40 = 0.00377$

Ⓗ3 M = −2930 kgm , N = 27100 kg.c. S = 12880 kg

断面 Ⓗ4 = 合ニ

$\tau = \frac{12880}{100\times0.847\times35} = 4.3\ kg/cm^2$
$\tau_0 = \frac{12880}{5.03\times7.5\times.847\times35}\times\frac{1}{2} = 5.8$,

中央柱 CD. (間隔 2.5 m c to c トス)



柱最大荷重 = 149,000
柱自重 0.40×0.90×4.7 @ 2400 = 4,100
} 153,100 kg.c.

$A_s = 22-19\phi = 62.37\times15 = 936$
$A_c = 40\times90 = 3600$
$A_i = 4536\ cm^2$
$\sigma_c = \frac{153100}{4536} = 33.8\ kg/cm^2.c$
$\sigma_s' = 15\times33.8 = 507$, c
$\tau = 0$

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上海標準隧道

中央部上下縦桁

支間 2.50m, 連續桁トス

荷重 $w = 59600$ kg/m (第44頁応力圖參照)

最大正彎曲率 $M_c = \frac{wl^2}{14} = \frac{59600 \times 2.50^2}{14} = 26600$ kgm 中央

最大負 〃 $M_s = -\frac{wl^2}{10} = -\frac{59600 \times 2.50^2}{10} = -37200$ 〃 支点

剪力 $S = \frac{wl}{2} = \frac{59600 \times 2.50}{2} = 74600$ kg 〃

柱ノ側面ニ於ケル彎曲率

$0.45S = 0.45 \times 74600 = 33550$

$-\frac{w \times 0.45^2}{2} = -0.101 \times 59600 = -6020$

$M_s = -37200$

$M_{cF} = -9720$ kgm

仝上剪力. $S_{cF} = S - 0.45w = 74600 - 0.45 \times 5960 = 47800$ kg

Haunch 先端ニ於ケル剪力.

$S_h = S - 0.80w = 74600 - 0.80 \times 59600 = 26900$ kg

上部縦桁

中央断面 $M_c = 26600$ kgm, $S = 0$

$b = 160$ cm (第2案), $h = 120$ cm, $d = 111$ cm, $d' = 7$ cm

$A_s = 8-22\phi = 30.41$ cm², $p = 30.41/160 \times 111 = 0.00172$

$A_s' = 4-22\phi = 15.20$ 〃, $p' = 15.2/〃 = 0.00086$

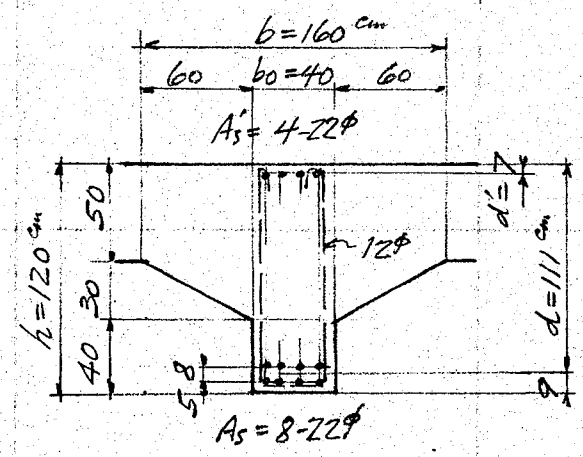
$d'/d = 7/111 = 0.0630$

$k = 0.200$, $L_c = 0.102$, $L_s = 0.00158$

$\sigma_c = \frac{26600 \times 100}{160 \times 111^2 \times 0.102} = 13.3$ kg/cm²

$\sigma_s = \frac{26600 \times 100}{160 \times 111^2 \times 0.00158} = 855$ 〃

$\tau = 0$



支点断面

$M_s = -37200$ kgm, ($S = 74600$ kg)

$b_0 = 40$, $h = 120 + \frac{35+45}{3} = 147$ cm, $d = 136$ cm, $d' = 5$ cm

$A_s = 8-22\phi = 30.41$ cm² $p = 30.41/40 \times 136 = 0.00559$

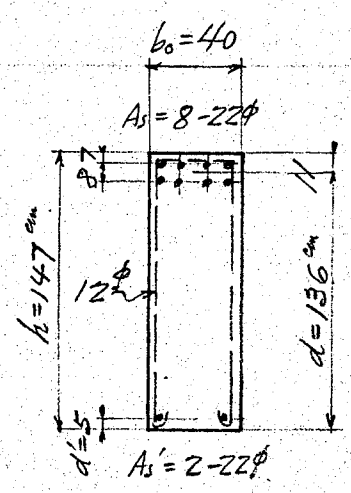
$A_s' = 2-22\phi = 7.60$ 〃 $p' = 7.60/〃 = 0.00140$

$d'/d = 5/136 = 0.0368$

$k = 0.320$, $L_c = 0.154$, $L_s = 0.00510$

$\sigma_c = \frac{37200 \times 100}{40 \times 136^2 \times 0.154} = 32.6$ kg/cm²

$\sigma_s = \frac{37200 \times 100}{40 \times 136^2 \times 0.00510} = 986$ 〃



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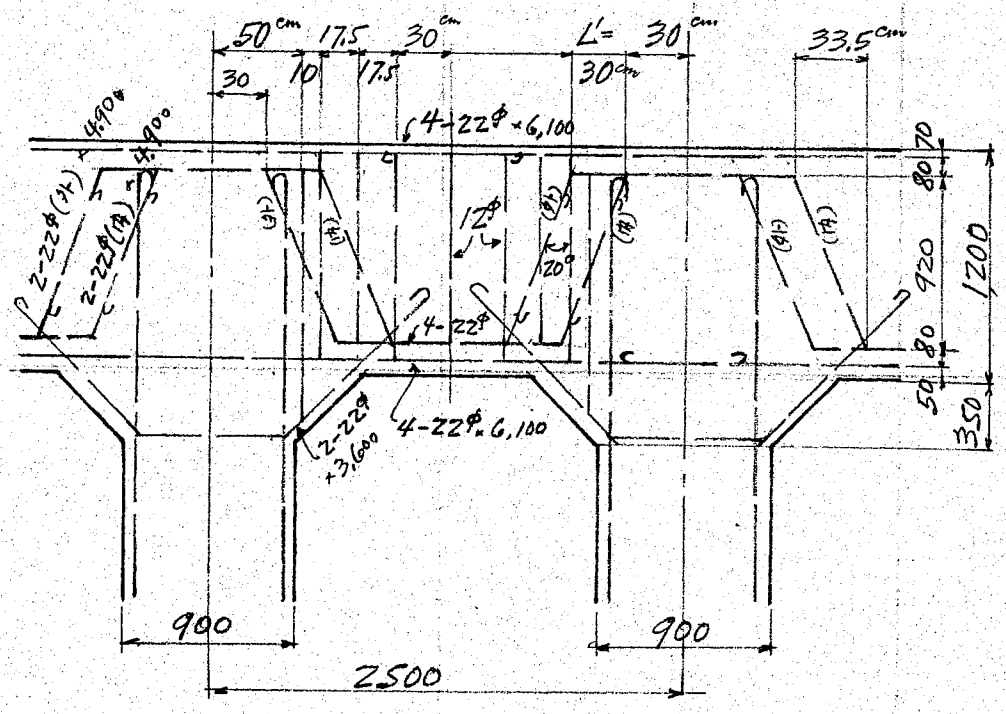
上海標準隧道

Haunch 先端及柱側面.



腹鉄筋ノ抵抗剪應力.

$\theta = 45° - 20 = 25°$, $\cos 25° = 0.906$

$$\tau' = \frac{1.41 \times 0.906 A_b \sigma_s}{L' b_o} + \frac{A_s \sigma_s}{a b_o}$$

$$= 1530 \frac{A_b}{L' b_o} + 1200 \frac{A_s}{a b_o}$$

$A_b = 2-22\phi = 7.60\ cm^2$
$L' = 30\ cm$ c to c
$b_o = 40\ cm$
$A_s = 2-12\phi = 2.26\ cm^2$
$a = \begin{cases} 10\ cm\ c\text{to}c & \text{--- 柱側面} \\ 17.5\ \text{〃} & \text{--- Haunch 先端} \end{cases}$

Haunch 先端.

剪力 $S_h = 26900\ kg$ $\quad \tau = \dfrac{26900}{40 \times 7/8 \times 111} = 6.9\ kg/cm^2$

抵抗剪應力 $\tau' = 1530 \times \dfrac{7.60}{30 \times 40} + 1200 \times \dfrac{2.26}{17.5 \times 40} =$

$= 9.70 + 3.9 = 13.6\ kg/cm^2 > 6.9$ ✓

柱側面

剪力 $S_{CF} = 47800\ kg$ $\quad h = 120 + \dfrac{35}{3} = 132\ cm$ $\quad d = 121\ cm$

剪應力 $\tau = \dfrac{47800}{40 \times 7/8 \times 121} = 11.3\ kg/cm^2$

抵抗剪應力 $\tau' = 1530 \times \dfrac{7.60}{30 \times 40} + 1200 \times \dfrac{2.26}{10 \times 40}$

$= 9.70 + 6.80 = 16.5\ kg/cm^2 > 11.3$ ✓

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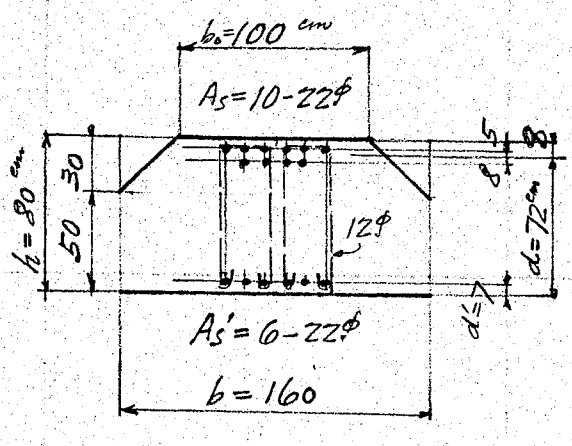
上海標準隧道

下部縦桁

中央断面



M_c = 26,600 kgm　　$S=0$

$b=160^{cm}$, $b_0=100^{cm}$,

$h=80^{cm}$, $d=72^{cm}$, $d'=7^{cm}$

A_s = 10 − 22φ = 38.01 cm²　　$p = 38.01/160\times72 = 0.00331$

A_s' = 6 − 22φ = 22.81　　$p' = 22.81/160\times72 = 0.00198$

$d'/d = 7/72 = 0.097$

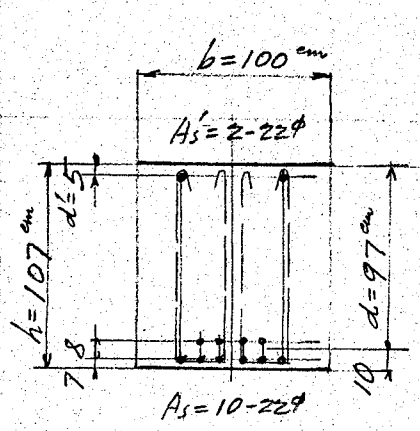
$k_0=0.256$, $L_c=0.136$, $L_s=0.00303$

$$\sigma_c = \frac{26600\times100}{160\times71^2\times0.136} = 24.3\ \text{kg/cm}^2$$

$$\sigma_s = \frac{26600\times100}{160\times71^2\times0.00303} = 1087\ ''$$

$\tau = 0$

支点断面



M_s = − 37,200 kgm, S = 74,600 kg

$b=100^{cm}$, $h=80+\frac{45+35}{3}=107^{cm}$, $d=97^{cm}$, $d'=5^{cm}$

A_s = 10−22φ = 38.01 cm²　　$p = 38.01/100\times97 = 0.00392$　　$\frac{d'}{d}=\frac{5}{97}=0.0515$

A_s' = 2−22φ = 7.60 ''　　$p' = 7.60/\,''\,'' = 0.00078$

$k_0=0.285$, $L_c=0.139$, $L_s=0.00355$

$$\sigma_c = \frac{37200\times100}{100\times97^2\times0.139} = 28.4\ \text{kg/cm}^2$$

$$\sigma_s = \frac{37200\times100}{100\times97^2\times0.00355} = 1113\ ''$$

此部ハ幅廣キ柱及haunchニヨリテ支ヘラルルヲ以テ剪應力ハ重視スルヲ要セズ"

Haunch 先端及ビ柱側面

Haunch 先端　　S_h = 26,900 kg　　$\tau = \frac{26900}{100\times\frac{7}{8}\times72} = 4.3\ \text{kg/cm}^2$

抵抗剪應力 $\tau' = 1530\times\frac{7.60}{30\times100}$ (←2-22φ) $+ 1200\times\frac{3.39}{17.5\times100}$ (←3-12φ(2本ト4本トノ平均))

$= 3.88 + 2.33 = 6.21\ \text{kg/cm}^2 > 4.3$

柱側面　　S_{cf} = 47,800 kg　　$h=80+\frac{35}{3}=92^{cm}$, $d=82^{cm}$

剪應力 $\tau = \frac{47800}{100\times\frac{7}{8}\times82} = 6.7\ \text{kg/cm}^2$

抵抗剪應力 $\tau' = 1530\times\frac{7.60}{30\times100}$ (←2-22φ) $+ 1200\times\frac{3.39}{10\times100}$ (←3-12φ(2本ト4本トノ平均))

$= 3.88 + 4.07 = 7.95\ \text{kg/cm}^2 > 6.7$

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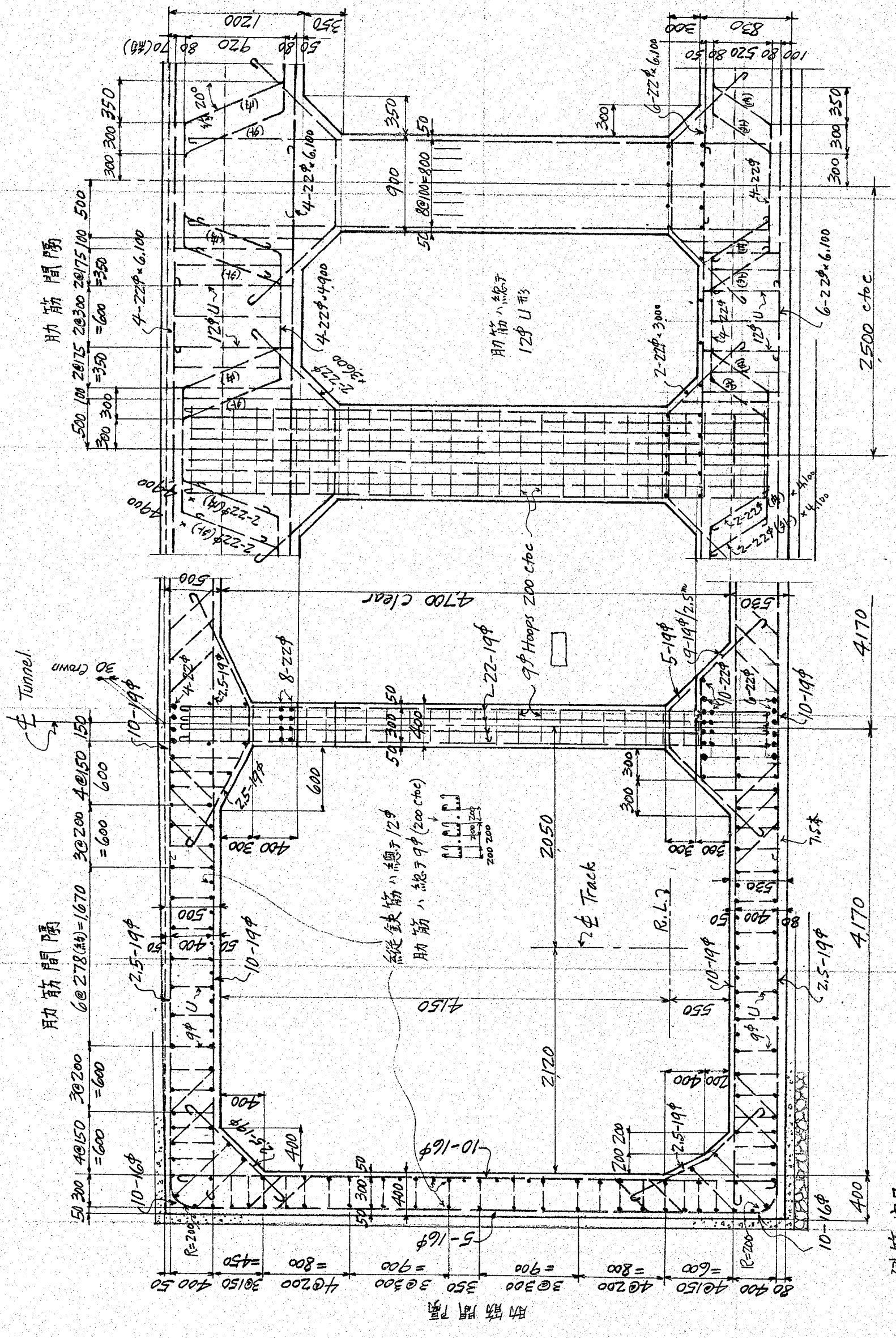
上海標準隧道

配筋圖



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設計　日付　類別

照査　日付　第　頁

上海高速鐵道
鐵筋混凝土標準型複線隧道
土被七.〇米 應力計算書

Standard Reinforced Concrete Tunnel.
Double Track
Mark S. C. T. 7.

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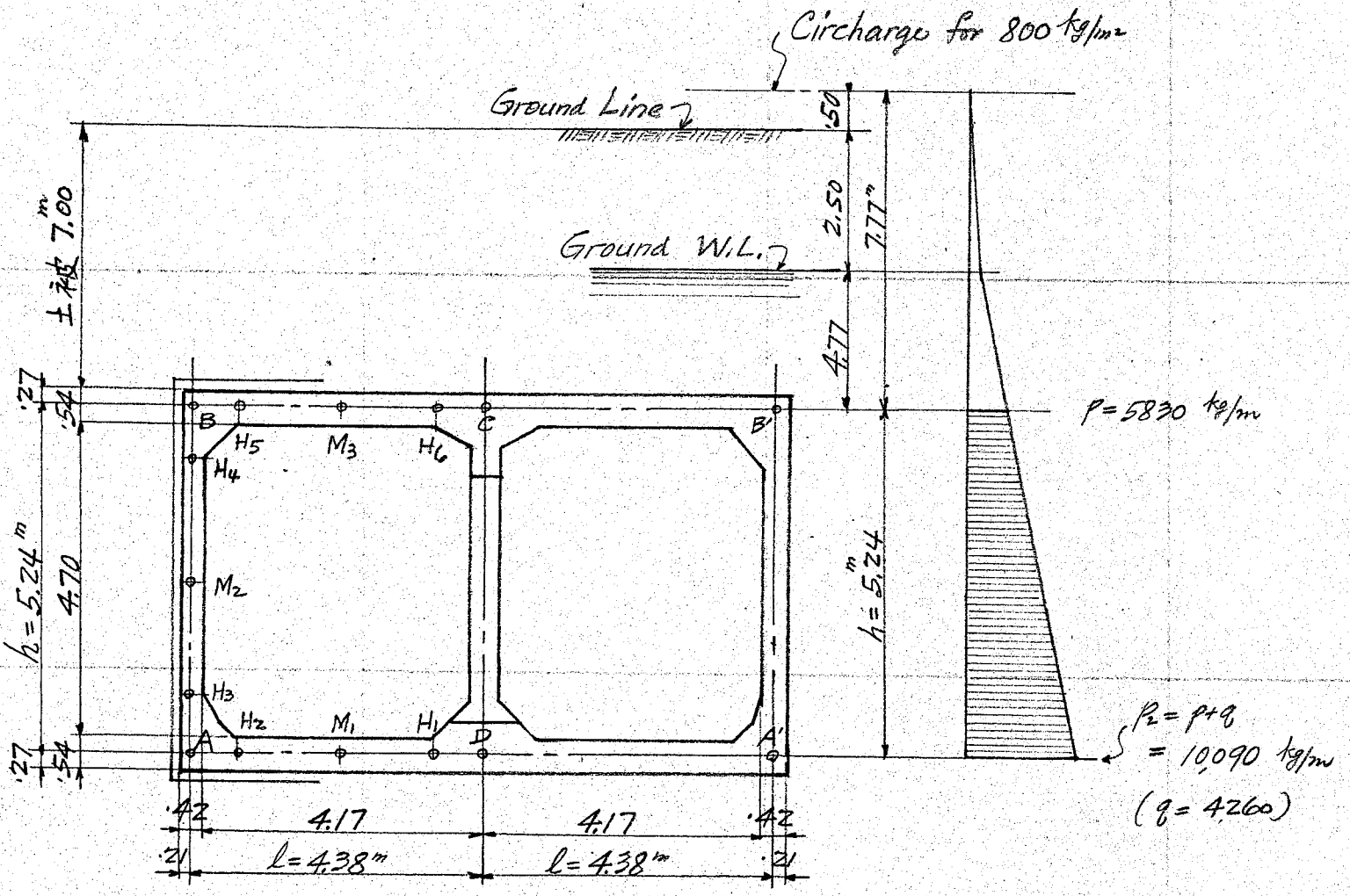
上海高速鐵道鐵筋混凝土標準隧道

土被 7.0m 標準隧道 S.C.T.7



上床荷重 w.

土被	地下水位以上	2.50 @ 1,600	=	4,000
〃	〃 以下	4.40 @ 2,000	=	8,800
被覆混凝土		0.10 @ 2,200	=	220
上床		0.54 @ 2400	=	1300
				14320
路面傳布荷重				800
			w =	15,120 kg/m²

下床荷重 上床荷重ト同一ナリト假定ス.

側壁荷重

B及ビB'点ニ於ケル荷重 p.

土被	2.50 @ 1600	=	4,000
〃	4.77 @ 2000	=	9,540
路面荷重			800
			14340 × 0.406 = 5,830 kg/m² = p

A及ビA'点ニ於ケル荷重 p+q.

5.24 @ 2000	= 10480 × 0.406	=	4260 〃 = q
			10,090 kg/m² = p+q

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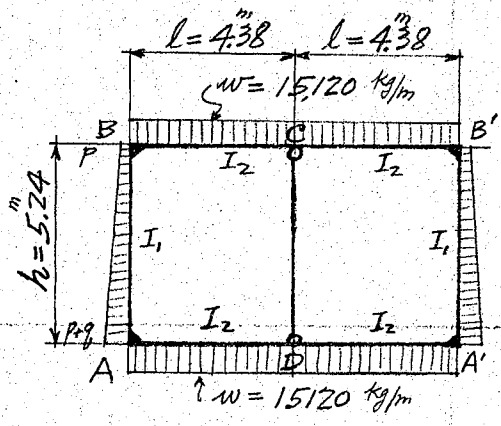
上海標準隧道

荷重狀態



Moments of Inertia.

$I_1 = \frac{1.0 \times 0.42^3}{12} = 0.00617\ m^4.$

$I_2 = \frac{1.0 \times 0.54^3}{12} = 0.01312\ m^4$

$K_1 = \frac{I_1}{h} = \frac{0.00617}{5.24} = 0.00118$

$K_2 = \frac{I_2}{l} = \frac{0.01312}{4.38} = 0.00300$

$K = \frac{K_2}{K_1} = \frac{0.00300}{0.00118} = 2.5424$

$12(1+2K) = 12(1+5.0848) = 73.0176$
$1+3K = 1+7.6272 = 8.6272$
$wl^2 = 15120 \times 4.38^2 = 290{,}000$

$61K_1+12K_2 = 0.0720+0.0360 = 0.1080$
$59K_1+8K_2 = 0.0696+0.0240 = 0.0936$
$31K_1+7K_2 = 0.0366+0.0210 = 0.0576$
$29K_1+3K_2 = 0.0342+0.0090 = 0.0432$
$120(6K_1+K_2)(K_1+2K_2) = 120 \times 0.0101 \times 0.0072 = 0.00873$
$K_2h^2 = 0.00300 \times 5.24^2 = 0.0824$

上下床ノ荷重 w = 依ル 彎曲率.

$M_A = M_B = -\frac{wl^2}{12(1+2K)} = -\frac{290{,}000}{73.0176} = -3970\ kgm$

$M_C = M_D = -\frac{(1+3K)wl^2}{12(1+2K)} = -\frac{8.6272 \times 290{,}000}{73.0176} = -34250$ 〃

両側壁ノ荷重 p 及ビ $p+q$ = 依ル 彎曲率

$M_A = -\frac{K_2h^2\{(61K_1+12K_2)(p+q)+(59K_1+8K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.0824(0.1080 \times 10{,}090 + 0.0936 \times 5{,}830)}{0.00873} = -15450\ kgm$ (1636)

$M_B = -\frac{K_2h^2\{(59K_1+8K_2)(p+q)+(61K_1+12K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = -\frac{0.0824(0.0936 \times 10{,}090 + 0.1080 \times 5830)}{0.00873} = -14860$ 〃 (1575)

$M_C = \frac{K_2h^2\{(31K_1+7K_2)(p+q)+(29K_1+3K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = \frac{0.0824(0.0576 \times 10{,}090 + 0.0432 \times 5830)}{0.00873} = 7870$ 〃 (834)

$M_D = \frac{K_2h^2\{(29K_1+3K_2)(p+q)+(31K_1+7K_2)p\}}{120(6K_1+K_2)(K_1+2K_2)} = \frac{0.0824(0.0432 \times 10{,}090 + 0.0576 \times 5830)}{0.00873} = 7290$ 〃 (772)

上下床及ビ左右側壁荷重 = 依ル合成彎曲率

	床荷重=依ル彎曲率	側壁荷重=依ル彎曲率	合成彎曲率
M_A	−3970 kgm	−15450 kgm	−19,420 kgm
M_B	−3970	−14860	−18,830 〃
M_C	−34250	7870	−26,380 〃
M_D	−34250	7290	−26,960 〃

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上海標準隧道

剪力.

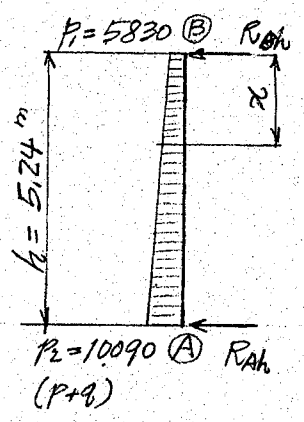
上床 $S_{BZ} = \frac{wl}{2} + \frac{M_C - M_B}{l} = \frac{15120 \times 4.38}{2} + \frac{-26380+18830}{4.38} = 33100 - 1720 = 31380\ kg$

〃 $S_{CZ} = -\frac{wl}{2} + \frac{M_C - M_B}{l} = -33100 - 1720 = -34820$ 〃

下床 $S_{AZ} = -\frac{wl}{2} + \frac{M_A - M_D}{l} = -33100 + \frac{-19420+26960}{4.38} = -33100 + 1720 = -31380$ 〃

〃 $S_{DZ} = \frac{wl}{2} + \frac{M_A - M_D}{l} = 33100 + 1720 = 34820$ 〃

側壁



AB ヲ Simple Beam トスル支力.

$R_{Ah} = \frac{h}{6}(2P_2 + P_1) = \frac{5.24}{6}(20180 + 5830) = 22{,}700\ kg$ (26010)

$R_{Bh} = \frac{h}{6}(2P_1 + P_2) = \frac{5.24}{6}(11660 + 10090) = 19{,}000$ 〃 (21750)

剪力.

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -19{,}000 + \frac{-18830+19420}{5.24} = -18890\ kg$ (110)

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 22700 + 110 = 22{,}810$ 〃

中間点ニ於ケル彎曲率及剪力.

下床 AD.

Ⓜ₁ 0 Shear ノ点 $x = -\frac{S_{AZ}}{w} = \frac{31380}{15120} = 2.075\ m$ (A点ヨリノ距離)

$M_A = -19{,}420$
$-S_{AZ}x = 31380 \times 2.075 = 65{,}100$
$-\frac{wx^2}{2} = -\frac{15120 \times 2.075^2}{2} = -32{,}550$
$M_1 = 13{,}130\ kgm$ $S_1 = 0$

Ⓗ₁ $x = 4.38 - 0.80 = 3.58\ m$

$M_A = -19{,}420$
$-S_{AZ}x = 31380 \times 3.58 = 112{,}300$
$-\frac{wx^2}{2} = -\frac{15120 \times 3.58^2}{2} = -96{,}800$
$M_{H1} = -3920\ kgm$

$S_{AZ} = -31{,}380$
$wx = 15120 \times 3.58 = 54{,}100$
$S_{H1} = 22{,}720\ kg$

Ⓗ₂ $x = 0.21 + 0.40 = 0.61\ m$

$M_A = -19{,}420$
$-S_{AZ}x = 31380 \times 0.61 = 19{,}140$
$-\frac{wx^2}{2} = -\frac{15120 \times 0.61^2}{2} = -2810$
$M_{H2} = -3090\ kgm$

$S_{AZ} = -31{,}380$
$wx = 15120 \times 0.61 = 9230$
$S_{H2} = -22{,}150\ kg$

軸力 $N_{AD} = S_{A1} = 22{,}810\ kg.C.$

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上海標準隧道

上床 BC

(M3) $x = 2.075^m$ (M1ト合一)

$M_B = -18830$
$S_{B2}x = 31380 \times 2.075 = 65100$
$-\frac{wx^2}{2} = -\frac{15120 \times 2.075^2}{2} = -32550$

$M_3 = 13720$ kgm, $S_3 = 0$

(H5) $x = 0.21 + 0.40 = 0.61^m$

-18830
$31380 \times 0.61 = 19140$
$-15120 \times 0.61^2 \div 2 = -2810$

$M_{H5} = -2500$ kgm, $S_{H5} = 22150$ kg

(H6) $x = 4.38 - 0.80 = 3.58^m$

-18830
$31380 \times 3.58 = 112300$
$-15120 \times 3.58^2 \div 2 = -96800$

$M_{H6} = -3330$ kgm $S_{H6} = -22720$ kg

軸力 $N_{BC} = -S_{B1} = 18890$ kg. C

側壁 AB

任意1点=於ケル剪力 $S_x = S_{B1} + \frac{qx^2}{2h} + px = -18890 + \frac{4260x^2}{2 \times 5.24} + 5830x$
$= 406x^2 + 5830x - 18890$

0 Shear 1点 $x^2 + 14.35x - 46.55 = 0$, $x = \frac{-14.35}{2} \pm \frac{\sqrt{14.35^2 + 4 \times 46.55}}{2} = 2.725$

任意1点=於ケル彎曲率

$M_x = -S_{B1}x - \frac{px^2}{2} - \frac{qx^3}{6h} + M_B = 18890x - 2915x^2 - \frac{4260x^3}{6 \times 5.24} - 18830$
$= -135.5x^3 - 2915x^2 + 18890x - 18830$

	x	$-135.5x^3$	$-2915x^2$	$+18890x$	-18830		M_x
(H4)	0.67m	−40	−1310	+12650	−18830	=	−7530 kgm
(M2)	2.725	−2740	−21650	+51500	−18830	=	8280 〃
(H3)	4.37	−11300	−55600	+82600	−18830	=	−3130 〃

	x	$406x^2$	$+5830x$	-18890		S_x
(H4)	0.67m	180	+3910	−18890	=	−14800 kg
(M2)	2.725	3020	+15870	−18890	=	0 〃
(H3)	4.37	7750	+25460	−18890	=	14320 〃

軸力 $N_{AB} = S_{B2} = 31380$ kg. C.

中央柱 CD.

軸力 $N_{CD} = -2S_{C2} = 34820 \times 2 = 69640$ kg. C. per meter strip of tunnel,
柱ノ間隔ヲ 2.5m c to c トスレバ
柱一本当リ軸力 $N_{CD} = 2.5^m @ 69640 = 174100$ kg. C.

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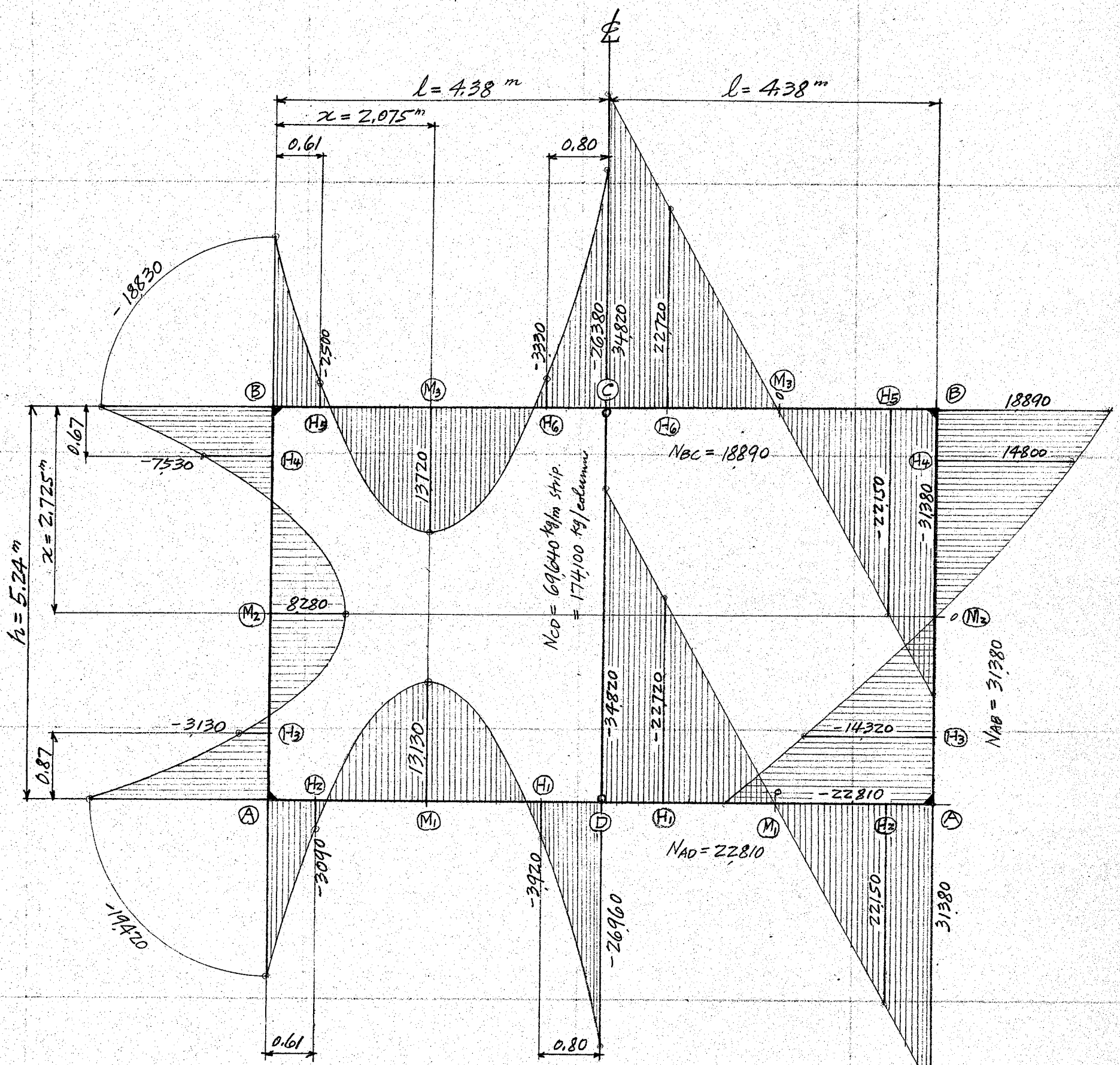
彎曲率及ビ剪力圖



彎曲率圖　　剪力圖

1/50 m = 10,000 kgm　　1/50 m = 10,000 kg

Scale 1:160

注意

M1, M2 及 M3 ハ最大正彎曲率ノ点
H1 乃至 H6 ハ各 Haunch ノ先端

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上海標準隧道

断面應力ノ計算

下床 AD

Ⓜ M= 13130 kgm N= 22810 kg.c. S=0

$d/h = 49/54 = 0.908$
$d'/h = 5/54 = 0.093$
$p_0 = 28.35/100\times54 = 0.00525$
$p_0' = 7.09/\,,\,, = 0.00131$
$u/h = 0.522$
$u = 28.2$ cm
$d-u = 20.8$

$\frac{M}{N} = \frac{13130\times100}{22810} = 57.6$
$d-u = 20.8$
$e = 78.4$ cm
$e' = d-44 = 34.4$ "
$e'/e = 0.439$
$\frac{Ne}{bd^2} = \frac{22810\times78.4}{100\times49^2} = 7.450$
$\frac{Ne}{bd^2\sigma_c} = 0.205$, $k = 0.440$
$\sigma_c = \frac{7.450}{0.205} = 36.4$ kg/cm²
$\sigma_s = 15\times36.4\times\frac{0.560}{0.440} = 695$ "

$b=100$ cm, $h=54$ cm
$d=49$ cm, $d'=5$ cm
$A_s = 10-19\phi = 28.35$ cm²
$A_s' = 2.5-19\phi = 7.09$ cm²
$p = 28.35/100\times49 = 0.00579$
$p' = 7.09/\,,\,, = 0.00145$
$d'/d = 5/49 = 0.102$

$\tau = 0$

Ⓓ M= -26960 kgm, N= 22810 kg.c S= 34820 kg

$d/h = 75/80 = 0.938$
$d'/h = 5/80 = 0.0625$
$p_0 = 28.35/100\times80 = 0.00354$
$p_0' = 7.09/\,,\,, = 0.00089$
$u/h = 0.514$
$u = 41.1$
$d-u = 33.9$

$\frac{M}{N} = \frac{26960\times100}{22810} = 118.2$
$d-u = 33.9$
$e = 152.1$ cm
$e' = e-70 = 82.1$ "
$e'/e = 0.540$
$\frac{Ne}{bd^2} = \frac{22810\times152.1}{100\times75^2} = 6.175$
$\frac{Ne}{bd^2\sigma_c} = 0.168$, $k = 0.355$
$\sigma_c = \frac{6.175}{0.168} = 36.8$ kg/cm²
$\sigma_s = 15\times36.8\times\frac{0.645}{0.355} = 1003$ "

$b=100$, $h = 54+\frac{80}{3} = 80$ cm
$d=75$, $d'=5$
$A_s = 10-19\phi = 28.35$
$A_s' = 2.5-19\phi = 7.09$
$p = 28.35/100\times75 = 0.00378$
$p' = 7.09/\,,\,, = 0.00095$
$d'/d = 5/75 = 0.0667$

$\tau = \frac{34820}{100\times0.882\times75} = 5.3$ kg/cm²
$\tau_0 = \frac{34820}{5.97\times10\times.882\times75}\times\frac{1}{2} = 4.4$ "

Ⓐ M= -19420 kgm, N= 22810 kg.c. S= -31380 kg

$d/h = 69/74 = 0.932$
$d'/h = 5/74 = 0.0676$
$p_0 = 20.1/100\times74 = 0.00272$
$p_0' = 7.09/\,,\,, = 0.00096$
$u/h = 0.509$
$u = 37.7$
$d-u = 31.3$ cm

$\frac{M}{N} = \frac{19420\times100}{22810} = 85.1$
$d-u = 31.3$
$e = 116.4$ cm
$e' = e-64 = 52.4$
$e'/e = 0.450$
$\frac{Ne}{bd^2} = \frac{22810\times116.4}{100\times69^2} = 5.580$
$\frac{Ne}{bd^2\sigma_c} = 0.164$, $k = 0.340$
$\sigma_c = \frac{5.580}{0.164} = 34.0$ kg/cm²
$\sigma_s = 15\times34.0\times\frac{0.66}{0.34} = 992$ "

$b=100$, $h = 54+\frac{61}{3} = 74$
$d=69$, $d'=5$
$A_s = 10-16\phi = 20.10$
$A_s' = 2.5-19\phi = 7.09$
$p = 20.1/100\times69 = 0.00291$
$p' = 7.09/\,,\,, = 0.00103$
$d'/d = 5/69 = 0.0724$

$\tau = \frac{31380}{100\times1887\times69} = 5.1$ kg/cm²
$\tau_0 = \frac{31380}{5.03\times10\times.887\times69}\times\frac{1}{2} = 5.1$ "

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(H1) $M = -3920$ kgm, $N = 22810$ kg.c. $S = 22720$ kg

$\tau = \frac{22720}{100 \times 7/8 \times 49} = 5.3$ kg/cm²

$\tau_0 = \frac{22720}{7.5 \times 5.97 \times 7/8 \times 49} \times \frac{1}{2} = 5.9$ 〃

下面ノ主鉄筋ハ 7.5 cm以上ト十ヶ所 lap ヲ長クシテ bond Stress ヲ軽減スルヿト

(H2) $M = -3090$ kgm, $N = 22810$ kg.c. $S = -22150$ kg

$\tau = \frac{22150}{100 \times 7/8 \times 49} = 5.2$ kg/cm²

$\tau_0 = \frac{22150}{7.5 \times 5.97 \times 7/8 \times 49} \times \frac{1}{2} = 5.8$ 〃

仝上

上床 BC.

(M3) $M = 13720$ kgm, $N = 18890$ kg.c. $S = 0$

$\frac{M}{N} = \frac{13720 \times 100}{18890} = 72.7$

$d - u = 20.8$

$e = 93.5$ cm

$e' = e - 44 = 49.5$

$e'/e = 0.530$

$\frac{Ne}{bd^2} = \frac{18890 \times 93.5}{100 \times 49^2} = 7.355$

$\frac{Ne}{bd^2\sigma_c} = 0.195$ $k = 0.415$

$\sigma_c = \frac{7.355}{0.195} = 37.7$ kg/cm²

$\sigma_s = 15 \times 37.7 \times \frac{0.585}{0.415} = 800$ 〃 $\tau = 0$

断面ハ (M1) = 仝ジ (第58頁参照).

(H5) 及ビ (H6) ハ夫々 (H2) 及ビ (H1) ト同一断面ヲ使用スルガ為念ノ為

(B) $M = -18830$ kgm, $N = 18890$ kg.c $S = 31380$ kg

$\frac{M}{N} = \frac{18830 \times 100}{18890} = 99.7$

$d - u = 31.3$

$e = 131.0$ cm

$e' = e - 64 = 67.0$ 〃

$e/e = 0.511$

$\frac{Ne}{bd^2} = \frac{18890 \times 131.0}{100 \times 69^2} = 5.200$

$\frac{Ne}{bd^2\sigma_c} = 0.159$, $k = 0.330$

$\sigma_c = \frac{5.200}{0.159} = 32.7$ kg/cm²

$\sigma_s = 15 \times 32.7 \times \frac{0.670}{0.330} = 998$ 〃

$\tau = \frac{31380}{100 \times 0.890 \times 69} = 5.1$ 〃

$\tau_0 = \frac{31380}{5.03 \times 10 \times 0.890 \times 69} \times \frac{1}{2} = 5.1$ 〃

断面ハ (A) = 仝ジ (第58頁参照)

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上海標準隧道

Ⓒ $M = -26380$ kgm, $N = 18890$ kg.c $S = -34820$ kg

断面Ⓓ=同じ (第58頁参照)

$\frac{M}{N} = \frac{26380 \times 100}{18890} = 139.6$
$d-u = 33.9$
$e = 173.5$ cm
$e' = e - 70 = 103.5$ "
$e'/e = 0.597$
$\frac{Ne}{bd^2} = \frac{18890 \times 173.5}{100 \times 75^2} = 5.825$
$\frac{Ne}{bd^2\sigma_c} = 0.164$, $k_c = 0.340$

$\sigma_c = \frac{5.825}{0.164} = 35.5$ kg/cm² $\tau = \frac{34820}{100 \times 0.887 \times 75} = 5.2$ kg/cm²
$\sigma_s = 15 \times 35.5 \times \frac{0.660}{0.340} = 1034$ " $\tau_0 = \frac{34820}{5.97 \times 10 \times .887 \times 75} \times \frac{1}{2} = 44$ "

側壁 AB

(M₂) $M = 8280$ kgm, $N = 31380$ kg, $S = 0$

$d/h = 37/42 = 0.881$
$d'/h = 5/42 = 0.119$
$p_0 = 20.1/100 \times 42 = 0.00478$
$p_0' = 10.1/$ " " $= 0.00239$
$u/h = 0.510$
$u = 21.4$
$d-u = 15.6$ cm

$\frac{M}{N} = \frac{8280 \times 100}{31380} = 26.4$
$d-u = 15.6$
$e = 42.0$ cm
$e' = e - 32 = 10.0$
$e'/e = 0.238$
$\frac{Ne}{bd^2} = \frac{31380 \times 42.0}{100 \times 37^2} = 9.630$
$\frac{Ne}{bd^2\sigma_c} = 0.238$, $k_c = 0.510$

$\sigma_c = \frac{9.630}{0.238} = 40.5$ kg/cm²
$\sigma_s = 15 \times 40.5 \times \frac{0.49}{0.51} = 584$ " $\tau = 0$

$b = 100$, $h = 42$
$d = 37$, $d' = 5$
$A_s = 10 - 16\phi = 20.1$
$A_s' = 5 - 16\phi = 10.1$
$p = 20.1/100 \times 37 = 0.00543$
$p' = 10.1/$ " " $= 0.00272$
$d'/d = 5/37 = 0.135$

Ⓐ $M = -19420$ kgm, $N = 31380$ kg.c. $S = 22810$ kg

$d/h = 66/71 = 0.930$
$d'/h = 5/71 = 0.0704$
$p_0 = 20.1/100 \times 71 = 0.00283$
$p_0' = 7.09/$ " $= 0.00100$
$u/h = 0.510$
$u = 36.2$
$d-u = 29.8$ cm

$\frac{M}{N} = \frac{19420 \times 100}{31380} = 61.9$
$d-u = 29.8$
$e = 91.7$ cm
$e' = e - 61 = 30.7$
$e'/e = 0.335$
$\frac{Ne}{bd^2} = \frac{31380 \times 91.7}{100 \times 66^2} = 6.605$
$\frac{Ne}{bd^2\sigma_c} = 0.182$, $k_c = 0.385$

$\sigma_c = \frac{6.605}{0.182} = 36.3$ kg/cm²
$\sigma_s = 15 \times 36.3 \times \frac{0.615}{0.385} = 871$ "
$\tau = \frac{22810}{100 \times 0.872 \times 66} = 4.0$ kg/cm²
$\tau_0 = \frac{22810}{5.03 \times 10 \times 0.872 \times 66} \times \frac{1}{2} = 3.9$ "

$b = 100$, $h = 42 + \frac{87}{3} = 71$ cm
$d = 66$, $d' = 5$
$A_s = 10 - 16\phi = 20.1$ cm²
$A_s' = 2.5 - 19\phi = 7.09$ "
$p = 20.1/100 \times 66 = 0.00305$
$p' = 7.09/$ " " $= 0.00107$
$d'/d = 5/66 = 0.076$

上海標準隧道

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Ⓑ $M=-18830$ kgm $N=31380$ kg.c. $S=-18890$ kg

$d/h = 59/64 = 0.922$
$d'/h = 5/64 = 0.0781$
$p_0 = 20.1/100\times64 = 0.00314$
$p_0' = 7.09/\,\,\,\,\,\,\,\, = 0.00111$
$u/h = 0.510$
$u = 32.6$
$d-u = 26.4$

$\frac{M}{N} = \frac{18830\times100}{31380} = 60.1$
$d-u = 26.4$
$e = 86.5$
$e' = e-54 = 32.5$
$e'/e = 0.376$
$\frac{Ne}{bd^2} = \frac{31380\times86.5}{100\cdot59^2} = 7.800$
$\frac{Ne}{bd^2\sigma_c} = 0.183$, $k = 0.390$

$\sigma_c = \frac{7.800}{0.183} = 42.6$ kg/cm²
$\sigma_s = 15\times42.6-\frac{0.610}{0.390} = 1000$ "

$b=100$, $h=42+\frac{67}{3}=64$
$d=59$, $d'=5$
$A_s = 10-16\phi = 20.1$
$A_s' = 2.5-19\phi = 7.09$
$p = 20.1/100\times59 = 0.00341$
$p' = 7.09/\,\,\,\,\,\,\,\, = 0.00120$
$d'/d = 5/59 = 0.0848$

$\tau = \frac{18890}{100\times0.870\times59} = 3.7$ kg/cm²
$\tau_0 = \frac{18890}{5.03\times10\times0.870\times59}\times\frac{1}{2} = 3.7$ "

Ⓗ4 $M=-7530$ kgm, $N=31380$ kg.c, $S=-14800$ kg

$e = \frac{M}{N} = \frac{7530\times100}{31380} = 24.0$ cm
$e/h = 24.0/42.0 = 0.572$
$d'/h = 5/42 = 0.119$
$k = 0.430$, $C = 0.197$

$\sigma_c = \frac{31380}{100\times42\times0.197} = 38.0$ kg/cm²
$\sigma_s = 15\times38.0\times\frac{1-0.430-0.119}{0.430} = 599$ "

$b=100$, $h=42$
$d=37$, $d'=5$
$A_s = A_s' = 7.5-16\phi = 15.07$
$p_0 = p_0' = 15.07/100\times42 = 0.00359$

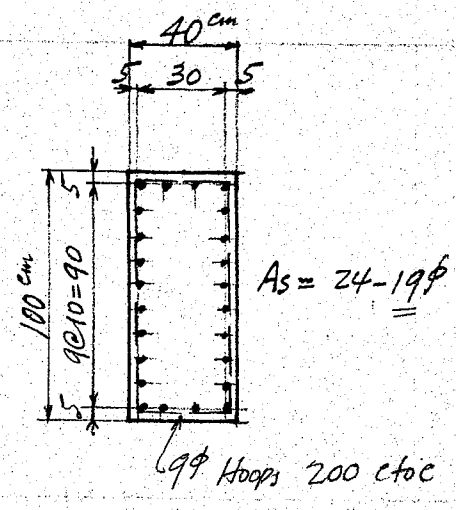
$\tau = \frac{14800}{100\times0.857\times37} = 4.7$ kg/cm²
$\tau_0 = \frac{14800}{5.03\times7.5\times0.857\times37}\times\frac{1}{2} = 6.2$ "

Ⓗ3 $M=-3130$ kgm, $N=31380$ kg.c $S=+14320$ kg

$\tau = \frac{14320}{100\times0.857\times37} = 4.5$ kg/cm²
$\tau_0 = \frac{14320}{5.03\times7.5\times0.857\times37}\times\frac{1}{2} = 6.0$ "

計算 Ⓗ4 = 同じ

中央柱 CD (間隔 2.50m c to c トス)



柱ノ最大荷重 = 174.100
柱ノ自重 $0.40\times1.00\times4.7$ @ 2400 = 4500
N_{CD} = 178,600 kg.c.

$A_s = 24-19\phi = 68.04\times15 = 1021$
$A_c = 40\times100 = 4000$
$A_i = 5021$ cm²

$\sigma_c = \frac{178600}{5021} = 35.6$ kg/cm² c
$\sigma_s' = 35.6\times15 = 534$ " c
$\tau = 0$

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上海標準隧道

中央部上下縦桁

支間 2.50m / 連続桁トス

荷重 $w = 69640$ kg/m (第57頁應力圖參照)

最大正彎曲率 $M_C = \frac{wl^2}{14} = \frac{69640 \times 2.50^2}{14} = 31{,}100$ kgm 中央

最大負 〃 $M_S = -\frac{wl^2}{10} = -\frac{69640 \times 2.50^2}{10} = -43{,}500$ 〃 支点

剪力 $S = \frac{wl}{2} = \frac{69640 \times 2.5}{2} = 87{,}000$ kg 〃

柱ノ側面ニ於ケル彎曲率

$0.50S = 0.50 \times 87000 = 43500$

$-\frac{w \times 0.5^2}{2} = -0.125 \times 69640 = -8700$

$M_S = -43500$

$M_{CF} = -8700$ kgm

仝上 剪力 $S_{CF} = S - 0.5w = 87000 - \frac{69640}{2} = 52180$ kg

Haunch 先端ニ於ケル剪力.

$S_h = S - 0.85w = 87000 - 0.85 \times 69640 = 27800$ kg

上部縦桁

中央断面

$M_C = 31{,}100$ kgm $S = 0$

$b = 160$ cm (1m2室), $h = 124$ cm, $d = 115$ cm, $d' = 7$ cm

$A_S = 8-22\phi = 30.41$ cm², $p = 30.41/160 \times 115 = 0.00166$

$A_S' = 4-22\phi = 15.20$ 〃, $p' = 15.20/$ 〃 $= 0.00083$

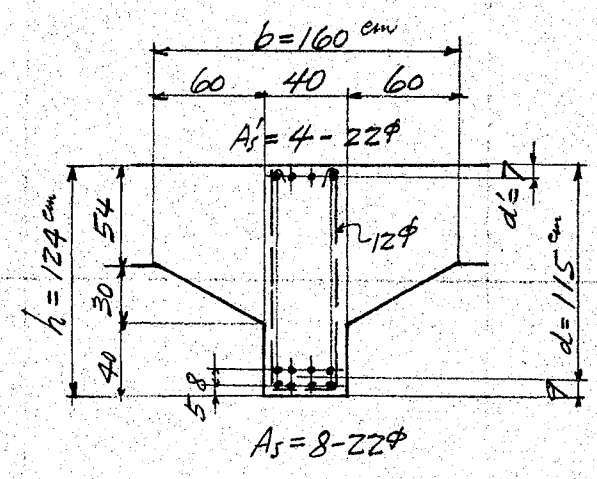
$d'/d = 7/115 = 0.061$

$k = 0.195$, $L_C = 0.100$, $L_S = 0.00150$

$\sigma_c = \frac{31100 \times 100}{160 \times 115^2 \times 0.100} = 14.7$ kg/cm²

$\sigma_S = \frac{31100 \times 100}{160 \times 115^2 \times 0.00150} = 981$ 〃

$\tau = 0$



支点断面

$M_S = -43{,}500$ kgm, $(S = 87000$ kg$)$

$b_0 = 40$, $h = 124 + \frac{35+50}{3} = 152$ cm, $d = 141$ cm, $d' = 5$ cm

$A_S = 8-22\phi = 30.41$ cm² $p = 30.41/40 \times 141 = 0.00540$

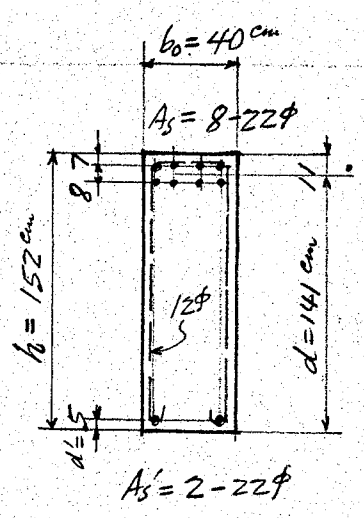
$A_S' = 2-22\phi = 7.60$ 〃 $p' = 7.60/$ 〃 〃 $= 0.00135$

$d'/d = 5/141 = 0.0355$

$k = 0.316$, $L_C = 0.159$, $L_S = 0.00491$

$\sigma_c = \frac{43500 \times 100}{40 \times 141^2 \times 0.159} = 34.4$ kg/cm²

$\sigma_S = \frac{43500 \times 100}{40 \times 141^2 \times 0.00491} = 1113$ 〃



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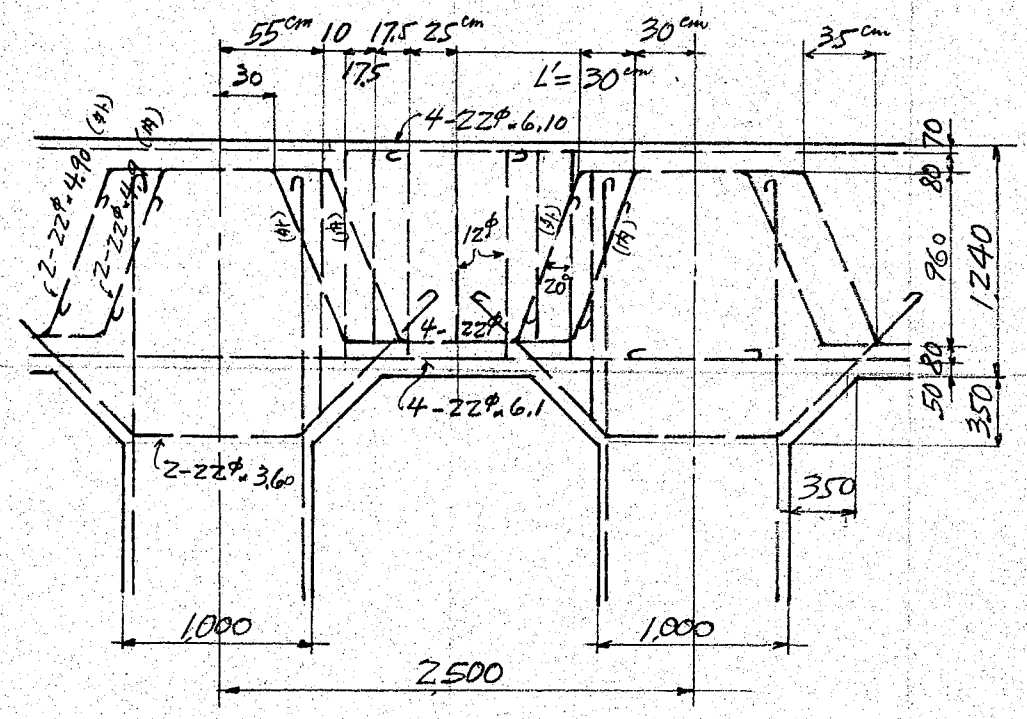
上海標準隧道

Haunch 先端及柱側面



腹鉄筋ノ抵抗剪力

$\theta = 45° - 20° = 25°$, $\cos 25° = 0.906$

$\tau' = 1530 \frac{A_b}{L' b_0} + 1200 \frac{A_s}{a b_0}$ (第50頁参照)

$A_b = 2\text{-}22\phi = 7.60\ cm^2$
$L' = 30\ cm$
$b_0 = 40$

$A_s = 2\text{-}12\phi = 2.26\ cm^2$
$a = \begin{cases} 10\ cm\ etc & \text{--- 柱側面} \\ 17.5\ \text{〃}\ \text{〃} & \text{--- Haunch 先端} \end{cases}$

Haunch 先端

剪力 $S_h = 27{,}800\ kg$ $\quad \tau = \frac{27800}{40 \times \frac{7}{8} \times 115} = 6.9\ kg/cm^2$

抵抗剪応力 $\tau' = 1530 \times \frac{7.60}{30 \times 40} + 1200 \times \frac{2.26}{17.5 \times 40}$

$= 9.70 + 3.90 = 13.6\ kg/cm^2 > 6.9$ ✓

柱側面

剪力 $S_{CF} = 52{,}180\ kg$ $\quad h = 124 + \frac{35}{3} = 136\ cm$ $\quad d = 125\ cm$

剪応力 $\tau = \frac{52180}{40 \times \frac{7}{8} \times 125} = 11.9\ kg/cm^2$

抵抗剪応力 $\tau' = 1530 \times \frac{7.60}{30 \times 40} + 1200 \times \frac{2.26}{10 \times 40}$

$= 9.70 + 6.80 = 16.5\ kg/cm^2 > 11.9$ ✓

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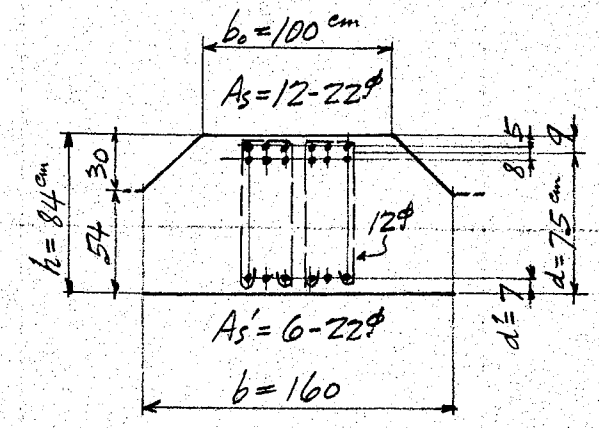
上海標準隧道

下部縦桁

中央断面

M_c = 31,100 kgm , S = 0



b = 160 cm , b_0 = 100 cm
h = 84 cm , d = 75 cm , d' = 7 cm

A_s = 12-22φ = 45.61 cm² p = 45.61/160×75 = 0.00380
A_s' = 6-22φ = 22.81 〃 p' = 22.81/〃〃 = 0.00190
d'/d = 7/75 = 0.0934

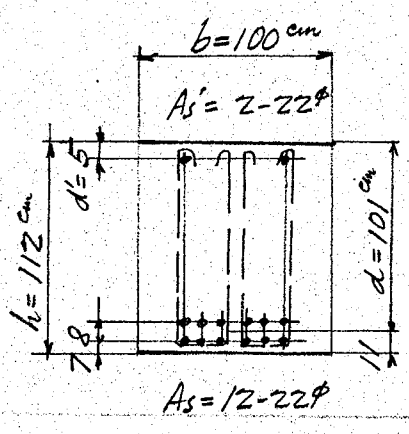
k = 0.270 , L_c = 0.141 , L_s = 0.00345

$\sigma_c = \frac{31100\times100}{160\times75^2\times0.141}$ = 24.5 kg/cm²

$\sigma_s = \frac{31100\times100}{160\times75^2\times0.00345}$ = 1001 〃

τ = 0

支点断面



M_s = − 43,500 kgm , S = 87,000 kg

b = 100 cm , $h = 84 + \frac{50+35}{3}$ = 112 cm , d = 101 cm d' = 5 cm

A_s = 12-22φ = 45.61 cm² p = 45.61/100×101 = 0.00452
A_s' = 6-22φ = 22.81 〃 p' = 22.81/〃〃 = 0.00226
d'/d = 5/101 = 0.0495

k = 0.287 , L_c = 0.157 , L_s = 0.00401

$\sigma_c = \frac{43500\times100}{100\times101^2\times0.157}$ = 27.1 kg/cm²

$\sigma_s = \frac{43500\times100}{100\times101^2\times0.00401}$ = 1063 〃

此部ハ中廣キ柱&haunch=ヨリテ支ヘラルルヲ以テ剪断力ハ之レヲ重視スル必要ナシ

Haunch 先端及び柱側面

Haunch 先端 S_h = 27,800 kg $\tau = \frac{27800}{100\times\frac{7}{8}\times75}$ = 4.2 kg/cm²

抵抗剪断力 $\tau' = 1530\times\frac{7.60}{30\times100} + 1200\times\frac{3.39}{17.5\times100}$ ← 2-22φ, ← 3-12φ(4本+2本ノ平均)−{ }

= 3.88 + 2.33 = 6.21 kg/cm² > 4.2 ✓

柱側面 S_{CF} = 52,180 kg $h = 84 + \frac{35}{3}$ = 96 cm d = 85 cm

剪断力 $\tau = \frac{52180}{100\times\frac{7}{8}\times85}$ = 7.0 kg/cm²

抵抗剪断力 $\tau' = 1530\times\frac{7.60}{30\times100} + 1200\times\frac{3.39}{10\times100}$

= 3.88 + 4.07 = 7.95 kg/cm² > 7.0 ✓

注意.
配筋ハ S.C.T.6 ニ準ズ (第52頁参照)

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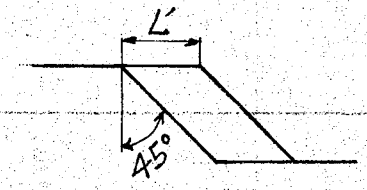
上海標準隧道

腹鉄筋ノ抵抗剪力

上下床及ビ側壁用

曲鉄筋 (幅 100 cm ニ付)

抵抗剪應力 $\tau' = \frac{1.41\,A_b\,\sigma_s}{L'\,b_o}$



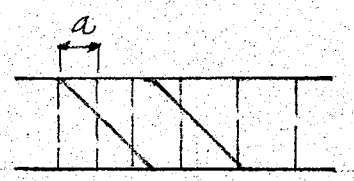
$= \frac{1.41 \times 2,011 \times 1200}{L' \times 100} = \frac{34}{L'}$ kg/cm² ---- 16φ曲鉄筋 1本分

$= \frac{1.41 \times 2,835 \times 1200}{L' \times 100} = \frac{48}{L'}$ 〃 --- 19φ 〃 1本分

L'	1-16φ τ'	2.5-16φ τ'	1-19φ τ'	2.5-19φ τ'
25 cm	1.36 kg/cm²	3.40 kg/cm²	1.92 kg/cm²	4.80 kg/cm²
30	1.13	2.83	1.60	4.00
35	0.97	2.43	1.37	3.43
40	0.85	2.13	1.20	3.00
50	0.68	1.70	0.96	2.40

肋筋 (垂直) (幅 100 cm ニ付)

抵抗剪應力 $\tau' = \frac{A_s\,\sigma_s}{a\,b_o}$



$= \frac{0.636 \times 1200}{a \times 100} = \frac{7.64}{a}$ kg/cm² ---- 9φ肋筋 1本分

$= \frac{1.131 \times 1200}{a \times 100} = \frac{13.58}{a}$ 〃 ------ 12φ 〃 1本分

a	1-9φ τ'	5-9φ τ'	1-12φ τ'	5-12φ τ'
15 cm	0.51 kg/cm²	2.55 kg/cm²	0.91 kg/cm²	4.55 kg/cm²
20	0.38	1.90	0.68	3.40
25	0.31	1.55	0.54	2.70
30	0.25	1.25	0.45	2.25
40	0.19	0.95	0.34	1.70
50	0.15	0.75	0.27	1.35

注意 肋ノ剪應力ガ 4.5 kg/cm² ヲ超エル場合ハ此個所並ニ之ニ隣接スル相当區間ニ亘リ全剪力ヲ腹鉄筋ニ負擔セシメ得ル様設計スベシ。
肋ノ剪應力ガ 4.5 kg/cm² 未滿ナル場合ト雖モ適当ナル間隔ニ肋筋ヲ配置スベシ。