

上海高速鐵道

混凝土
鐵筋

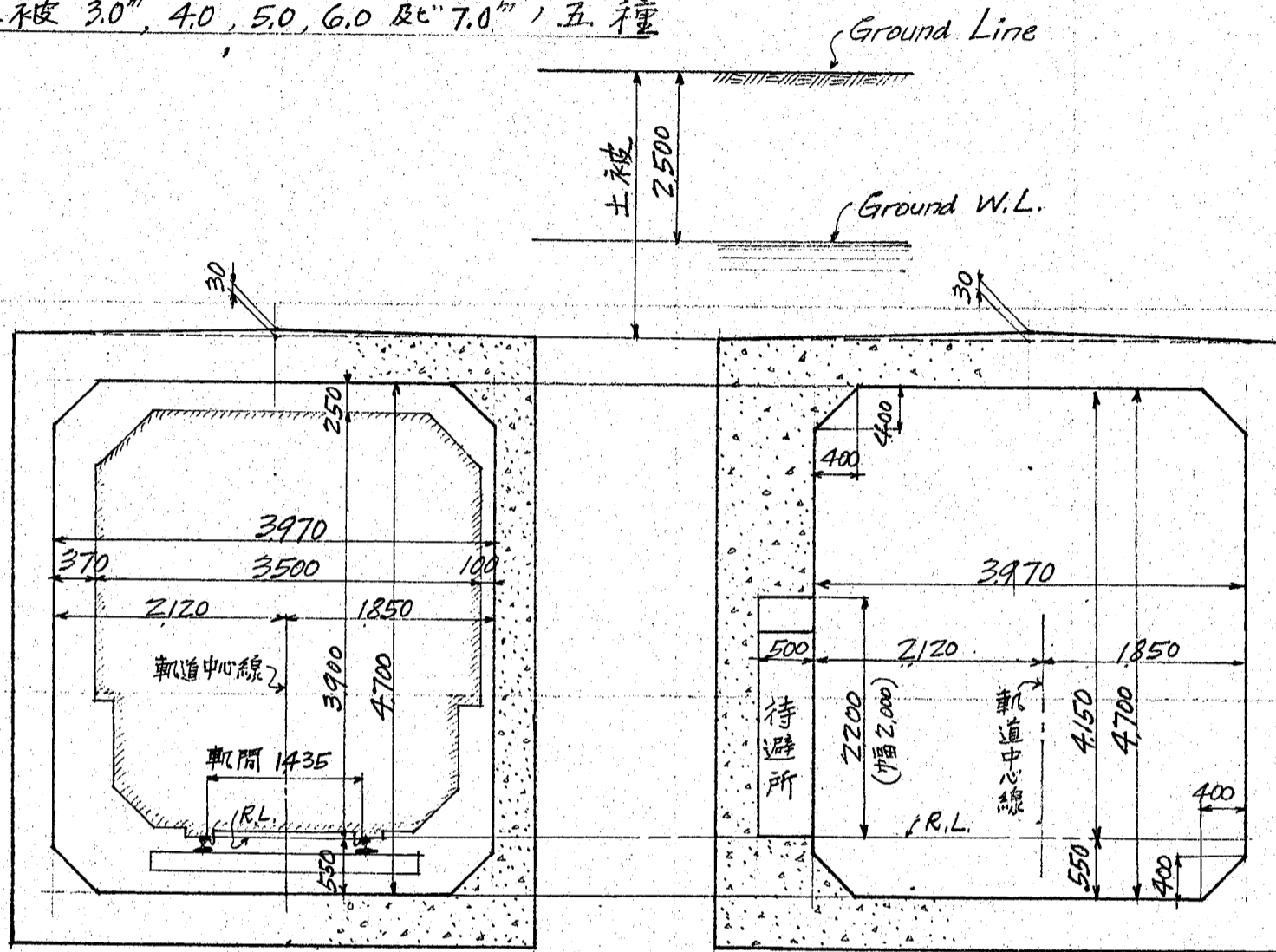
單線標準隧道

應力計算書

上海高速鐵道鐵筋混凝土單線標準隧道

鐵筋混凝土單線標準隧道

土被 3.0, 4.0, 5.0, 6.0 及 7.0 五種



標準断面

待避所断面

縮尺 1:60

寸法 2200 x 500 x 2000
間隔 約 10.0 etc.

一般設計條件

- 土被 3.0; 4.0; 5.0; 6.0 及 7.0 五種
- 地下水位 地表面以下 2.5m 卜假定ス
- 土、息角 $\phi = 25^\circ$ 卜 土圧係数 $C = \frac{1 - \sin\phi}{1 + \sin\phi} = \frac{0.5774}{1.4226} = 0.406$
- 土、重量 地下水位以上 1600 kg/m³
 以下 2000 "

路面傳布荷重及被覆混凝土

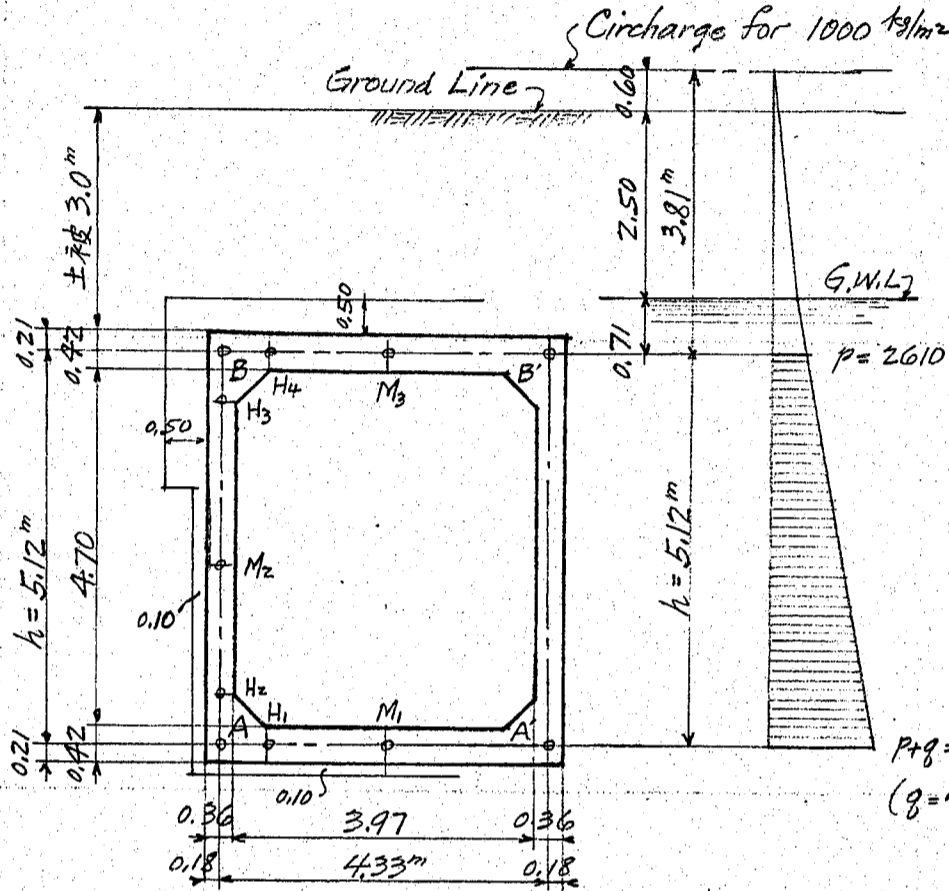
隧道呼稱	土被	Circharge Load.	換算土深	被覆混凝土厚	
SCT3S	3.0 ^m	1,000 kg/m ²	0.6 ^m	上床及側壁上部 50 ^{cm}	下床及側壁下部 10 ^{cm} (上部ハ防密施設)
SCT4S	4.0	900	0.55	" " 50	" " 10 (")
SCT5S	5.0	800	0.5	上床及側壁 10	下床 10
SCT6S	6.0	800	0.5	" " 10	" " 10
SCT7S	7.0	800	0.5	" " 10	" " 10

上海高速鐵道
鐵筋混凝土標準型單線隧道
土被 三〇米 應力計算書

Standard Reinforced Concrete Tunnel.
Single Track
Mark SCT3S

上海高速鉄道、鉄筋混凝土単線標準隧道

土被 3.0m 標準隧道 SCT3S



上床荷重 w

土被 地下水位以上 $2.5 \text{m} @ 1600 = 4000$
被覆混凝土 $0.5 @ 2200 = 1100$
上床 $0.42 @ 2400 = 1010$

6110

路面傳布荷重

1000

$w = 7110 \text{ kg/m}^2$

下床荷重

上床荷重と同一と假定ス

側壁荷重

上部荷重

土被 $2.5 \text{m} @ 1600 = 4000$

$0.71 @ 2000 = 1420$

路面荷重

1000

6420

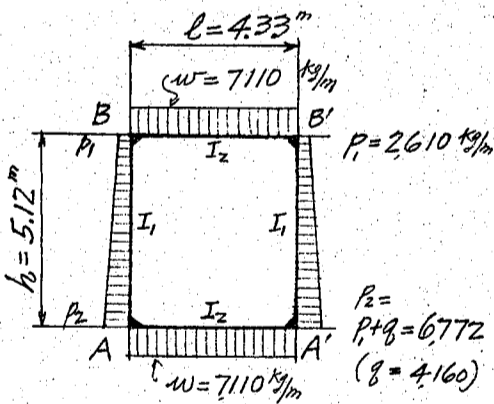
荷重 $P_1 = 6420 \times 0.406 = 2610 \text{ kg/m}^2$

下部荷重

$Q = 5.12 @ 2000 \times 0.406 = 4160$

荷重 $P_2 + Q = 6770$

荷重状態



Moments of Inertia.

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

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

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

$$12(1+K) = 12 \times 2.868 = 34.416$$

$$K_2 = \frac{I_2}{l} = \frac{0.00617}{4.33} = 0.00142$$

$$\frac{K}{60(1+K)(3+K)} = \frac{1.868}{60 \times 2.868 \times 4.868}$$

$$K = \frac{K_2}{K_1} = \frac{0.00142}{0.00076} = 1.868$$

$$= 0.00223$$

上下床、荷重 $w =$ 依りて彎曲率

$$M_A = M_B = - \frac{wl^2}{12(1+K)} = - \frac{7110 \times 4.33^2}{34.416} = -3870 \text{ kgm}$$

兩側壁荷重 p 及び $p+q =$ 依りて彎曲率

$$M_A = - \frac{Kh^2}{60(1+K)(3+K)} \{7P_1 + 8P_2 + K(2P_1 + 3P_2)\} = -0.00223 \times 5.12^2 \{18270 + 54180 + 1.868(5220 + 20320)\}$$

$$= -0.05846 \times 120150 = -7030 \text{ kgm}$$

$$M_B = - \frac{Kh^2}{60(1+K)(3+K)} \{8P_1 + 7P_2 + K(3P_1 + 2P_2)\} = -0.00223 \times 5.12^2 \{20880 + 47400 + 1.868(7830 + 13544)\}$$

$$= -0.05846 \times 108230 = -6330 \text{ kgm}$$

上下床及左右兩側壁荷重 = 依りて合成彎曲率

床荷重 側壁荷重 合成彎曲率

M_A	-3870 kgm	-7030 kgm	-10900 kgm
M_B	-3870	-6330	-10200

上海標準隧道

剪力

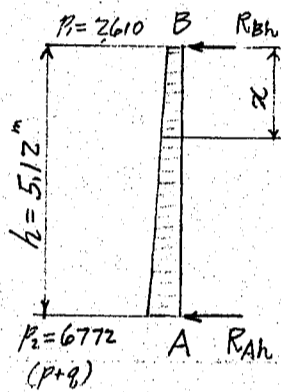
上床 $S_{B2} = \frac{wl}{2} = \frac{7110 \times 4.33}{2} = 15,390 \text{ kg}$

$S_{H4} = 15,390 - 0.58 \times 7110 = 11,260$

下床 $S_{A2} = -\frac{wl}{2} = -15,390 \text{ kg}$

$S_{H1} = -11,260$

側壁



AB 7 Simple Beam 12m 支力

$R_{Ah} = \frac{h}{6} (2p_2 + p_1) = \frac{5.12}{6} (13544 + 2610) = 13,780 \text{ kg}$

$R_{Bh} = \frac{h}{6} (2p_1 + p_2) = \frac{5.12}{6} (5220 + 6772) = 10,230$

剪力

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -10,230 + \frac{-10,200 + 10,900}{5.12} = -10,090 \text{ kg}$

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 13,780 + 140 = 13,920$

任意 1 点 = 任意の剪力

$S_x = S_{B1} + \frac{qx^2}{2h} + p_1 x = -10,090 + \frac{4160}{2 \times 5.12} x^2 + 2610x$

$= 406x^2 + 2610x - 10,090$

0 Shear 点

$x^2 + 6.43x - 24.85 = 0$

$x = \frac{-6.43 \pm \sqrt{6.43^2 + 4 \times 24.85}}{2} = 2.715 \text{ m}$

点	x	$406x^2$	$+ 2610x$	$- 10090$	= S_x
(H3)	0.61m	150	+ 1590	- 10090	= -8350 kg
(M2)	2.715	3000	+ 7090	- 10090	= 0
(H2)	4.51	8240	+ 11750	- 10090	= 9900

中間点 = 任意の弯曲率

下床 AA'

(M1) $\frac{wl^2}{8} = \frac{7110 \times 4.33^2}{8} = 16,650$

$M_A = -10,900$

$M_1 = 5,750 \text{ kgm}$

軸力 $N_{AA'} = S_{A1} = 13,920 \text{ kg.C}$

(H1) $-16,650 \times \frac{1.525^2}{2.165^2} = -8,930$

$M_1 = 5,750$

$M_{H1} = -3,180 \text{ kgm}$

上床 BB'

(M3) $\frac{wl^2}{8} = 16,650$

$M_B = -10,200$

$M_3 = 6,450 \text{ kgm}$

軸力 $N_{BB'} = -S_{B1} = 10,090 \text{ kg.C}$

上海標準隧道

$$\begin{aligned} \textcircled{H4} \quad & -16650 \times \frac{1.585^2}{2.165^2} = -8930 \\ M_3 \quad & = 6450 \\ M_{H4} \quad & = -2480 \text{ kgm} \end{aligned}$$

側壁 AB.

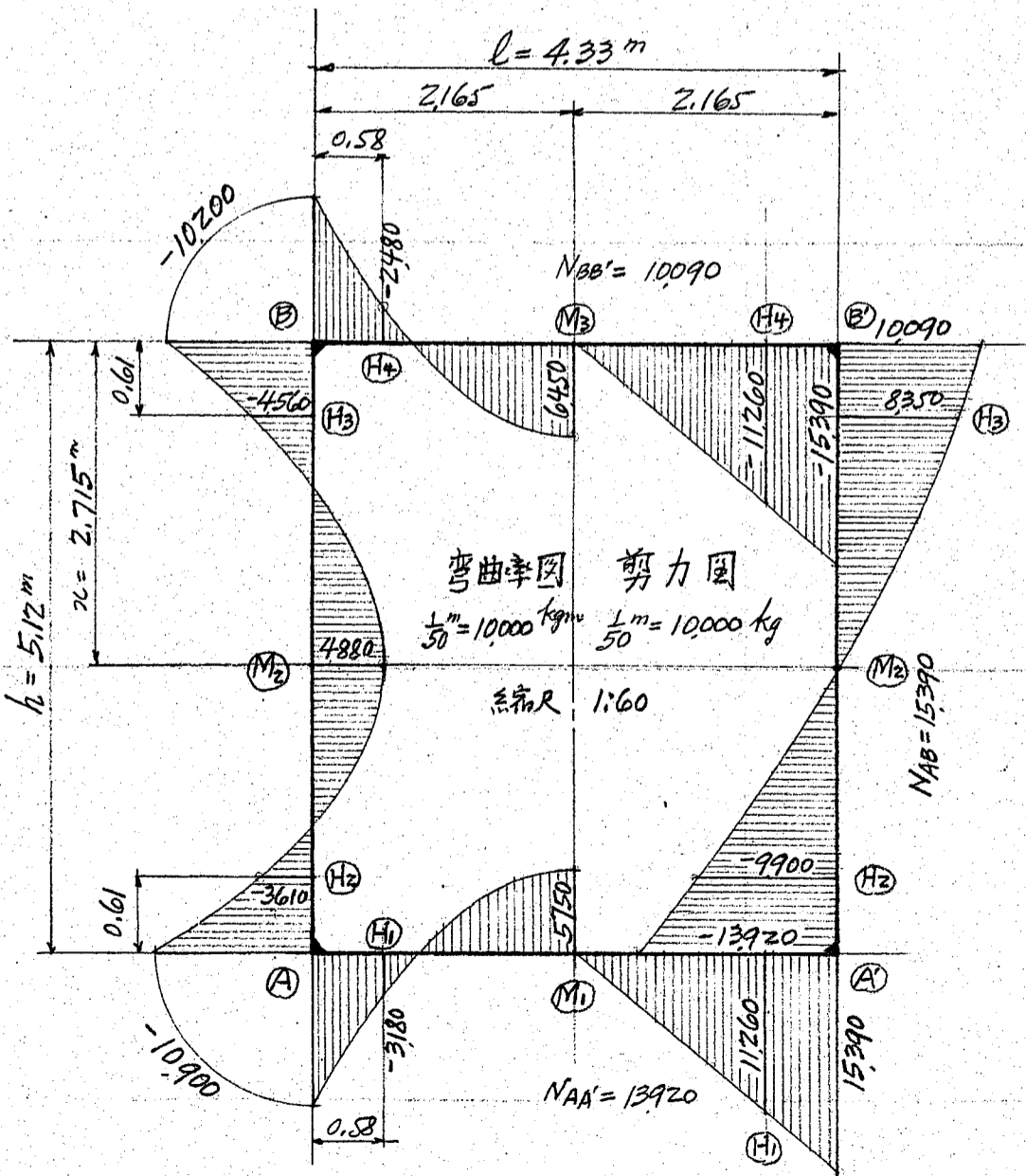
任意 1 點 = 任意 彎曲率.

$$\begin{aligned} M_x &= -S_{B1}x - \frac{Px^2}{2} - \frac{qx^3}{6h} + M_B \\ &= 10090x - 1305x^2 - \frac{4160}{6 \times 5.12}x^3 - 10200 \\ &= -135.5x^3 - 1305x^2 + 10090x - 10200 \end{aligned}$$

	x	$-135.5x^3$	$-1305x^2$	$+10090x$	-10200	$= M_x$
$\textcircled{H3}$	0.61 ^m	-30	-485	+6160	-10200	= -4560 kgm
$\textcircled{M2}$	2.715	-2710	-9610	+27400	-10200	= 4880 "
$\textcircled{H2}$	4.51	-12430	-26530	+45550	-10200	= -3610 "

軸力 $N_{AB} = S_{B2} = 15390 \text{ kg. c}$

彎曲率及剪力图



$\textcircled{M1}, \textcircled{M2}$ 及 $\textcircled{M3}$ 最大彎曲率 1 點.
 $\textcircled{H1}$ 乃至 $\textcircled{H4}$ 八夫々 haumde 先端

上海標準隧道

断面應力計算

下床 AA'

(M₀) M = 5,750 kgm N = 13,920 kg.c. S = 0

$d/h = 37/42 = 0.882$
 $d'/h = 5/42 = 0.119$
 $p_0 = \frac{A_s}{bh} = \frac{20.10}{100 \times 42} = 0.00479$
 $p'_0 = \frac{A'_s}{bh} = \frac{5.03}{100 \times 42} = 0.00119$
 $u/h = 0.518$
 $u = 21.8 \text{ cm}$
 $d-u = 15.2$

$\frac{M}{N} = \frac{5750 \times 100}{13920} = 41.3$
 $d-u = 15.2$
 $e = 56.5 \text{ cm}$
 $e' = e - 32 = 24.5$
 $e'/e = 24.5/56.5 = 0.434$
 $\frac{Ne}{bd^2} = \frac{13920 \times 56.5}{100 \times 37^2} = 5.750$
 $\frac{Ne}{bd^2 \sigma_c} = 0.202, k_u = 0.440$
 $\sigma_c = \frac{5.750}{0.202} = 28.5 \text{ kg/cm}^2$
 $\sigma_s = 15 \times 28.5 \times \frac{0.56}{0.44} = 544, \tau = 0$

$b = 100 \text{ cm}, h = 42 \text{ cm}$
 $d = 37 \text{ cm}, d' = 5 \text{ cm}$
 $A_s = 10-16\phi = 20.10 \text{ cm}^2$
 $A'_s = 2.5-16\phi = 5.03$
 $p = \frac{A_s}{bd} = \frac{20.10}{100 \times 37} = 0.00544$
 $p'_0 = \frac{A'_s}{bd} = \frac{5.03}{100 \times 37} = 0.00136$
 $d'/d = 5/37 = 0.135$

(A) M = -10,900 kgm, N = 13,920 kg.c. S = -15,390 kg

$d/h = 56/61 = 0.918$
 $d'/h = 5/61 = 0.082$
 $p_0 = \frac{20.10}{100 \times 61} = 0.00330$
 $p'_0 = 0.00082$
 $u/h = 0.512$
 $u = 31.2 \text{ cm}$
 $d-u = 24.8$

$\frac{M}{N} = \frac{10900 \times 100}{13920} = 78.3$
 $d-u = 24.8$
 $e = 103.1 \text{ cm}$
 $e' = e - 51 = 52.1$
 $e'/e = 0.505$
 $\frac{Ne}{bd^2} = \frac{13920 \times 103.1}{100 \times 56^2} = 4.580$
 $\frac{Ne}{bd^2 \sigma_c} = 0.165, k_u = 0.355$
 $\sigma_c = \frac{4.580}{0.165} = 27.8 \text{ kg/cm}^2$
 $\sigma_s = 15 \times 27.8 \times \frac{0.645}{0.355} = 758$

$b = 100, h = 42 + \frac{56}{3} = 61 \text{ cm}$
 $d = 56, d' = 5$
 $A_s = 10-16\phi = 20.10$
 $A'_s = 2.5-16\phi = 5.03$
 $p = \frac{20.10}{100 \times 56} = 0.00359$
 $p'_0 = 0.00089$
 $d'/d = 5/56 = 0.089$

$\tau = \frac{15390}{100 \times 0.882 \times 56} = 3.1 \text{ kg/cm}^2$
 $\tau_0 = \frac{15390}{5.03 \times 10 \times 0.882 \times 56} \times \frac{1}{2} = 3.1$

(Bent-up bar を使用しない場合の bond stress = 3.5 kg/cm²)
 Shear を半室 = 標準以下全し

(H) M = -3,180 kgm N = 13,920 kg.c. S = -11,260 kg

$e = \frac{M}{N} = \frac{3180 \times 100}{13920} = 22.9$
 $d'/h = 5/42 = 0.119$
 $e'/h = 22.9/42 = 0.546$
 $k_u = 0.395, C = 0.179$

$b = 100, h = 42$
 $d = 37, d' = 5$
 $A_s = A'_s = 5-16\phi = 10.05 \text{ cm}^2$
 $p_0 = p'_0 = \frac{10.05}{100 \times 42} = 0.00240$

$\sigma_c = \frac{N}{bhC} = \frac{13920}{100 \times 42 \times 0.179} = 18.5 \text{ kg/cm}^2$
 $\sigma_s = \sigma_c \frac{1-k-d'/h}{k} = 15 \times 18.5 \times \frac{1-0.395-0.119}{0.395} = 341$
 $\tau = \frac{11260}{100 \times 0.868 \times 37} = 3.5 \text{ kg/cm}^2$
 $\tau_0 = \frac{11260}{5.03 \times 7.5 \times 0.868 \times 37} \times \frac{1}{2} = 4.6$

(下面主鉄筋が 7.5 本 + 7 本 標準 lap を長くとす)

上海標準隧道

上床 BB'

(M3)

$M = 6450 \text{ kgm}, N = 10090 \text{ kg.c.}, S = 0$

$\frac{M}{N} = \frac{6450 \times 100}{10090} = 63.9$

$d-u = 15.2$

$e = 79.1 \text{ cm}$

$e' = e - 32 = 47.1$

$e/e = 0.595$

$\frac{Ne}{bd^2} = \frac{10090 \times 79.1}{100 \times 37^2} = 5.830$

$\frac{Ne}{bd^2 \sigma_c} = 0.184, k = 0.395$

$\sigma_c = \frac{5.830}{0.184} = 31.7 \text{ kg/cm}^2$

$\sigma_s = 15 \times 31.7 \times \frac{0.605}{0.395} = 728, \tau = 0$

断面 (M1) = 全寸
(第5頁参照)

(H4)

$M = -2480 \text{ kgm}, N = 10090 \text{ kg.c.}, S = 11260 \text{ kg}$

(H) ト全 - 断面ヲ使用スルハ安全ナリ $\tau = 3.5 \text{ kg/cm}^2$

(B)

$M = -10200 \text{ kgm}, N = 10090 \text{ kg.c.}, S = 15390 \text{ kg}$

$\frac{M}{N} = \frac{10200 \times 100}{10090} = 94.7$

$d-u = 24.8$

$e = 119.5 \text{ cm}$

$e' = e - 51 = 68.5$

$e/e = 0.573$

$\frac{Ne}{bd^2} = \frac{10090 \times 119.5}{100 \times 56^2} = 3.845$

$\frac{Ne}{bd^2 \sigma_c} = 0.162, k = 0.340$

$\sigma_c = \frac{3.845}{0.162} = 23.7 \text{ kg/cm}^2$

$\sigma_s = 15 \times 23.7 \times \frac{0.660}{0.340} = 691$

$\tau = \frac{15390}{100 \times 887 \times 56} = 3.1 \text{ kg/cm}^2$

$\tau_0 = \frac{15390}{5.03 \times 10 \times 887 \times 56} \times \frac{1}{2} = 3.1$

断面 (A) = 全寸
(第5頁参照)

側壁 A-B

(M2)

$M = 4880 \text{ kgm}, N = 15390 \text{ kg.c.}, S = 0$

$d/h = 31/36 = 0.862$

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

$\rho = 20.10/100 \times 36 = 0.00538$

$\rho' = 0.00279$

$u/h = 0.518$

$u = 18.70 \text{ cm}$

$d-u = 12.3$

$\frac{M}{N} = \frac{4880 \times 100}{15390} = 31.7$

$d-u = 12.3$

$e = 44.0 \text{ cm}$

$e' = e - 26 = 18.0$

$e/e = 0.410$

$\frac{Ne}{bd^2} = \frac{15390 \times 44.0}{100 \times 31^2} = 7.050$

$\frac{Ne}{bd^2 \sigma_c} = 0.226, k = 0.470$

$\sigma_c = \frac{7.050}{0.226} = 31.2 \text{ kg/cm}^2$

$\sigma_s = 15 \times 31.2 \times \frac{0.530}{0.470} = 528, \tau = 0$

$b = 100, h = 36$

$d = 31, d' = 5$

$A_s = 10 - 16^{\#} = 20.10$

$A_s' = 5 - 16^{\#} = 10.05$

$\rho = 20.10/100 \times 31 = 0.00648$

$\rho' = 0.00324$

$d'/d = 5/31 = 0.161$

Ⓐ $M = -10900 \text{ kgm}, N = 15390 \text{ kg.c.}, S = 13920 \text{ kg}$

$$\frac{M}{N} = \frac{10900 \times 100}{15390} = 70.9$$

$$d-u = 22.4$$

$$e = 93.3 \text{ cm}$$

$$e' = e - 46 = 47.3$$

$$e'/e = 0.507$$

$$\frac{Ne}{bd^2} = \frac{15390 \times 93.3}{100 \times 51^2} = 5.525$$

$$\frac{Ne}{bd^2 c} = 0.173, k = 0.370$$

$$b = 100, h = 36 + \frac{61}{3} = 56$$

$$d = 51, d' = 5$$

$$A_s = 10 - 16^{\circ} = 20.10$$

$$A_s' = 2.5 - 16^{\circ} = 5.03$$

$$p = \frac{20.10}{100 \times 51} = 0.00394$$

$$p' = \frac{5.03}{100 \times 51} = 0.00099$$

$$d'/d = \frac{5}{51} = 0.098$$

$$\sigma_c = \frac{5.525}{0.173} = 31.9 \text{ kg/cm}^2, \tau = \frac{13920}{100 \times 0.877 \times 51} = 3.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 31.9 \times \frac{0.630}{0.370} = 817, \tau_0 = \frac{13920}{5.03 \times 10 \times 0.877 \times 51} \times \frac{1}{2} = 3.1$$

Ⓑ $M = -10200 \text{ kgm}, N = 15390 \text{ kg.c.}, S = 10090 \text{ kg}$

$$\frac{M}{N} = \frac{10200 \times 100}{15390} = 66.3$$

$$d-u = 22.4$$

$$e = 88.7 \text{ cm}$$

$$e' = e - 46 = 42.7$$

$$e'/e = 0.482$$

$$\frac{Ne}{bd^2} = \frac{15390 \times 88.7}{100 \times 51^2} = 5.250$$

$$\frac{Ne}{bd^2 c} = 0.175, k = 0.375$$

断面ハ上記 Ⓐ = 全シ

$$\sigma_c = \frac{5.250}{0.175} = 30.0 \text{ kg/cm}^2, \tau = \frac{10090}{100 \times 0.875 \times 51} = 2.3 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 30.0 \times \frac{0.625}{0.375} = 750, \tau_0 = \frac{10090}{5.03 \times 10 \times 0.875 \times 51} \times \frac{1}{2} = 2.3$$

Ⓒ $M = -4560 \text{ kgm}, N = 15390 \text{ kg.c.}, S = -8350 \text{ kg}$

$$e = \frac{M}{N} = \frac{4560 \times 100}{15390} = 29.6 \text{ cm}$$

$$e'/h = \frac{29.6}{36} = 0.823$$

$$d'/h = \frac{5}{36} = 0.139$$

$$k = 0.365, c = 0.135$$

$$b = 100, h = 36$$

$$d = 31, d' = 5$$

$$A_s = A_s' = 7.5 - 16^{\circ} = 15.07$$

$$p_0 = p_0' = \frac{15.07}{100 \times 36} = 0.00419$$

$$\sigma_c = \frac{15390}{100 \times 36 \times 0.135} = 31.6 \text{ kg/cm}^2, \tau = \frac{8350}{100 \times 0.878 \times 31} = 3.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 31.6 \times \frac{1 - 0.365 - 0.139}{0.365} = 645, \tau_0 = \frac{8350}{5.03 \times 7.5 \times 0.878 \times 31} \times \frac{1}{2} = 4.1$$

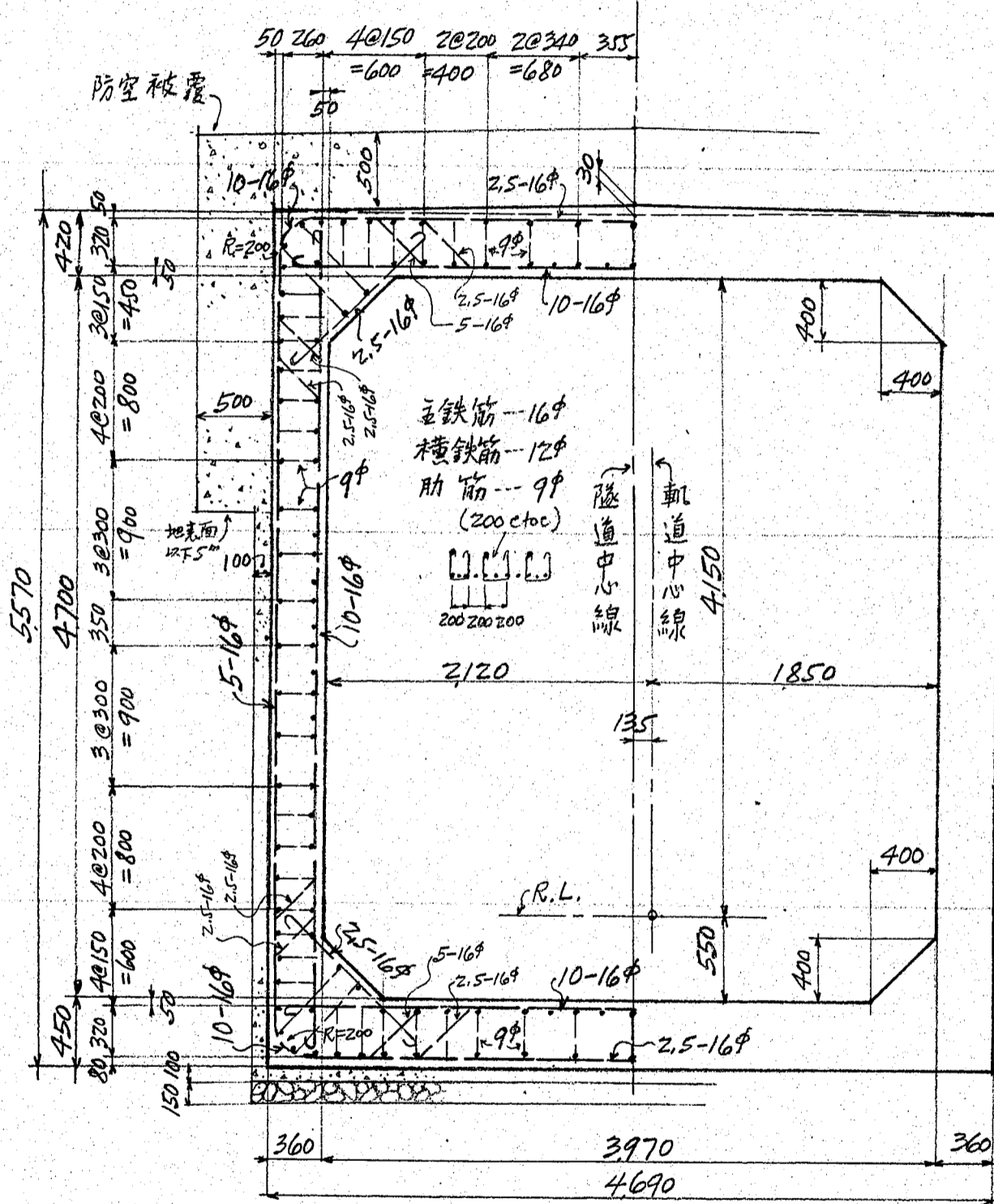
Ⓓ $M = -3610 \text{ kgm}, N = 15390 \text{ kg.c.}, S = 9900 \text{ kg}$

断面ハ上記 Ⓒ = 全シ

$$\tau = \frac{9900}{100 \times 0.878 \times 31} = 3.7 \text{ kg/cm}^2$$

$$\tau_0 = \frac{9900}{5.03 \times 7.5 \times 0.878 \times 31} \times \frac{1}{2} = 4.8$$

配筋図



土被 3.0m 標準隧道配筋図

縮尺 1:40

注意 待避所，部分 = 上記と同様，配筋は
ナシの外更 = 待避所特有，鉄筋はテ補強
ス。

鉄筋，定尺

- 9φ --- 3.6", 4.5, 5.5, 6.1"
- 12φ --- 3.6", 4.5, 4.9, 5.5, 6.1, 6.7, 7.3"
- 16φ --- " " " " " " " "

腹鉄筋間隔，第34頁参考表参照，ナ

上海高速鐵道
鐵筋混凝土標準型單線隧道
土被四〇米應力計算書

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

上海標準隧道

剪力

上床 $S_{B2} = \frac{wl}{2} = \frac{9010 \times 4.33}{2} = 19500 \text{ kg}$

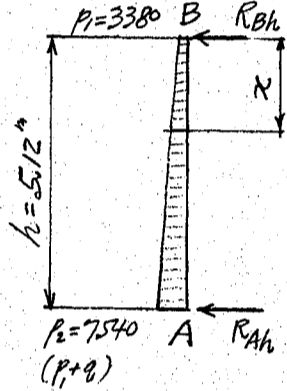
$S_{H4} = 19500 - 0.58 \times 9010 = 14280 \text{ .}$

下床

$S_{A2} = -19500 \text{ .}$

$S_{H1} = -14280 \text{ .}$

側壁



AB Simple Beam 反力

$R_{Ah} = \frac{h}{6} (2P_2 + P_1) = \frac{5.12}{6} (15080 + 3380) = 15750 \text{ kg}$

$R_{Bh} = \frac{h}{6} (2P_1 + P_2) = \frac{5.12}{6} (6760 + 7540) = 12200 \text{ .}$

剪力

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -12200 + \frac{-12340 + 13040}{5.12} = -12060 \text{ kg}$

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 15750 + 140 = 15890 \text{ .}$

任意 1 点 = 於 x 剪力

$S_x = S_{B1} + \frac{qx^2}{2h} + px = -12060 + \frac{4160}{2 \times 5.12} x^2 + 3380x$

$= 406x^2 + 3380x - 12060$

0 Shear 1 点.

$x^2 + 8.32x - 29.72 = 0$

$x = \frac{-8.32 \pm \sqrt{8.32^2 + 4 \times 29.72}}{2} = 2.700 \text{ m}$

	x	$406x^2$	$+ 3380x$	$- 12060$	$= M_x$
(H3)	0.61m	150	+ 2060	- 12060	= - 9850 kg
(M2)	2.700	2950	+ 9110	- 12060	= 0 ,
(H2)	4.51	8250	+ 15220	- 12060	= 11410 ,

中間点 = 於 x 弯曲率

下床 AA'

(M1) $\frac{wl^2}{8} = \frac{9010 \times 4.33^2}{8} = 21090$

$M_A = -13040$
 $M_1 = 8050 \text{ kgm}$

軸力 $N_{AA'} = S_{M1} = 15890 \text{ kg.c.}$

(H1) $-21090 \times \frac{1.585^2}{2.165^2} = -11310$

$M_1 = \frac{8050}{M_{H1}} = -3260 \text{ kgm}$

上床 BB'

(M3) $\frac{wl^2}{8} = 21090$

$M_B = -12340$
 $M_3 = 8750 \text{ kgm}$

軸力 $N_{BB'} = -S_{B1} = 12060 \text{ kg.c.}$

上海標準隧道

$$\begin{aligned} (H_4) \quad & -21090 \times \frac{1.585^2}{2.165^2} = -11310 \\ M_3 & = \frac{8750}{M_{H_4} = -2560 \text{ kgm}} \end{aligned}$$

側壁 AB.

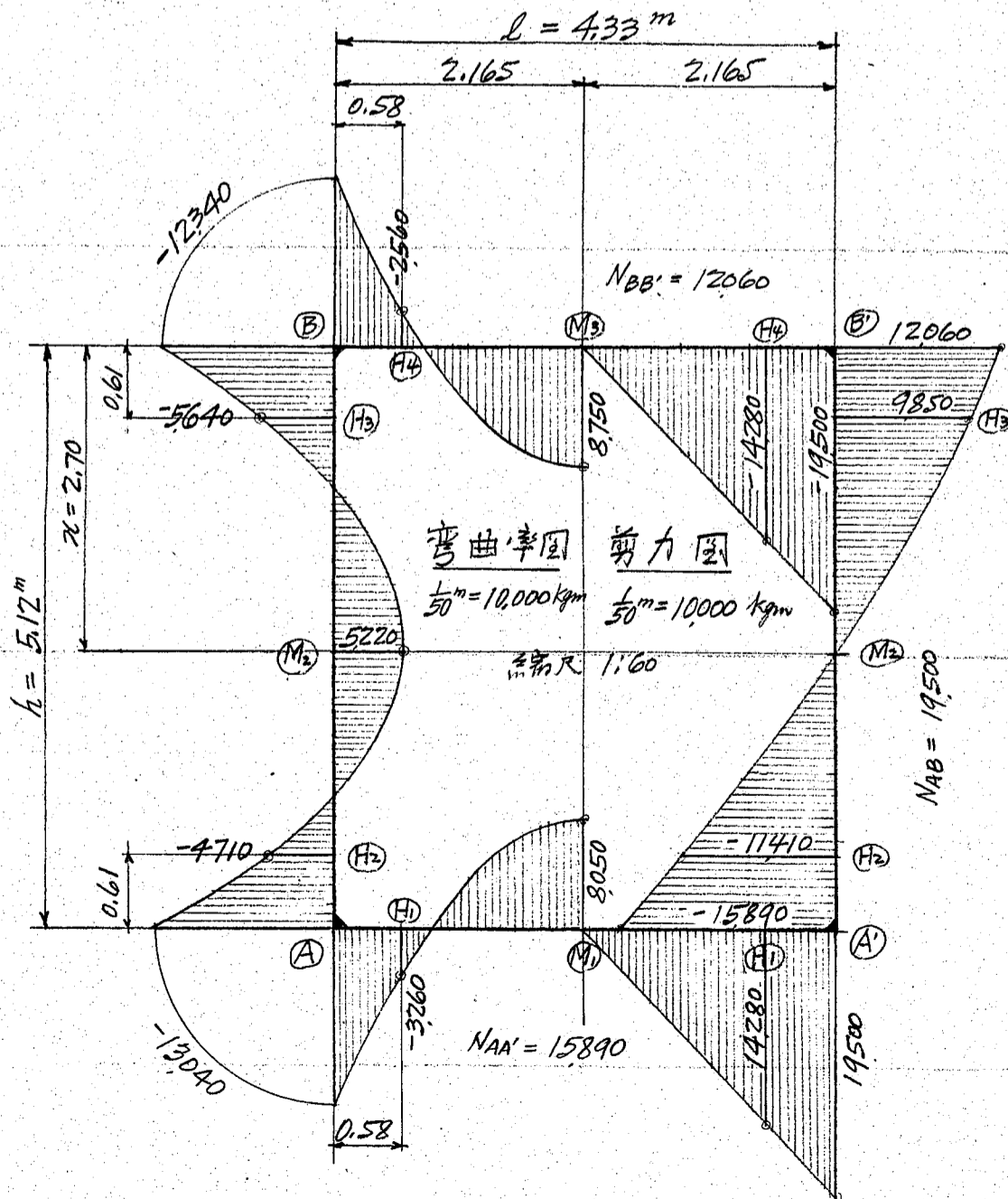
任意1点 = 於此弯曲率

$$\begin{aligned} M_x &= -S_{B1}x - \frac{Px^2}{2} - \frac{qx^3}{6h} + M_B \\ &= 12060x - 1690x^2 - \frac{4160}{6 \times 5.12}x^3 - 12340 \\ &= -135.5x^3 - 1690x^2 + 12060x - 12340 \end{aligned}$$

x	$-135.5x^3 - 1690x^2 + 12060x - 12340$	$= M_{2c}$
(H ₃) 0.61m	-30 - 630 + 7360 - 12340	= -5640 kgm
(M ₂) 2.70	-2670 - 12320 + 32550 - 12340	= 5220 "
(H ₂) 4.51	-12420 - 34350 + 54400 - 12340	= -4710 "

軸力 $N_{AB} = S_{B2} = 19500 \text{ kg.c.}$

彎曲率及剪力圖



M_1, M_2, M_3 , 最大弯曲率, 点
 H_1, H_2 至 H_4 , 於 Haunch 一端

断面應力計算

下床 AA'

断面ハ 特記セザル限リ 總テ SCT35 型 = 同シ
(第5乃至8頁参照)

(M₁) M = 8050 kgm N = 15890 kg.C S = 0.

$$\frac{M}{N} = \frac{8050 \times 100}{15890} = 50.7$$

$$d-u = 15.2$$

$$e = 65.9 \text{ cm}$$

$$e' = e - 32 = 33.9 "$$

$$e/e = 0.515$$

$$\frac{Ne}{bd^2} = \frac{15890 \times 65.9}{100 \times 37^2} = 7.650$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.192 \quad k = 0.415$$

$$\sigma_c = \frac{7.650}{0.192} = 39.8 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 39.8 \times \frac{0.585}{0.415} = 842 "$$

$$\tau = 0$$

(断面ハ 第5頁参照)
b = 100, h = 42
d = 37, d' = 5
A_s = 10-16 ϕ
A_s' = 2.5-16 ϕ

(A) M = -13040 kgm, N = 15890 kg.C, S = -19500 kg

$$\frac{M}{N} = \frac{13040 \times 100}{15890} = 82.1$$

$$d-u = 24.8$$

$$e = 106.9 \text{ cm}$$

$$e' = e - 51 = 55.9 "$$

$$e/e = 0.523$$

$$\frac{Ne}{bd^2} = \frac{15890 \times 106.9}{100 \times 56^2} = 5.420$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.164 \quad k = 0.355$$

$$\sigma_c = \frac{5.420}{0.164} = 33.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 33.1 \times \frac{0.645}{0.355} = 901 "$$

b = 100, h = 61
d = 56, d' = 5
A_s = 10-16 ϕ
A_s' = 2.5-16 ϕ

$$\tau = \frac{19500}{100 \times 0.882 \times 56} = 3.9 \text{ kg/cm}^2$$

$$\tau_o = \frac{19500}{5.03 \times 10 \times 0.882 \times 56} \times \frac{1}{2} = 3.9 "$$

(H₁) M = -3260 kgm, N = 15890 kg.C, S = -14280 kg

$$e = \frac{M}{N} = \frac{3260 \times 100}{15890} = 20.5 \text{ cm}$$

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

$$e/h = 20.5/42 = 0.488$$

$$k = 0.433 \quad c = 0.205$$

b = 100, h = 42
d = 37, d' = 5
A_s = A_s' = 5-16 ϕ = 10.05

$$\sigma_c = \frac{N}{bh_c} = \frac{15890}{100 \times 42 \times 0.205} = 18.5 \text{ kg/cm}^2$$

$$\sigma_s = \sigma_c \frac{1-k-d'/h}{k} = 18.5 \times \frac{1-0.433-0.119}{0.433} = 245 "$$

$$\tau = \frac{14280}{100 \times 0.856 \times 37} = 4.5 \text{ kg/cm}^2$$

$$\tau_o = \frac{14280}{5.03 \times 7.5 \times 0.856 \times 37} \times \frac{1}{2} = 6.0 "$$

(下面主鉄筋ハ 7.5本トナリ接
lapヲ長ス)

上海標準隧道

上床 BB'

(M3)

$M = 8750 \text{ kgm}, N = 12060 \text{ kg.c.}, S = 0$

$\frac{M}{N} = \frac{8750 \times 100}{12060} = 72.5$
 $d-u = 15.2$
 $e = 87.7 \text{ cm}$
 $e' = e - 32 = 55.7$
 $e'/e = 0.635$

$\frac{Ne}{bd^2} = \frac{12060 \times 87.7}{100 \times 37^2} = 7.735$

$\frac{Ne}{bd^2 \sigma_c} = 0.181, k = 0.387$

$\sigma_c = \frac{7.735}{0.181} = 42.7 \text{ kg/cm}^2$

$\sigma_s = 15 \times 42.7 \times \frac{0.613}{0.387} = 1015 \text{ " } \tau = 0$

断面ハ (M) = 合工
(詳細ハ 第 5 頁 参照)

(H4)

$M = -2560 \text{ kgm}, N = 12060 \text{ kg.c.}, S = 14280 \text{ kg}$

(H1) と 同 - 断面ヲ 使用スルニ 適合ナリ $\tau = 4.5 \text{ kg/cm}^2$

(B)

$M = -12340 \text{ kgm}, N = 12060 \text{ kg.c.}, S = 19500 \text{ kg}$

$\frac{M}{N} = \frac{12340 \times 100}{12060} = 102.3$
 $d-u = 24.8$
 $e = 127.1 \text{ cm}$
 $e' = e - 51 = 76.1$
 $e'/e = 0.598$

$\frac{Ne}{bd^2} = \frac{12060 \times 127.1}{100 \times 56^2} = 4.890$

$\frac{Ne}{bd^2 \sigma_c} = 0.160, k = 0.335$

$\sigma_c = \frac{4.890}{0.160} = 30.6 \text{ kg/cm}^2$

$\tau = \frac{19500}{100 \times 0.888 \times 56} = 39 \text{ kg/cm}^2$

$\sigma_s = 15 \times 30.6 \times \frac{0.665}{0.335} = 910 \text{ "}$

$\tau_0 = \frac{19500}{5.03 \times 10 \times 0.888 \times 56} \times \frac{1}{2} = 3.9$

断面ハ (A) = 同工
(第 12 及 5 頁 参照)

側壁 AB

(M2)

$M = 5220 \text{ kgm}, N = 19500 \text{ kg.c.}, S = 0$

$\frac{M}{N} = \frac{5220 \times 100}{19500} = 26.8$
 $d-u = 12.3$
 $e = 39.1 \text{ cm}$
 $e' = e - 26 = 13.1$
 $e'/e = 0.335$

$\frac{Ne}{bd^2} = \frac{19500 \times 39.1}{100 \times 31^2} = 7.940$

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

$\sigma_c = \frac{7.940}{0.238} = 33.4 \text{ kg/cm}^2$

$\sigma_s = 15 \times 33.4 \times \frac{0.495}{0.505} = 491 \text{ " } \tau = 0$

(断面ハ 37 頁 参照)

$b = 100, h = 36$

$d = 31, d' = 5$

$A_s = 10 - 16^{\#}$

$A_s' = 5 - 16^{\#}$

① $M = -13040 \text{ kgm}, N = 19500 \text{ kg.e}, S = 15890 \text{ kg}$
 $\frac{M}{N} = \frac{13040 \times 100}{19500} = 66.9$
 $d-u = 22.4$
 $e = 89.3 \text{ cm}$
 $e' = e - 46 = 43.3$
 $e'/e = 0.485$
 $\frac{Ne}{bd^2} = \frac{19500 \times 89.3}{100 \times 51^2} = 6.690$
 $\frac{Ne}{bd^2 \sigma_c} = 0.175, k = 0.375$
 $\sigma_c = \frac{6.690}{0.175} = 38.2 \text{ kg/cm}^2, \tau = \frac{15890}{100 \times 0.875 \times 51} = 3.6 \text{ kg/cm}^2$
 $\sigma_s = 15 \times 38.2 \times \frac{0.625}{0.375} = 954, \tau_0 = \frac{15890}{503 \times 10 \times 0.875 \times 51} \times \frac{1}{2} = 3.5$
 (断面「第7頁参照」
 $b=100, h=56$
 $d=51, d'=5$
 $A_s=10-16\phi$
 $A_s'=25-16\phi$

② $M = -12340 \text{ kgm}, N = 19500 \text{ kg.e}, S = -12060 \text{ kg}$
 $\frac{M}{N} = \frac{12340 \times 100}{19500} = 63.3$
 $d-u = 22.4$
 $e = 85.7 \text{ cm}$
 $e' = e - 46 = 39.7$
 $e'/e = 0.464$
 $\frac{Ne}{bd^2} = \frac{19500 \times 85.7}{100 \times 51^2} = 6.430$
 $\frac{Ne}{bd^2 \sigma_c} = 0.177, k = 0.380$
 $\sigma_c = \frac{6.430}{0.177} = 36.3 \text{ kg/cm}^2, \tau = \frac{12060}{100 \times 0.873 \times 51} = 2.7 \text{ kg/cm}^2$
 $\sigma_s = 15 \times 36.3 \times \frac{0.620}{0.380} = 890, \tau_0 = \frac{12060}{503 \times 10 \times 0.873 \times 51} \times \frac{1}{2} = 2.7$
 断面「①」= 全寸

③ $M = -5640 \text{ kgm}, N = 19500 \text{ kg.e}, S = -9850 \text{ kg}$
 $e = \frac{M}{N} = \frac{5640 \times 100}{19500} = 28.9 \text{ cm}$
 $\frac{e}{h} = \frac{28.9}{36} = 0.803$
 $\frac{d}{h} = \frac{5}{36} = 0.139$
 $k = 0.370, c = 0.140$
 $\frac{Ne}{bd^2 \sigma_c} = 0.140, \sigma_c = \frac{19500}{100 \times 36 \times 0.140} = 38.7 \text{ kg/cm}^2, \tau = \frac{9850}{100 \times 0.877 \times 31} = 3.6 \text{ kg/cm}^2$
 $\sigma_s = 15 \times 38.7 \times \frac{0.630 - 0.139}{0.370} = 770 \text{ kg/cm}^2, \tau_0 = \frac{9850}{503 \times 7.5 \times 0.877 \times 31} \times \frac{1}{2} = 4.8$
 (断面「第7頁参照」
 $b=100, h=36$
 $d=31, d'=5$
 $A_s=A_s'=7.5-16\phi$

④ $M = -4710 \text{ kgm}, N = 19500 \text{ kg.e}, S = 11410 \text{ kg}$
 $\tau = \frac{11410}{100 \times 0.877 \times 31} = 4.2 \text{ kg/cm}^2$
 $\tau_0 = \frac{11410}{503 \times 7.5 \times 0.877 \times 31} \times \frac{1}{2} = 5.6$
 断面「③」= 全寸

隧道断面「S.C.T.35型」ト全寸全寸 (第8頁参照)
 (但し側壁防空被覆ヲ1米減キ所=テ止ドム事)

上海高速鐵道

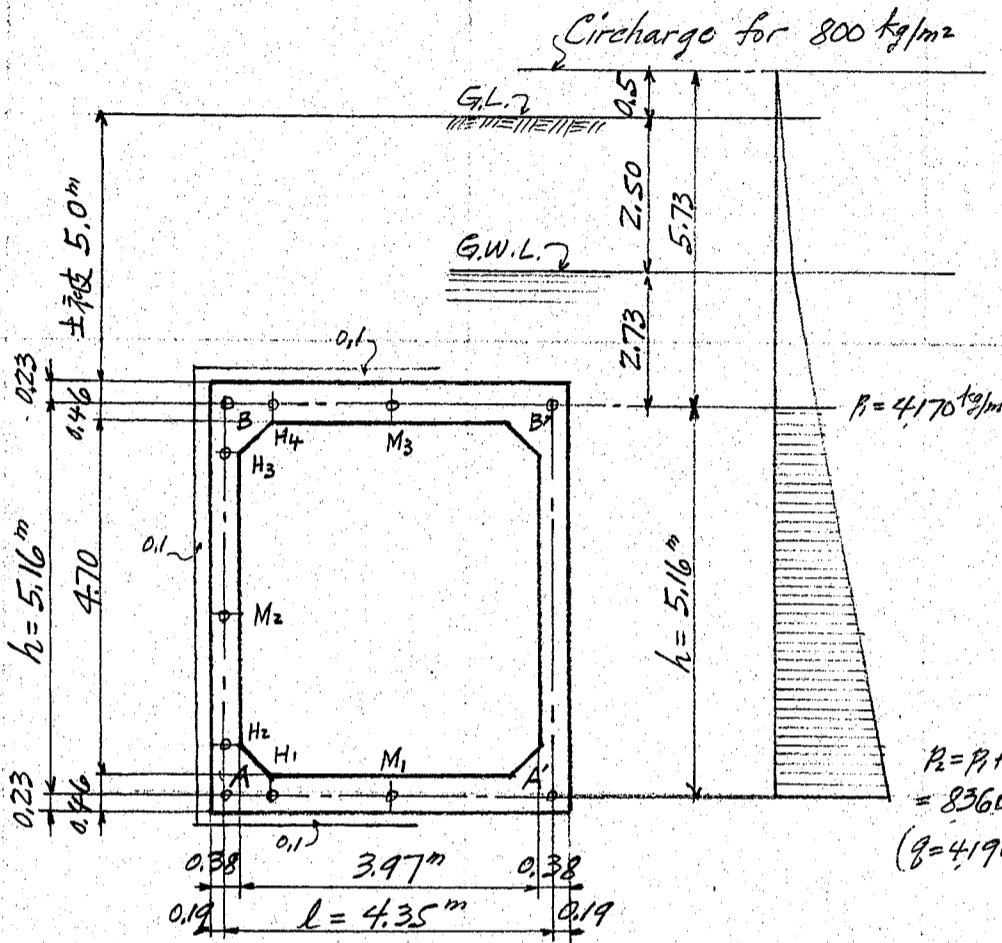
鐵筋混凝土標準型單線隧道

土被五・〇米應力計算書

Standard Reinforced Concrete Tunnel.
Single Tracks
Mark. S.C.T.5S.

上海高速鐵道 鐵筋混凝土單線標準隧道

土被 5.0m 標準隧道 S.C.T.5.5



上床荷重
土被 地下水位以上 2.5 @ 1600 = 4000
" " 以下 2.4 @ 2000 = 4800
被覆混凝土 0.1 @ 2200 = 220
上床 0.46 @ 2400 = 1100
10120
路面傳布荷重 w = 800
10920 kg/m²

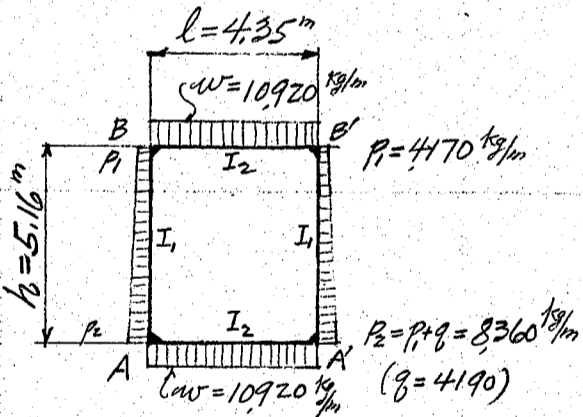
下床荷重 上床荷重同一假定

側壁荷重
上部荷重
土被 2.5 @ 1600 = 4000
" 2.73 @ 2000 = 5460
路面荷重 800
10260
荷重 p₁ = 10260 × 0.406 = 4170 kg/m²

$P_2 = P_1 + q = 8360 \text{ kg/m}$
(q = 4190)

下部荷重
q = 5.16 @ 2000 × 0.406 = 4190
荷重 p₂ = p₁ + q = 8360 kg/m²

荷重狀態



Moments of Inertia

$I_1 = \frac{1.0 \cdot 0.38^3}{12} = 0.00457 \text{ m}^4$, $K_1 = \frac{I_1}{h} = \frac{0.00457}{5.16} = 0.00089$
 $I_2 = \frac{1.0 \cdot 0.46^3}{12} = 0.00811$, $K_2 = \frac{I_2}{l} = \frac{0.00811}{4.35} = 0.00186$

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

$12(1+K) = 12 \times 3.090 = 37.080$

$\frac{K}{60(1+K)(3+K)} = \frac{2.090}{60 \times 3.090 \times 5.090} = 0.002215$

上下床荷重 w = 依心弯曲率

$M_A = M_B = - \frac{w l^2}{12(1+K)} = - \frac{10920 \times 4.35^2}{37.080} = - 5570 \text{ kgm}$

側壁荷重 p₁ 及 p₂ = 依心弯曲率

$M_A = - \frac{K h^2}{60(1+K)(3+K)} \{ 7P_1 + 8P_2 + K(2P_1 + 3P_2) \} = - 0.002215 \times 5.16^2 \{ 29190 + 66880 + 2.090(8340 + 25080) \}$
= - 9790 kgm

$M_B = - \frac{K h^2}{60(1+K)(3+K)} \{ 8P_1 + 7P_2 + K(3P_1 + 2P_2) \} = - 0.002215 \times 5.16^2 \{ 33360 + 58520 + 2.090(12510 + 16720) \}$
= - 9020 kgm

上下床及左右兩側壁荷重 = 依心合成弯曲率

床荷重 側壁荷重 合成弯曲率

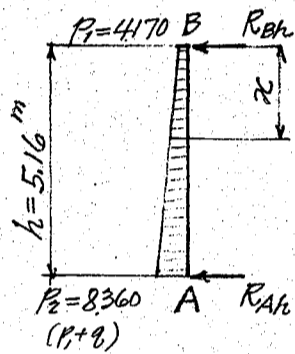
M_A - 5570 kgm - 9790 kgm - 15360 kgm

M_B - 5570 - 9020 - 14590 kgm

剪力

上床 $S_{B2} = \frac{wl}{2} = \frac{10920 \times 4.35}{2} = 23750 \text{ kg}$
 ' $S_{H4} = 23750 - 0.59 \times 10920 = 17310 \text{ '}$
 下床 $S_{A2} = -23750 \text{ '}$
 ' $S_{H1} = -17310 \text{ '}$

側壁



AB 7 Simple Beam 1-2w 3力.

$R_{Ah} = \frac{h}{6}(2P_2 + P_1) = \frac{5.16}{6}(16720 + 4170) = 17950 \text{ kg}$

$R_{Bh} = \frac{h}{6}(2P_1 + P_2) = \frac{5.16}{6}(8340 + 8360) = 14350 \text{ '}$

剪力

$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -14350 + \frac{74590 + 15360}{5.16} = -14200 \text{ kg}$

$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 17950 + 150 = 18100 \text{ '}$

任意 1 點 = 於 5w 剪力

$S_x = S_{B1} + \frac{qx^2}{2h} + P_2x = -14200 + \frac{4190}{2 \times 5.16}x^2 + 4170x$
 $= 406x^2 + 4170x - 14200$

0 Shear 1 點.

$x^2 + 10.27x - 35.0 = 0$

$x = -\frac{10.27}{2} \pm \frac{\sqrt{10.27^2 + 4 \times 35.0}}{2} = 2.700 \text{ m}$

	x	$406x^2$	$+ 4170x$	$- 14200$	= S_x
(H3)	0.63m	160	+ 2630	- 14200	= -11410 kg
(M2)	2.70	2960	+ 11240	- 14200	= 0
(H2)	4.53	8330	+ 18880	- 14200	= 13010

中間點 = 於 5w 彎曲率

下床 AA'

(M1) $\frac{wl^2}{8} = \frac{10920 \times 4.35^2}{8} = 25800$
 $M_A = -15360$
 $M_1 = 10440 \text{ kgm}$

軸力

$N_{AA'} = S_{A1} = 18100 \text{ kg.c}$

(H1) $-25800 \times \frac{1.585^2}{2.175^2} = -12700$
 $M_1 = 10440$
 $M_{H1} = -3260 \text{ kgm}$

上床 BB'

(M3) $\frac{wl^2}{8} = 25800$
 $M_B = -14590$
 $M_3 = 11210 \text{ kgm}$

軸力

$N_{BB'} = -S_{B1} = 14200 \text{ kg.c}$

上海標準隧道

$$\begin{aligned} (H_4) \quad -25800 \times \frac{1.585^2}{2.175^2} &= -13700 \\ M_3 &= \frac{11210}{M_{H4} = -2490 \text{ kgm}} \end{aligned}$$

側壁 AB

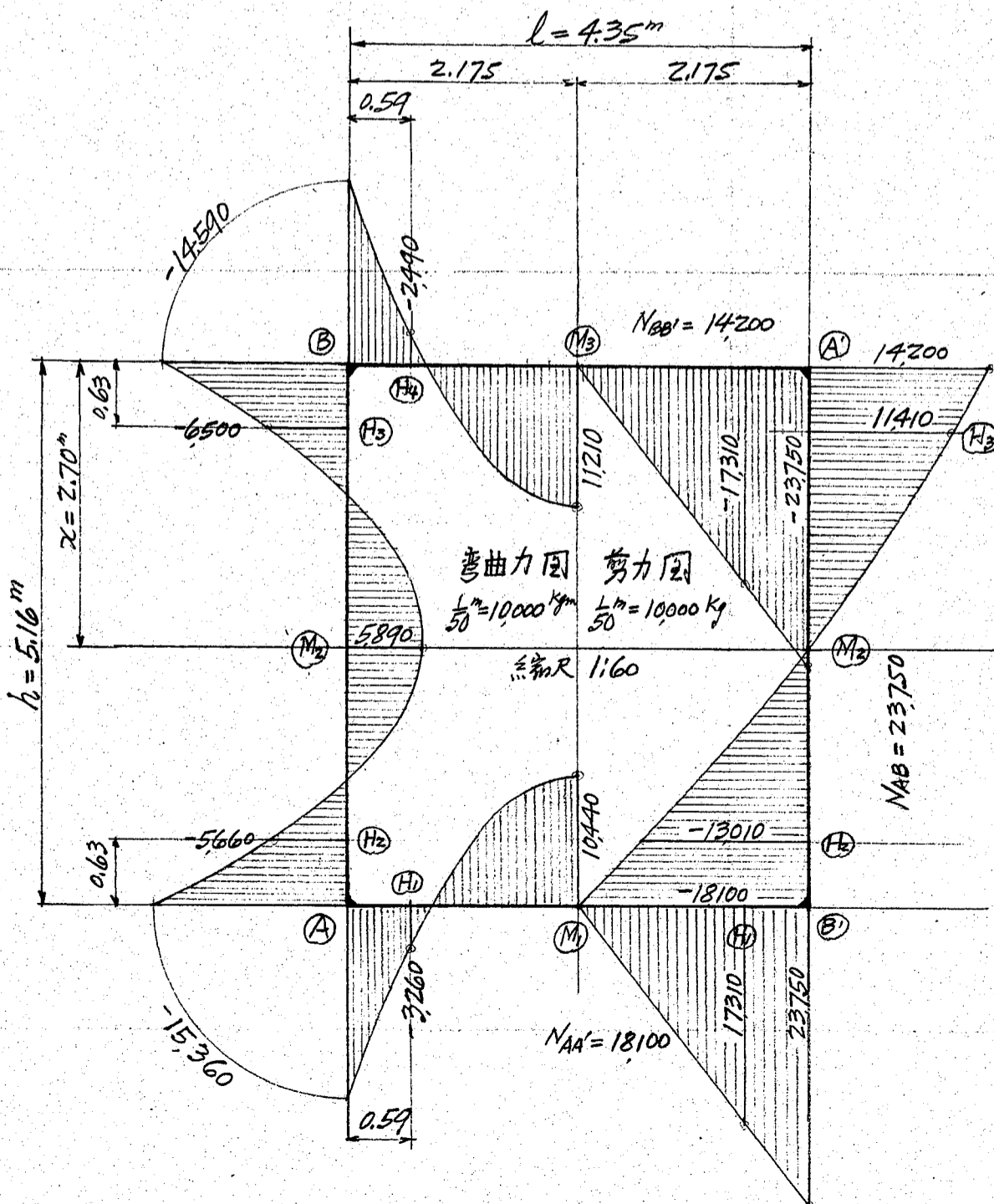
任意 1 点 = 於此弯曲率

$$\begin{aligned} M_x &= -S_{B1}x - \frac{Px^2}{2} - \frac{qx^3}{6h} + M_B \\ &= 14200x - 2085x^2 - \frac{4190}{6 \times 5.16} x^3 - 14590 \\ &= -135.5x^3 - 2085x^2 + 14200x - 14590 \end{aligned}$$

	x		Mx
(H3)	0.63m	- 30 - 830 + 8950 - 14590	= -6500 kgm
(M2)	2.70	- 2670 - 15200 + 38350 - 14590	= 5890 "
(H2)	4.53	- 12590 - 42780 + 64300 - 14590	= -5660 "

軸力 $N_{AB} = S_{B2} = 23750 \text{ kg.c.}$

彎曲率及剪力圖



M_1, M_2, M_3 最大弯曲率点
 H_1 至 H_4 为 Haunch 先端

断面應力計算

下床 AA'

(M₁)

$M = 10440 \text{ kgm}$ $N = 18100 \text{ kg.c.}$ $S = 0$

(S.C.T.5-33頁参照)

$d-u = 17.2 \text{ cm}$

$\frac{M}{N} = \frac{10440 \times 100}{18100} = 57.7$
 $d-u = 17.2$
 $e = 74.9 \text{ cm}$

$e' = e - 36 = 38.9$

$e'/e = 38.9/74.9 = 0.520$

$\frac{Ne}{bd^2} = \frac{18100 \times 74.9}{100 \times 41^2} = 8.060$

$\frac{Ne}{bd^2 \sigma_c} = 0.186$ $k = 0.400$

$\sigma_c = \frac{8.060}{0.186} = 43.3 \text{ kg/cm}^2$

$\sigma_s = 15 \times 43.3 \times \frac{0.600}{0.400} = 975$ $\tau = \tau_0 = 0$

$b = 100 \text{ cm}$ $h = 46 \text{ cm}$

$d = 41 \text{ cm}$ $d' = 5 \text{ cm}$

$A_s = 10-16\phi = 20.10 \text{ cm}^2$

$A_s' = 2.5-16\phi = 5.03$

$p = 20.10/100 \times 41 = 0.00491$

$p' = 5.03/100 \times 41 = 0.00123$

$d'/d = 5/41 = 0.122$

(A)

$M = -15360 \text{ kgm}$ $N = 18100 \text{ kg.c.}$ $S = -23750 \text{ kg}$

(S.C.T.5-33頁参照)

$d-u = 27.2 \text{ cm}$

$\frac{M}{N} = \frac{15360 \times 100}{18100} = 85.0$

$d-u = 27.2$

$e = 112.2 \text{ cm}$

$e' = e - 56 = 56.2$

$e'/e = 56.2/112.2 = 0.501$

$\frac{Ne}{bd^2} = \frac{18100 \times 112.2}{100 \times 61^2} = 5.460$

$\frac{Ne}{bd^2 \sigma_c} = 0.164$ $k = 0.350$

$\sigma_c = \frac{5.460}{0.164} = 33.3 \text{ kg/cm}^2$

$\sigma_s = 15 \times 33.3 \times \frac{0.600}{0.350} = 900$

$\tau = \frac{23750}{100 \times 0.883 \times 61} = 4.4 \text{ kg/cm}^2$

$\tau_0 = \frac{23750}{5.03 \times 10 \times 0.883 \times 61} \times \frac{1}{2} = 4.4$

$b = 100$ $h = 46 + \frac{59}{3} = 66$

$d = 61$ $d' = 5$

$A_s = 10-16\phi = 20.10$

$A_s' = 2.5-16\phi = 5.03$

$p = 20.10/100 \times 61 = 0.00330$

$p' = 5.03/100 \times 61 = 0.00083$

$d'/d = 5/61 = 0.082$

(H₁)

$M = -3260 \text{ kgm}$ $N = 18100 \text{ kg.c.}$ $S = -17310 \text{ kg}$

$\tau = \frac{17310}{100 \times \frac{7}{8} \times 41} = 4.8 \text{ kg/cm}^2$

$\tau_0 = \frac{17310}{5.03 \times 10 \times \frac{7}{8} \times 41} \times \frac{1}{2} = 4.8$

$b = 100$ $h = 46$

$d = 41$ $d' = 5$

$A_s = 7.5-16\phi = 15.08$

$A_s' = 2.5-16\phi = 5.03$

(下部主鉄筋が10本+1本接lapヲ長クスルナリ)

上床 BB'

(M₃)

$M = 11210 \text{ kgm}$ $N = 14200 \text{ kg.c.}$ $S = 0$

$\frac{M}{N} = \frac{11210 \times 100}{14200} = 79.0$

$d-u = 17.2$

$e = 96.2 \text{ cm}$

$e' = e - 36 = 60.2$

$e'/e = 60.2/96.2 = 0.626$

$\frac{Ne}{bd^2} = \frac{14200 \times 96.2}{100 \times 41^2} = 8.130$

断面 (M₁) = 同シ

上海標準隧道

$$\frac{Ne}{bd^2\sigma_c} = 0.179, k = 0.380$$

$$\sigma_c = \frac{8.130}{0.179} = 45.4 \text{ kg/cm}^2$$

$$\sigma_s = 45.4 \times 15 \times \frac{0.620}{0.380} = 1111 \quad \tau = \tau_0 = 0$$

③ $M = -14590 \text{ kgm}, N = 14200 \text{ kg.c.}, S = 23750 \text{ kg.}$

$$\frac{M}{N} = \frac{14590 \times 100}{14200} = 102.7 \text{ cm}$$

$$d-u = \frac{27.2}{129.9} \text{ cm}$$

$$e = 73.9$$

$$e' = e - 56 = 17.9$$

$$\frac{e'}{e} = 0.569$$

$$\frac{Ne}{bd^2} = \frac{14200 \times 129.90}{100 \times 61^2} = 4.960$$

$$\frac{Ne}{bd^2\sigma_c} = 0.157, k = 0.330$$

$$\sigma_c = \frac{4.960}{0.157} = 31.6 \text{ kg/cm}^2, \tau = \frac{23750}{100 \times 0.890 \times 61} = 44 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 31.6 \times \frac{0.670}{0.330} = 962, \tau_0 = \frac{23750}{503 \times 10 \times 0.890 \times 61} \times \frac{1}{2} = 43$$

断面 (A) = 同 (第18頁参照)

④ $M = -2490 \text{ kgm}, N = 14200 \text{ kg.c.}, S = 17310 \text{ kg}$

$$\tau = 4.8 \text{ kg/cm}^2$$

$$\tau_0 = 4.8$$

断面 (H) = 同 (第18頁参照)

側壁 AB

⑤ $M = 5890 \text{ kgm}, N = 23750 \text{ kg.c.}, S = 0$

$$\frac{M}{N} = \frac{5890 \times 100}{23750} = 24.8$$

$$d-u = 13.5$$

$$e = 38.3 \text{ cm}$$

$$e' = e - 28 = 10.3$$

$$\frac{e'}{e} = 0.269$$

$$\frac{Ne}{bd^2} = \frac{23750 \times 38.3}{100 \times 33^2} = 8.355$$

$$\frac{Ne}{bd^2\sigma_c} = 0.243, k = 0.520$$

$$\sigma_c = \frac{8.355}{0.243} = 34.4 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 34.4 \times \frac{0.480}{0.520} = 477, \tau = \tau_0 = 0$$

$$b = 100, h = 38$$

$$d = 33, d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A_s' = 5 - 16^\circ = 10.05$$

$$p = 20.10 / 100 \times 33 = 0.00609$$

$$p' = 10.05 / \dots = 0.00305$$

$$d'/d = 5/33 = 0.152$$

(S.C.T.5 --- 35頁参照)

$$d-u = 13.5 \text{ cm}$$

⑥ $M = -15360 \text{ kgm}, N = 23750 \text{ kg.c.}, S = 18100 \text{ kg}$

$$\frac{M}{N} = \frac{15360 \times 100}{23750} = 64.7$$

$$d-u = 23.6$$

$$e = 88.3 \text{ cm}$$

$$e' = e - 49 = 39.3$$

$$\frac{e'}{e} = 0.445$$

$$\frac{Ne}{bd^2} = \frac{23750 \times 88.3}{100 \times 54^2} = 7.190$$

$$\frac{Ne}{bd^2\sigma_c} = 0.243, k = 0.520$$

$$b = 100, h = 38 + \frac{63}{3} = 59$$

$$d = 54, d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A_s' = 2.5 - 16^\circ = 5.03$$

$$p = 20.10 / 100 \times 54 = 0.00372$$

$$p' = 5.03 / \dots = 0.00093$$

$$d'/d = 5/54 = 0.0925$$

$$d/h = 54/59 = 0.915$$

$$d'/h = 5/59 = 0.0847$$

$$p = 20.10 / 100 \times 59 = 0.00341$$

$$p' = 5.03 / \dots = 0.00085$$

$$u/h = 0.515, u = 30.4$$

$$d-u = 23.6 \text{ cm}$$

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

$$\sigma_c = \frac{7.190}{0.178} = 40.4 \text{ kg/cm}^2, \tau = \frac{18100}{100 \times 0.873 \times 54} = 3.8 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 40.4 \times \frac{0.620}{0.380} = 990, \tau_0 = \frac{18100}{5.03 \times 10 \times 0.873 \times 54 \times \frac{1}{2}} = 3.8$$

Ⓐ $M = 14590 \text{ kgm}, N = 23750 \text{ kg.c}, S = -14200 \text{ kg}$

$$\frac{M}{N} = \frac{14590 \times 100}{23750} = 61.5$$

断面 (A) = 同上
(第19頁参照)

$$d-u = \frac{23.6}{85.1 \text{ cm}}$$

$$e = 36.1$$

$$e/e = 0.425$$

$$\frac{Ne}{bd^2} = \frac{23750 \times 85.1}{100 \times 54^2} = 6.930$$

$$\frac{Ne}{bd^2c} = 0.178, k = 0.385$$

$$\sigma_c = \frac{6.930}{0.178} = 39.0 \text{ kg/cm}^2, \tau = \frac{14200}{100 \times 0.870 \times 54} = 3.0 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 39.0 \times \frac{0.615}{0.385} = 934, \tau_0 = \frac{14200}{5.03 \times 10 \times 0.870 \times 54 \times \frac{1}{2}} = 3.0$$

Ⓑ $M = -6500 \text{ kgm}, N = 23750 \text{ kg.c}, S = -11410 \text{ kg}$

$$e = \frac{M}{N} = \frac{6500 \times 100}{23750} = 27.4 \text{ cm}$$

$$b = 100, h = 38$$

$$d = 33, d' = 5$$

$$A_s = A_s' = 7.5 - 16^{\#} = 15.07$$

$$\rho = \rho' = 15.07 / 100 \times 38 = 0.00397$$

$$e/h = 27.4 / 38 = 0.722$$

$$d'/h = 5 / 38 = 0.132$$

$$k = 0.385, c = 0.157$$

$$\sigma_c = \frac{23750}{100 \times 38 \times 0.157} = 39.8 \text{ kg/cm}^2, \tau = \frac{11410}{100 \times 0.872 \times 33} = 4.0 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 39.8 \times \frac{1 - 0.385 - 0.132}{0.385} = 750, \tau_0 = \frac{11410}{5.03 \times 7.5 \times 0.872 \times 33 \times \frac{1}{2}} = 5.3$$

Ⓒ $M = -5660 \text{ kgm}, N = 23750 \text{ kg.c}, S = 13010 \text{ kg}$

断面 (C) = 同上

$$\tau = \frac{13010}{100 \times 0.872 \times 33} = 4.5 \text{ kg/cm}^2$$

$$\tau_0 = \frac{13010}{5.03 \times 7.5 \times 0.872 \times 33 \times \frac{1}{2}} = 6.0$$

配筋は S.C.T.S.S 型 = 準ス (第8頁参照)

但し Haunch (H3) 及 (H4) = 於ては bond bar 10 本 + 接 lap 7 長スニシ。

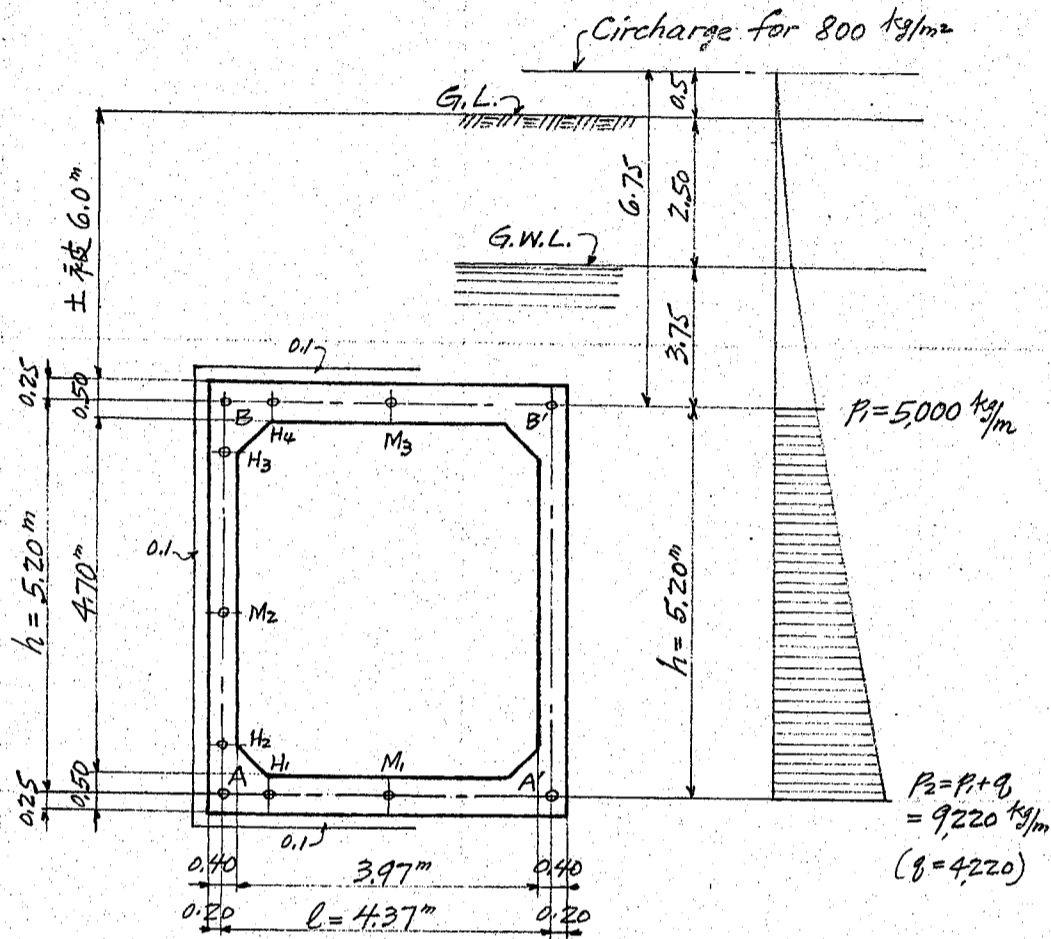
上海高速鐵道

鐵筋混凝土標準型單線隧道

土被六米應力計算書

Standard Reinforced Concrete Tunnel.
Single Track.
Mark. S.C.T. G.S

土被 6.0m 標準隧道 S.C.T.G.S



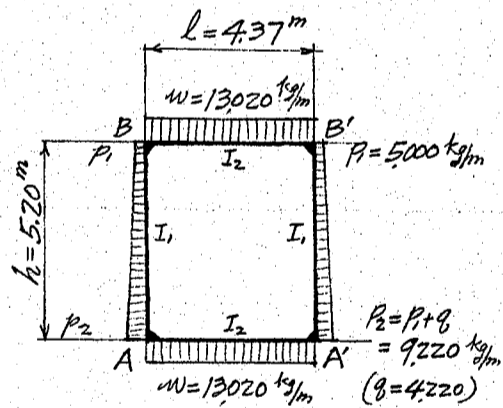
上床荷重
土被 地下水位以上 2.5" @ 1600 = 4000
" " 以下 3.4 @ 2000 = 6800
被覆混凝土 0.1 @ 2200 = 220
上床 0.50 @ 2400 = 1200
12220
路面傳布荷重 = 800
W = 13020 kg/m²

下床荷重 上床荷重と同じ假定ス。

側壁荷重
上部荷重
土被 2.5" @ 1600 = 4000
" 3.75 @ 2000 = 7500
路面荷重 800
12300
荷重 $p_1 = 12300 \times 0.406 = 5000 \text{ kg/m}^2$

下部荷重
 $q = 520 \times 2000 \times 0.406 = 4220$
荷重 $p_2 = p + q = 9220 \text{ kg/m}^2$

荷重状態



Moments of Inertia.

$$I_1 = \frac{1.0 \times 0.40^3}{12} = 0.00533 \text{ m}^4 \quad k_1 = \frac{I_1}{h} = \frac{0.00533}{5.20} = 0.00102$$

$$I_2 = \frac{1.0 \times 0.50^3}{12} = 0.01042 \text{ m}^4 \quad k_2 = \frac{I_2}{l} = \frac{0.01042}{4.37} = 0.00238$$

$$k = \frac{k_2}{k_1} = \frac{0.00238}{0.00102} = 2.3333$$

$$12(1+k) = 12 \times 3.3333 = 40.0000$$

$$\frac{k}{60(1+k)(3+k)} = \frac{2.3333}{60 \times 3.3333 \times 5.3333} = 0.00219$$

上下床 / 荷重 $w =$ 依 w 弯曲率

$$M_A = M_B = -\frac{w l^2}{12(1+k)} = -\frac{13020 \times 4.37^2}{40.0000} = -6210 \text{ kgm}$$

側壁荷重 p_1 及 $p_2 = 2w$ 弯曲率.

$$M_A = -\frac{k h^2}{60(1+k)(3+k)} \{7p_1 + 8p_2 + k(2p_1 + 3p_2)\} = -0.00219 \times 5.20^2 \{35000 + 73760 + 2.3333(10000 + 27660)\} = -11640 \text{ kgm}$$

$$M_B = -\frac{k h^2}{60(1+k)(3+k)} \{8p_1 + 7p_2 + k(3p_1 + 2p_2)\} = -0.00219 \times 5.20^2 \{40000 + 64540 + 2.3333(15000 + 18440)\} = -10810 \text{ kgm}$$

上下床及左右側壁 / 荷重 = 依 w 合成弯曲率

	床荷重	側壁荷重	合成弯曲率
M_A	- 6210 kgm	- 11640 kgm	- 17850 kgm
M_B	- 6210 "	- 10810 "	- 17020 "

上海標準隧道

剪力

上床

$$S_{B2} = \frac{wl}{2} = \frac{13020 \times 4.37}{2} = 28450 \text{ kg}$$

"

$$S_{H4} = 28450 - 0.60 \times 13020 = 20640 "$$

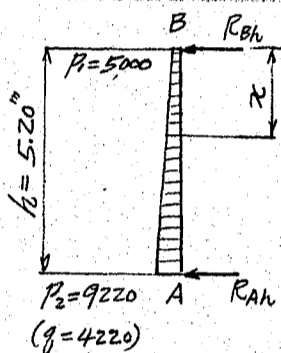
下床

$$S_{A2} = -28450 "$$

"

$$S_{H1} = -20640 "$$

側壁



AB 7 Simple Beam 12m 7力.

$$R_{Ah} = \frac{h}{6} (2p_2 + p_1) = \frac{5.20}{6} (18440 + 5000) = 20300 \text{ kg}$$

$$R_{Bh} = \frac{h}{6} (2p_1 + p_2) = \frac{5.20}{6} (10000 + 9220) = 16650 "$$

剪力

$$S_{B1} = -R_{Bh} + \frac{M_B - M_A}{h} = -16650 + \frac{-17020 + 17850}{5.20} = -16490 \text{ kg}$$

$$S_{A1} = R_{Ah} + \frac{M_B - M_A}{h} = 20300 + 160 = 20460 "$$

任意 1点 = 於ける剪力

$$S_x = S_{B1} + \frac{qx^2}{2h} + p_1x = -16490 + \frac{4220}{2 \times 5.20} x^2 + 5000x$$

$$= 406x^2 + 5000x - 16490$$

0 Shear 1点

$$x^2 + 12.31x - 40.64 = 0$$

$$x = -\frac{12.31}{2} \pm \frac{\sqrt{12.31^2 + 4064 \times 4}}{2} = 2.705 \text{ m}$$

	x	406x ²	+ 5000x	- 16490	= S _x
(H ₃)	0.65 ^m	170	+ 3250	- 16490	= -13070 kg
(M ₂)	2.705	2970	+ 13520	- 16490	= 0
(H ₂)	4.55	8400	+ 22750	- 16490	= 14660

中間点 = 於ける弯曲率

下床 AA'

$$(M_1) \quad \frac{wl^2}{8} = \frac{13020 \times 4.37^2}{8} = 31080$$

$$M_A = -17850$$

$$M_1 = 13230 \text{ kgm}$$

$$\text{軸力 } N_{AA'} = S_{A1} = 20460 \text{ kg.c}$$

$$(H_1) \quad -31080 \times \frac{1.585^2}{2.185^2} = -16370$$

$$M_1 = 13230$$

$$M_{H1} = -3140 \text{ kgm}$$

上床 BB'

$$(M_3) \quad 31080 - 17020 = 14060 \text{ kgm} = M_3$$

$$(H_4) \quad -16370 + 14060 = -2310 \text{ kgm} = M_{H4}$$

$$\text{軸力 } N_{BB} = -S_{B1} = 16490 \text{ kg.c}$$

側壁 AB.

任意 1 点 = 於 x 處之彎曲率

$$M_x = -S_{B1}x - \frac{P_1}{2}x^2 - \frac{q}{6l}x^3 + M_B$$

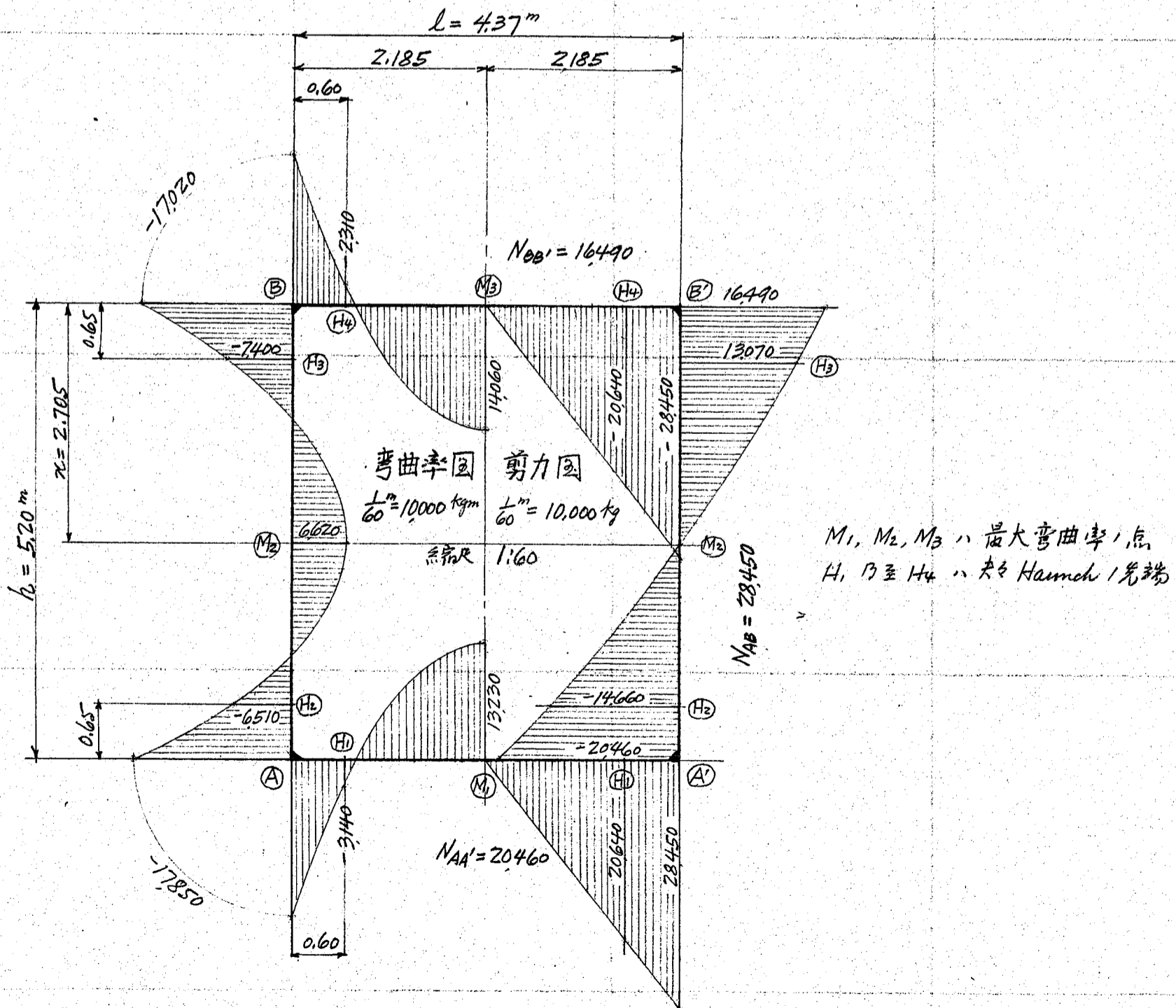
$$= 16490x - 2500x^2 - \frac{4220}{6 \times 5.20}x^3 - 17020$$

$$= -135.5x^3 - 2500x^2 + 16490x - 17020$$

	x				M_x
(H ₃)	0.65 ^m	- 40	- 1060	+ 10,720	- 17,020 = - 7,400 kgm
(M ₂)	2.705	- 2,680	- 18,280	+ 44,600	- 17,020 = 6,620 "
(H ₂)	4.55	- 12,770	- 51,770	+ 75,050	- 17,020 = - 6,510 "

軸力 $S_{AB} = S_{B2} = 28450 \text{ kg. c.}$

彎曲率及剪力图



断面應力計算

下床 A-A

(M1)

$M = 13230 \text{ kgm}, N = 20460 \text{ kg.c.}, S = 0.$

(S.C.T.6 --- 45頁参照)

$d-u = 18.8 \text{ cm}$

$\frac{M}{N} = \frac{13230 \times 100}{20460} = 64.7$

$d-u = 18.8$

$e = 83.5 \text{ cm}$

$e' = e - 40 = 43.5$

$e/e' = 0.521$

$\frac{Ne}{bd^2} = \frac{20460 \times 83.5}{100 \times 45^2} = 8.440$

$\frac{Ne}{bd^2 \sigma_c} = 0.201, k = 0.430$

$\sigma_c = \frac{8.440}{0.201} = 42.0 \text{ kg/cm}^2$

$\sigma_s = 15 \times 42.0 \times \frac{0.570}{0.430} = 836, \tau = \tau_0 = 0$

$b = 100 \text{ cm}, h = 50 \text{ cm}$

$d = 45 \text{ cm}, d' = 5 \text{ cm}$

$A_s = 10-19\phi = 28.35 \text{ cm}^2$

$A_s' = 2.5-19\phi = 7.09$

$p = 28.35/100 \times 45 = 0.00630$

$p' = 7.09/100 \times 45 = 0.00157$

$d'/d = 5/45 = 0.111$

(A)

$M = -17850 \text{ kgm}, N = 20460 \text{ kg.c.}, S = -28450 \text{ kg}$

(S.C.T.6 --- 45頁参照)

$d-u = 29.4$

$\frac{M}{N} = \frac{17850 \times 100}{20460} = 87.3$

$d-u = 29.4$

$e = 116.7 \text{ cm}$

$e' = e - 60 = 56.7$

$e/e' = 0.486$

$\frac{Ne}{bd^2} = \frac{20460 \times 116.7}{100 \times 65^2} = 5.650$

$\frac{Ne}{bd^2 \sigma_c} = 0.165, k = 0.342$

$\sigma_c = \frac{5.650}{0.165} = 34.3 \text{ kg/cm}^2, \tau = \frac{28450}{100 \times 0.886 \times 65} = 4.9 \text{ kg/cm}^2$

$\sigma_s = 15 \times 34.3 \times \frac{0.658}{0.342} = 990, \tau_0 = \frac{28450}{5.03 \times 10 \times 0.886 \times 65} \times \frac{1}{2} = 4.9$

$b = 100, h = 50 + \frac{60}{3} = 70$

$d = 65, d' = 5$

$A_s = 10-16\phi = 20.10$

$A_s' = 2.5-19\phi = 7.09$

$p = 20.10/100 \times 65 = 0.00309$

$p' = 7.09/100 \times 65 = 0.00109$

$d'/d = 5/65 = 0.077$

(H)

$M = -3140 \text{ kgm}, N = 20460 \text{ kg.c.}, S = -20640 \text{ kg}$

bond bar. $5-19\phi = 29.9$
 $5-16\phi = 25.2$
 55.1 cm

lap \Rightarrow 5.5 = 2 上記の材料

$\tau = \frac{20640}{100 \times 7.8 \times 45} = 5.2 \text{ kg/cm}^2$

$\tau_0 = \frac{20640}{55.1 \times 7.8 \times 45} \times \frac{1}{2} = 4.8$

$b = 100, h = 50$

$d = 45, d' = 5$

$A_s = 7.5-19\phi = 21.25 \text{ cm}^2$

$A_s' = 2.5-19\phi = 7.09$

上床 BB'

(M3)

$M = 14060 \text{ kgm}, N = 16490 \text{ kg.c.}, S = 0.$

$\frac{M}{N} = \frac{14060 \times 100}{16490} = 85.4$

$d-u = 18.8$

$e = 104.2 \text{ cm}$

$e' = e - 40 = 64.2$

$e/e' = 0.615$

$\frac{Ne}{bd^2} = \frac{16490 \times 104.2}{100 \times 45^2} = 8.480$

$\frac{Ne}{bd^2 \sigma_c} = 0.192, k = 0.405$

断面 (M3) = 全

$$\sigma_c = \frac{8.480}{0.192} = 44.2 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 44.2 \times \frac{0.591}{0.405} = 974 \text{ " } \tau = \tau_0 = 0$$

③ $M = 17,020 \text{ kgm}, N = 16,490 \text{ kg}, S = 28,450 \text{ kg}$

$$\frac{M}{N} = \frac{17020 \times 100}{16490} = 103.2$$

$$d-u = 29.4$$

$$e = 132.6 \text{ cm}$$

$$e' = e - 60 = 72.6 \text{ "}$$

$$e'/e = 0.547$$

$$\frac{Ne}{bd^2} = \frac{16490 \times 132.6}{100 \times 65^2} = 5.180$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.158, k = 0.325$$

$$\sigma_c = \frac{5.180}{0.158} = 32.8 \text{ kg/cm}^2, \tau = \frac{28450}{100 \times 0.892 \times 65} = 4.9 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 32.8 \times \frac{0.675}{0.325} = 1022 \text{ " } \tau_0 = \frac{28450}{503 \times 10 \times 0.892 \times 65} \times \frac{1}{2} = 4.9 \text{ "}$$

断面ハ ㉔ = 全二
(第 24 頁参照)

④ $M = -2,310 \text{ kgm}, N = 16,490 \text{ kg}, S = 20,640 \text{ kg}$

$$\tau = \frac{20640}{100 \times 78 \times 45} = 5.2 \text{ kg/cm}^2$$

$$\tau_0 = \frac{20640}{551 \times 78 \times 45} \times \frac{1}{2} = 4.8 \text{ "}$$

断面ハ ㉔ = 全二
(第 24 頁参照)

側壁 AB

① $M = 6,620 \text{ kgm}, N = 28,450 \text{ kg}, S = 0$

(S.C.T.6 --- 47 頁参照)

$$d-u = 14.5 \text{ cm}$$

$$\frac{M}{N} = \frac{6620 \times 100}{28450} = 23.3$$

$$d-u = 14.5$$

$$e = 37.8 \text{ cm}$$

$$e' = e - 30 = 7.8 \text{ "}$$

$$e'/e = 0.206$$

$$\frac{Ne}{bd^2} = \frac{28450 \times 37.8}{100 \times 35^2} = 8.77$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.250, k = 0.540$$

$$\sigma_c = \frac{8.77}{0.250} = 35.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 35.1 \times \frac{0.460}{0.540} = 449 \text{ " } \tau = \tau_0 = 0$$

$$b = 100, h = 40$$

$$d = 35, d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A_s' = 5 - 16^\circ = 10.05$$

$$p = 20.10 / 100 \times 35 = 0.00575$$

$$p' = 10.05 / 100 \times 5 = 0.00288$$

$$d'/d = 5 / 35 = 0.143$$

② $M = -17,850 \text{ kgm}, N = 28,450 \text{ kg}, S = 20,460 \text{ kg}$

$$d/h = 57/62 = 0.919$$

$$d'/h = 5/62 = 0.0806$$

$$p_0 = 20.10 / 100 \times 62 = 0.00324$$

$$p_0' = 7.09 / 100 \times 5 = 0.00114$$

$$u/h = 0.510$$

$$u = 31.6$$

$$d-u = 25.4 \text{ cm}$$

$$\frac{M}{N} = \frac{17850 \times 100}{28450} = 62.8$$

$$d-u = 25.4$$

$$e = 88.2 \text{ cm}$$

$$e' = e - 52 = 36.2 \text{ "}$$

$$e'/e = 0.411$$

$$\frac{Ne}{bd^2} = \frac{28450 \times 88.2}{100 \times 57^2} = 7.725$$

$$b = 100, h = 40 + \frac{65}{3} = 62$$

$$d = 57, d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A_s' = 2.5 - 19^\circ = 7.09$$

$$p = 20.10 / 100 \times 57 = 0.00353$$

$$p' = 7.09 / 100 \times 5 = 0.00124$$

$$d'/d = 5/57 = 0.0877$$

$$\frac{Ne}{bd^2\sigma_c} = 0.184 \quad k = 0.375$$

$$\sigma_c = \frac{7.725}{0.184} = 42.0 \text{ kg/cm}^2 \quad \tau = \frac{20460}{100 \times 0.875 \times 57} = 4.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 42.0 \times \frac{0.625}{0.375} = 1050 \text{ " } \quad \tau_0 = \frac{20460}{5.03 \times 10 \times 0.875 \times 57} \times \frac{1}{2} = 4.1 \text{ "}$$

(B) $M = -17020 \text{ kgm}, \quad N = 28450 \text{ kg.c.}, \quad S = -16490 \text{ kg}$

$$\frac{M}{N} = \frac{17020 \times 100}{28450} = 59.8$$

$$d-u = 25.4$$

$$e = 85.2 \text{ cm}$$

$$e' = e - 52 = 34.2 \text{ "}$$

$$e'/e = 0.402$$

$$\frac{Ne}{bd^2} = \frac{28450 \times 85.2}{100 \times 57^2} = 7.470$$

$$\frac{Ne}{bd^2\sigma_c} = 0.186 \quad k = 0.380$$

$$\sigma_c = \frac{7.470}{0.186} = 40.2 \text{ kg/cm}^2 \quad \tau = \frac{16490}{100 \times 0.873 \times 57} = 3.3 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 40.2 \times \frac{0.620}{0.380} = 985 \text{ " } \quad \tau_0 = \frac{16490}{5.03 \times 10 \times 0.873 \times 57} \times \frac{1}{2} = 3.3 \text{ "}$$

断面 (A) = 全寸
(第 25 参照)

(H3) $M = -7400 \text{ kgm}, \quad N = 28450 \text{ kg.c.}, \quad S = -13070 \text{ kg}$

$$e = \frac{M}{N} = \frac{7400 \times 100}{28450} = 26.0 \text{ cm}$$

$$e/h = 26.0/40 = 0.650$$

$$d'/h = 5/40 = 0.125$$

$$k = 0.400 \quad c = 0.170$$

$$\sigma_c = \frac{28450}{100 \times 40 \times 0.170} = 41.8 \text{ kg/cm}^2 \quad \tau = \frac{13070}{100 \times 0.867 \times 35} = 4.3 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 41.8 \times \frac{1 - 0.400 \times 0.125}{0.400} = 745 \text{ " } \quad \tau_0 = \frac{13070}{5.03 \times 7.5 \times 0.867 \times 35} \times \frac{1}{2} = 5.7$$

$b=100, \quad h=40$
 $d=35, \quad d'=5$
 $A_s = A_s' = 7.5 \times 16^2 = 15.07 \text{ cm}^2$
 $\rho = \rho' = 15.07/100 \times 40 = 0.00377$

(H2) $M = -6510 \text{ kgm}, \quad N = 28450 \text{ kg.c.}, \quad S = 14660 \text{ kg}$

$$\tau = \frac{14660}{100 \times 0.867 \times 35} = 4.8 \text{ kg/cm}^2$$

$$\tau_0 = \frac{14660}{5.03 \times 7.5 \times 0.867 \times 35} \times \frac{1}{2} = 6.4 \text{ "}$$

断面 (H2) = 全寸

配筋ハ末尾ニ示ス S.C.T. 7S 型ニ準ズ (第 33 頁参照)

上海高速鐵道

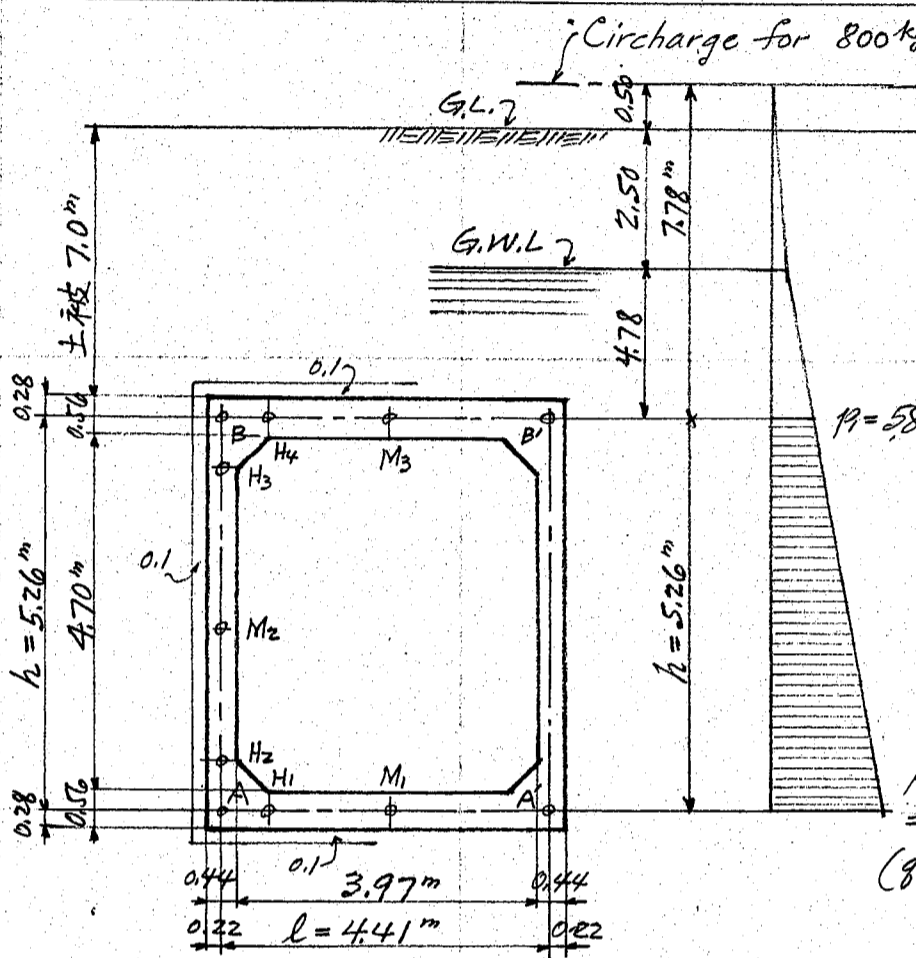
鐵筋混凝土標準型單線隧道

土被七〇米 應力計算書

Standard Reinforced Concrete Tunnel.
Single Track

Mark S.C.T. 7.S

土被 7.0m 標準隧道 S.C.T.75



上床荷重

土被, 地下水位以上	2.5 @ 1600 =	4,000
" " 以下	4.4 @ 2000 =	8,800
被覆混凝土	0.1 @ 2200 =	220
上床	0.56 @ 2400 =	1,340
		<u>14,360</u>
路面傳布荷重		800
	$w =$	<u>15,160 kg/m²</u>

下床荷重 上床荷重ト合一ト假定ス

側壁荷重

上部荷重		
土被	2.5 @ 1600 =	4,000
"	4.78 @ 2000 =	9,560
路面荷重		800
		<u>14,360</u>

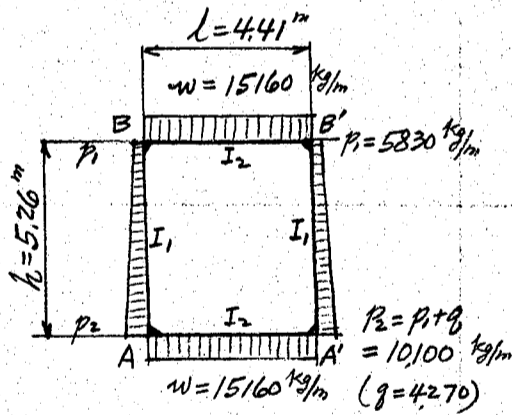
荷重 $P_1 = 14,360 \times 0.406 = 5,830 \text{ kg/m}^2$

下部荷重

$q = 5,260 \times 2000 \times 0.406 = 4,270$

荷重 $P_2 = P_1 + q = 10,100 \text{ kg/m}^2$

荷重状態



Moments of Inertia.

$I_1 = \frac{1.0 \times 0.44^3}{12} = 0.00710 \text{ m}^4$ $k_1 = \frac{I_1}{h} = \frac{0.00710}{5.26} = 0.00135$

$I_2 = \frac{1.0 \times 0.56^3}{12} = 0.01463$ $k_2 = \frac{I_2}{l} = \frac{0.01463}{4.41} = 0.00332$

$k = \frac{k_2}{k_1} = \frac{0.00332}{0.00135} = 2.4600$

$12(1+k) = 12 \times 3.4600 = 41.5200$

$\frac{k}{60(1+k)(3+k)} = \frac{2.4600}{60 \times 3.4600 \times 5.460} = 0.00217$

上下床、荷重 $w =$ 依り 弯曲率

$M_A = M_B = -\frac{wl^2}{12(1+k)} = -\frac{15160 \times 4.41^2}{41.5200} = -7,100 \text{ kgm}$

側壁荷重 P_1 及び $P_2 =$ 依り 弯曲率

$M_A = -\frac{kh^2}{60(1+k)(3+k)} \{7P_1 + 8P_2 + k(2P_1 + 3P_2)\} = -0.00217 \times 5.26^2 \{40,810 + 80,800 + 2,4600(11,660 + 30,300)\}$
 $= -13,490 \text{ kgm}$

$M_B = -\frac{kh^2}{60(1+k)(3+k)} \{8P_1 + 7P_2 + k(3P_1 + 2P_2)\} = -0.00217 \times 5.26^2 \{46,640 + 70,700 + 2,4600(17,490 + 20,200)\}$
 $= -12,610 \text{ kgm}$

上下床及左右側壁、荷重 = 依り 合成 弯曲率

床荷重 側壁荷重 合成 弯曲率

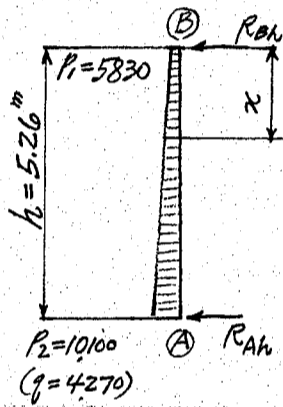
M_A	- 7,100 kgm	- 13,490 kgm	- 20,590 kgm
M_B	- 7,100	- 12,610	- 19,710 kgm

上海標準隧道

剪力

上床 $S_{B2} = \frac{wl}{2} = \frac{15160 \times 4.41}{2} = 33430 \text{ kg}$
 " $S_{H4} = 33430 - 0.62 \times 15160 = 24030 "$
 下床 $S_{A2} = -33430 "$
 " $S_{H1} = -24030 "$

側壁



AB 7 Simple Beam 1-2m 反力
 $R_{AH} = \frac{h}{6} (2P_2 + P_1) = \frac{5.26}{6} (20200 + 5830) = 22800 \text{ kg}$
 $R_{vH} = \frac{h}{6} (2P_1 + P_2) = \frac{5.26}{6} (11660 + 10100) = 19070 "$
 剪力
 $S_{B1} = -R_{vH} + \frac{M_B - M_A}{h} = -19070 + \frac{-19710 + 20590}{5.26} = -18900 \text{ kg}$
 $S_{A1} = R_{AH} + \frac{M_B - M_A}{h} = 22800 + 170 = 22970 "$

任意 1 点 = 於 x m 剪力

$S_x = S_{B1} + \frac{qx^2}{2h} + P_1 x = -18900 + \frac{4270}{2 \times 5.26} x^2 + 5830x$
 $= 406x^2 + 5830x - 18900$

剪力 加 零 点

$x^2 + 14.35x - 46.60 = 0$
 $x = -\frac{14.35}{2} \pm \frac{\sqrt{14.35^2 + 4 \times 46.60}}{2} = 2.730 \text{ m}$

	x	$406x^2$	$+ 5830x$	$- 18900$	$= S_x$
(H3)	0.68 m	190	+ 3960	- 18900	= -14750 kg
(M2)	2.73	3020	+ 15880	- 18900	= 0
(H2)	4.58	8510	+ 27270	- 18900	= 16880

中間点 = 於 x m 弯曲率

下床 AA'

(M1) $\frac{wl^2}{8} = \frac{15160 \times 4.41^2}{8} = 36850$
 $M_A = -20590$
 $M_1 = 16260 \text{ kgm}$

軸力 $N_{AA'} = 22970 \text{ kg.c}$

(H1) $-36850 \times \frac{1.585^2}{2.205^2} = -19070$
 $M_1 = 16230$
 $M_{H1} = -2840 \text{ kgm}$

上床 BB'

(M3) $36850 - 19710 = 17140 \text{ kgm} = M_3$

(H4) $-19070 + 17140 = -1930 = M_{H4}$

軸力 $N_{BB'} = -S_{B1} = 18900 \text{ kg.c}$

上海標準隧道

側壁 AB

任意1点 = 於 \$x\$ の弯曲率

$$M_x = -S_B x - \frac{P}{2} x^2 - \frac{q}{6h} x^3 + M_B$$

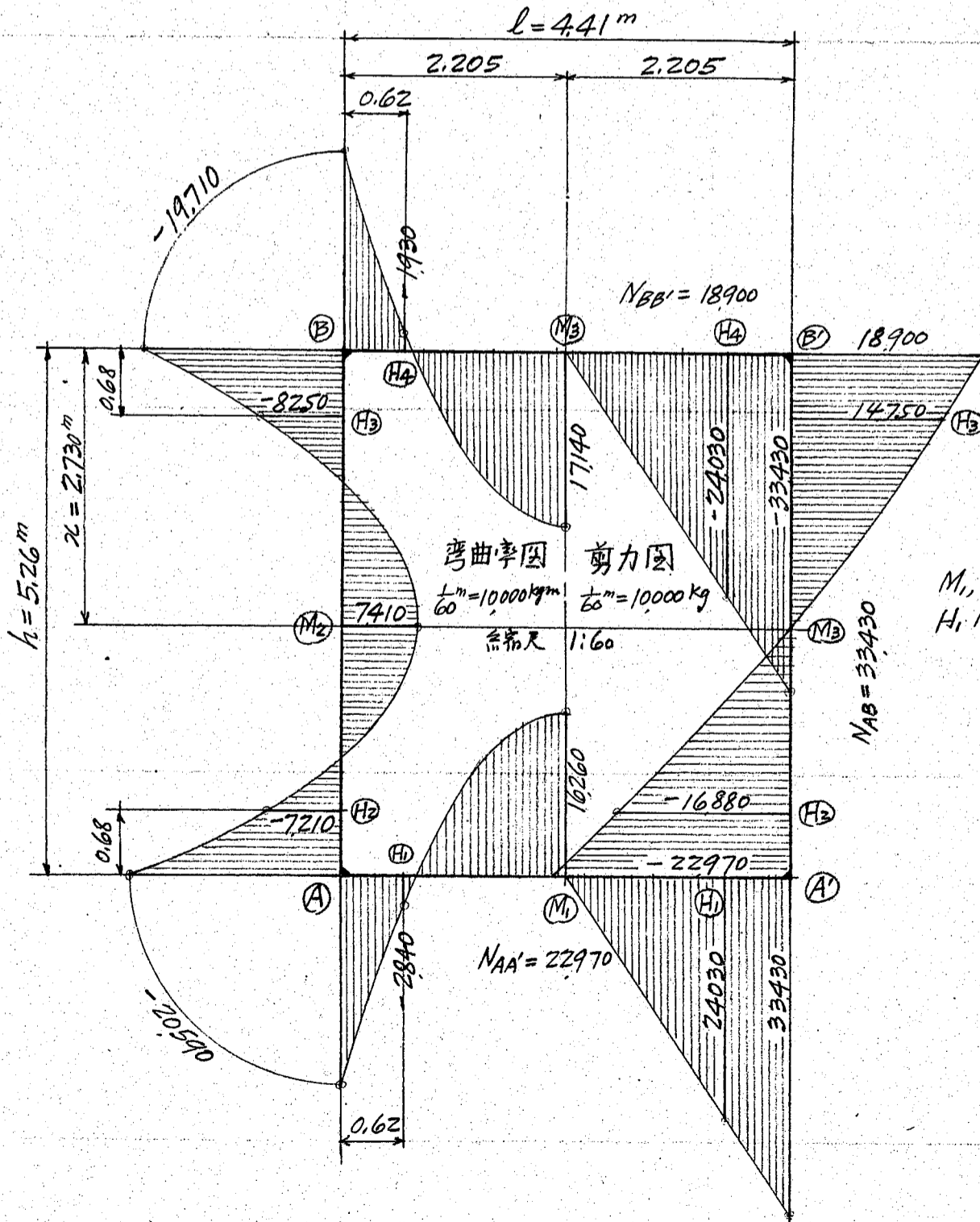
$$= 18900x - 2915x^2 - \frac{4270}{6 \times 5.26} x^3 - 19710$$

$$= -135.5x^3 - 2915x^2 + 18900x - 19710$$

\$x\$	\$M_x\$
(H ₃) 0.68m	- 8250 kgm
(M ₂) 2.73	7410 "
(H ₂) 4.58	- 7210 "

軸力 \$S_{AB} = S_B = 33430\$ kg.c.

彎曲率及ヒ剪力圖



\$M_1, M_2, M_3\$ は最大弯曲率点
\$H_1\$ 乃至 \$H_4\$ は夫々 haunch 先端

断面应力計算

下床 A-A

(M)

$M = 16,260 \text{ kgm}, N = 22,970 \text{ kg.c}, S = 0.$

$d/h = 51/56 = 0.910$
 $d'/h = 5/56 = 0.0893$
 $p_0 = 28.35/100 \times 56 = 0.00506$
 $p_0' = 7.09/100 = 0.00127$
 $u/h = 0.522$
 $u = 29.3$
 $d-u = 21.7 \text{ cm}$

$\frac{M}{N} = \frac{16260 \times 100}{22970} = 70.9$
 $d-u = 21.7$
 $e = 92.6 \text{ cm}$
 $e' = e - 46 = 46.6$
 $e/e = 0.503$

$\frac{Ne}{bd^2} = \frac{22970 \times 92.6}{100 \times 51^2} = 8.180$

$\frac{Ne}{bd^2 \sigma_c} = 0.194, k = 0.415$

$\sigma_c = \frac{8.180}{0.194} = 42.2 \text{ kg/cm}^2$

$\sigma_s = 15 \times 42.2 \times \frac{0.585}{0.415} = 892 \text{ kg/cm}^2, \tau = \tau_0 = 0.$

$b = 100 \text{ cm}, h = 56 \text{ cm}$
 $d = 51, d' = 5$
 $A_s = 10-19\phi = 28.35 \text{ cm}^2$
 $A_s' = 2.5-19\phi = 7.09$
 $p = 28.35/100 \times 51 = 0.00506$
 $p' = 7.09/100 = 0.00127$
 $d'/d = 5/51 = 0.098$

(A)

$M = -20,590 \text{ kgm}, N = 22,970 \text{ kg.c}, S = -33,430 \text{ kg}$

$d/h = 72/77 = 0.935$
 $d'/h = 5/77 = 0.065$
 $p_0 = 20.10/100 \times 77 = 0.00261$
 $p_0' = 7.09/100 = 0.00092$
 $u/h = 0.508$
 $u = 39.1$
 $d-u = 32.9 \text{ cm}$

$\frac{M}{N} = \frac{20590 \times 100}{22970} = 89.7$
 $d-u = 32.9$
 $e = 122.6 \text{ cm}$
 $e' = e - 67 = 55.6$
 $e/e = 0.453$

$\frac{Ne}{bd^2} = \frac{22970 \times 122.6}{100 \times 72^2} = 6.435$

$\frac{Ne}{bd^2 \sigma_c} = 0.161, k = 0.335$

$\sigma_c = \frac{6.435}{0.161} = 40.0 \text{ kg/cm}^2, \tau = \frac{33430}{100 \times 0.888 \times 72} = 5.2 \text{ kg/cm}^2$

$\sigma_s = 15 \times 40.0 \times \frac{0.665}{0.335} = 1,192 \text{ kg/cm}^2, \tau_0 = \frac{33430}{5.03 \times 10 \times 0.888 \times 72} \times \frac{1}{2} = 5.2$

$b = 100, h = 56 + \frac{62}{3} = 77$
 $d = 72, d' = 5$
 $A_s = 10-16\phi = 20.10$
 $A_s' = 2.5-19\phi = 7.09$
 $p = 20.10/100 \times 72 = 0.00279$
 $p' = 7.09/100 = 0.00099$
 $d'/d = 5/72 = 0.0695$

(H)

$M = -2,840 \text{ kgm}, N = 22,970 \text{ kg.c}, S = -24,030 \text{ kg}$

bond bars
 $5-19\phi = 29.9$
 $5-16\phi = 25.2$
 55.1 cm

lap 7% s = 2.1 以上 1 面 1 根

上床 BB'

(M3)

$M = 17,140 \text{ kgm}, N = 18,900 \text{ kg.c}, S = 0$

$\frac{M}{N} = \frac{17140 \times 100}{18900} = 90.7$
 $d-u = 21.7$
 $e = 112.4 \text{ cm}$
 $e' = e - 46 = 66.4$
 $e/e = 0.590$

$\frac{Ne}{bd^2} = \frac{18900 \times 112.4}{100 \times 51^2} = 8.170$

$\frac{Ne}{bd^2 \sigma_c} = 0.186, k = 0.395$

断面 (M3) = 全 2

$$\sigma_c = \frac{8.170}{0.186} = 43.9 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 43.9 \times \frac{0.605}{0.395} = 1010 \text{ " } \quad \tau = \tau_0 = 0$$

(B)

$$M = -19710 \text{ kgm} \quad N = 18900 \text{ kg.c.} \quad S = 33430 \text{ kg}$$

$$\frac{M}{N} = \frac{19710 \times 100}{18900} = 104.3$$

$$d-u = 32.9$$

$$e = 137.2 \text{ cm}$$

$$e' = e - 67 = 70.2 \text{ "}$$

$$e/e = 0.512$$

$$\frac{Ne}{bd^2} = \frac{18900 \times 137.2}{100 \times 72^2} = 5.000$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.156, \quad k = 0.320$$

$$\sigma_c = \frac{5.000}{0.156} = 32.1 \text{ kg/cm}^2$$

$$\tau = \frac{33430}{100 \times 0.893 \times 72} = 5.2 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 32.1 \times \frac{0.680}{0.320} = 1023 \text{ "}$$

$$\tau_0 = \frac{33430}{5.03 \times 10 \times 0.893 \times 72} \times \frac{1}{2} = 5.2 \text{ "}$$

断面 (A) = 全二
(第30頁参照)

(H4)

$$M = -1930 \text{ kgm}, \quad N = 18900 \text{ kg.c.} \quad S = 24030 \text{ kg}$$

$$\tau = \frac{24030}{100 \times 78 \times 51} = 5.4 \text{ kg/cm}^2$$

$$\tau_0 = \frac{24030}{55.1 \times 78 \times 51} = 4.9 \text{ "}$$

(H) 卜断面全一
(第30頁参照)

側壁 AB

(M3)

$$M = 7410 \text{ kgm} \quad N = 33430 \text{ kg.c.} \quad S = 0$$

$$d/h = 39/44 = 0.886$$

$$d'/h = 5/44 = 0.114$$

$$p_0 = 20.10/100 \times 44 = 0.00457$$

$$p'_0 = 10.05/ \text{ " } = 0.00278$$

$$u/h = 0.510$$

$$u = 22.4 \text{ cm}$$

$$d-u = 16.6 \text{ "}$$

$$\frac{M}{N} = \frac{7410 \times 100}{33430} = 22.2$$

$$d-u = 16.6$$

$$e = 38.8 \text{ cm}$$

$$e' = e - 34 = 4.8$$

$$e/e = 0.124$$

$$\frac{Ne}{bd^2} = \frac{33430 \times 38.8}{100 \times 39^2} = 8.530$$

$$\frac{Ne}{bd^2 \sigma_c} = 0.258, \quad k = 0.570$$

$$\sigma_c = \frac{8.530}{0.258} = 33.1 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 33.1 \times \frac{0.430}{0.570} = 374 \text{ " } \quad \tau = \tau_0 = 0$$

$$b = 100, \quad h = 44$$

$$d = 39, \quad d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A'_s = 5 - 16^\circ = 10.05$$

$$p = 20.10/100 \times 39 = 0.00515$$

$$p' = 10.05/ \text{ " } = 0.00258$$

$$d'/d = 5/39 = 0.128$$

(A)

$$M = -20590 \text{ kgm}, \quad N = 33430 \text{ kg.c.} \quad S = 22970 \text{ kg}$$

$$d/h = 62/67 = 0.926$$

$$d'/h = 5/67 = 0.0746$$

$$p_0 = 20.10/100 \times 67 = 0.00360$$

$$p'_0 = 7.09/ \text{ " } = 0.00106$$

$$u/h = 0.510$$

$$u = 34.2 \text{ cm}$$

$$d-u = 27.8 \text{ "}$$

$$\frac{M}{N} = \frac{20590 \times 100}{33430} = 61.6$$

$$d-u = 27.8$$

$$e = 89.4 \text{ cm}$$

$$e' = e - 57 = 32.4 \text{ "}$$

$$e/e = 0.363$$

$$\frac{Ne}{bd^2} = \frac{33430 \times 89.4}{100 \times 62^2} = 7.775$$

$$b = 100, \quad h = 44 + \frac{68}{3} = 67$$

$$d = 62, \quad d' = 5$$

$$A_s = 10 - 16^\circ = 20.10$$

$$A'_s = 2.5 - 19^\circ = 7.09$$

$$p = 20.1/100 \times 62 = 0.00324$$

$$p' = 7.09/ \text{ " } = 0.00114$$

$$d'/d = 5/62 = 0.0806$$

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

$$\sigma_c = \frac{7.775}{0.181} = 43.0 \text{ kg/cm}^2 \quad \tau = \frac{22970}{100 \times 0.872 \times 62} = 4.2 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 43.0 \times \frac{0.615}{0.385} = 1029 \quad \tau_0 = \frac{22970}{5.03 \times 10 \times 0.872 \times 62} \times \frac{1}{2} = 4.2$$

(B)

$$M = -19710 \text{ kgm}, \quad N = 33430 \text{ kg.c.}, \quad S = -18900 \text{ kg}$$

$$\frac{M}{N} = \frac{19710 \times 100}{33430} = 59.0$$

断面 (A) = 全二
(第 31 頁参照)

$$d-u = 27.8$$

$$e = 86.8 \text{ cm}$$

$$e' = e - 57 = 29.8$$

$$\frac{e'}{e} = 0.343$$

$$\frac{Ne}{bd^2} = \frac{33430 \times 86.8}{100 \times 62^2} = 7.550$$

$$\frac{Ne}{bd^2\sigma_c} = 0.182 \quad k = 0.390$$

$$\sigma_c = \frac{7.550}{0.182} = 42.6 \text{ kg/cm}^2 \quad \tau = \frac{18900}{100 \times 0.870 \times 62} = 3.5 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 42.6 \times \frac{0.610}{0.390} = 1002 \quad \tau_0 = \frac{18900}{5.03 \times 10 \times 0.870 \times 62} \times \frac{1}{2} = 3.5$$

(H3)

$$M = -8250 \text{ kgm}, \quad N = 33430 \text{ kg.c.}, \quad S = -14750 \text{ kg}$$

$$e = \frac{M}{N} = \frac{8250 \times 100}{33430} = 24.7 \text{ cm}$$

$$b = 100 \text{ cm}, \quad h = 44 \text{ cm}$$

$$d = 39, \quad d' = 5$$

$$A_s = A_s' = 7.5 - 16^{\circ} = 15.07 \text{ cm}^2$$

$$\rho_0 = \rho_0' = \frac{15.07}{100 \times 44} = 0.00343$$

$$\frac{e'}{h} = \frac{24.7}{44} = 0.562$$

$$\frac{d'}{h} = \frac{5}{44} = 0.114$$

$$k = 0.428, \quad c = 0.196$$

$$\sigma_c = \frac{33430}{100 \times 44 \times 0.196} = 38.8 \text{ kg/cm}^2 \quad \tau = \frac{14750}{100 \times 0.857 \times 39} = 4.4 \text{ kg/cm}^2$$

$$\sigma_s = 15 \times 38.8 \times \frac{1 - 0.428 - 0.114}{0.428} = 623 \quad \tau_0 = \frac{14750}{5.03 \times 7.5 \times 0.857 \times 39} \times \frac{1}{2} = 5.8$$

(H2)

$$M = -7210 \text{ kgm}, \quad N = 33430 \text{ kg.c.}, \quad S = 16880 \text{ kg}$$

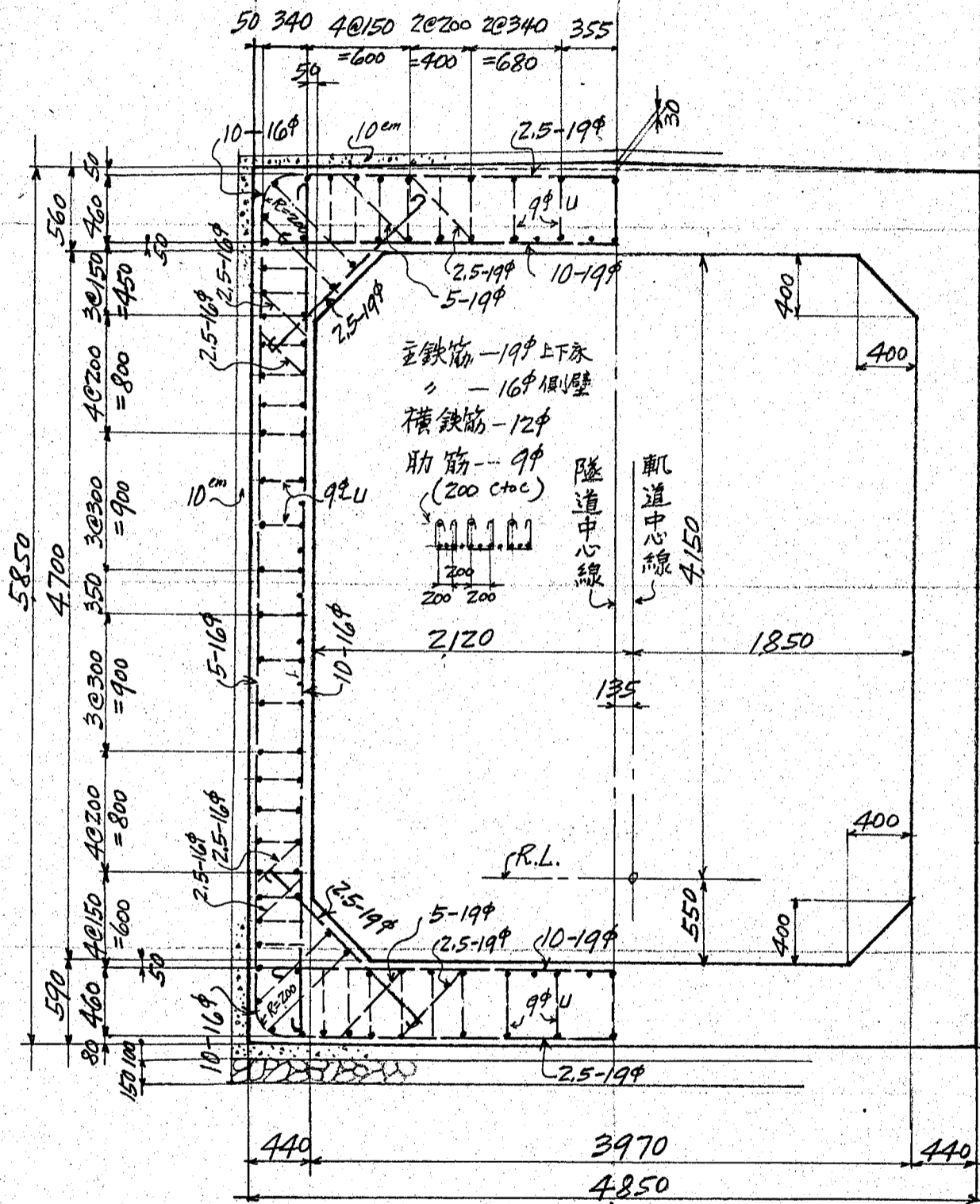
$$\tau = \frac{16880}{100 \times 0.857 \times 39} = 5.0 \text{ kg/cm}^2$$

断面 (H2) = 全二

$$\tau_0 = \frac{16880}{5.03 \times 7.5 \times 0.857 \times 39} \times \frac{1}{2} = 6.7$$

上海標準隧道

配筋圖



土被7.0m標準型隧道配筋圖

縮尺 1:40

注意. 待避所部分ハ上記ト同様、配筋ヲナシタル外更ニ待避所特有ノ鉄筋ヲ以テ補強スベシ。鉄筋ノ定尺

- 9φ --- 3.6m, 4.5, 5.5, 6.1m
- 12φ --- 3.6m, 4.5, 4.9, 5.5, 6.1, 6.7, 7.3m
- 16φ --- " " " " " " " "
- 19φ --- " " " " " " " "

腹鉄筋ノ間隔ハ第34頁参考表参照ノト

腹鉄筋 / 抵抗剪力

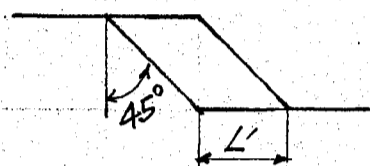
上下床及比側壁用

曲鉄筋 (幅 100 cm = 付)

$$\text{抵抗剪應力 } \tau' = \frac{1.41 A_b \sigma_s}{L' b_0}$$

$$= \frac{1.41 \times 2.011 \times 1200}{L' \times 100} = \frac{34}{L'} \text{ kg/cm}^2 \text{ ----- } 16\phi \text{ 曲鉄筋 1本分}$$

$$= \frac{1.41 \times 2.835 \times 1200}{L' \times 100} = \frac{48}{L'} \text{ " " " " " " 19\phi " " 1本分}$$



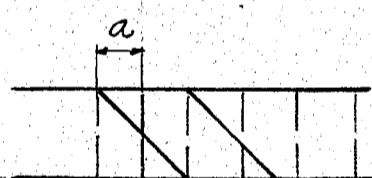
L'	1-16φ τ'	2.5-16φ τ'	1-19φ τ'	2.5-19φ τ'
25cm	1.36 kg/cm ²	3.40 kg/cm ²	1.92 kg/cm ²	4.80 kg/cm ²
30	1.13	2.83	1.60	4.00
35	0.97	2.43	1.37	3.43
40	0.85	2.13	1.20	3.00
50	0.68	1.70	0.96	2.40

助筋 (垂直) (幅 100 cm = 付)

$$\text{抵抗剪力 } \tau' = \frac{A_s \sigma_s}{a b_0}$$

$$= \frac{0.636 \times 1200}{a \times 100} = \frac{7.64}{a} \text{ kg/cm}^2 \text{ ----- } 9\phi \text{ 助筋 1本分}$$

$$= \frac{1.131 \times 1200}{a \times 100} = \frac{13.58}{a} \text{ " " " " " " 12\phi " " 1本分}$$



a	1-9φ τ'	5-9φ τ'	1-12φ τ'	5-12φ τ'
15cm	0.51 kg/cm ²	2.55 kg/cm ²	0.91 kg/cm ²	4.55 kg/cm ²
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、版ノ剪應力カ 4.5 kg/cm² ヲ超エル場合ハ此個所並ニ之レニ隣接スル相當区間ニ亙リ全剪力ヲ腹鉄筋ニ負擔セシメ得ル様設計スベシ。
版ノ剪應力カ 4.5 kg/cm² 未滿ナル場合ト雖モ適當ナル間隔ニ助筋ヲ配置スベシ。

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