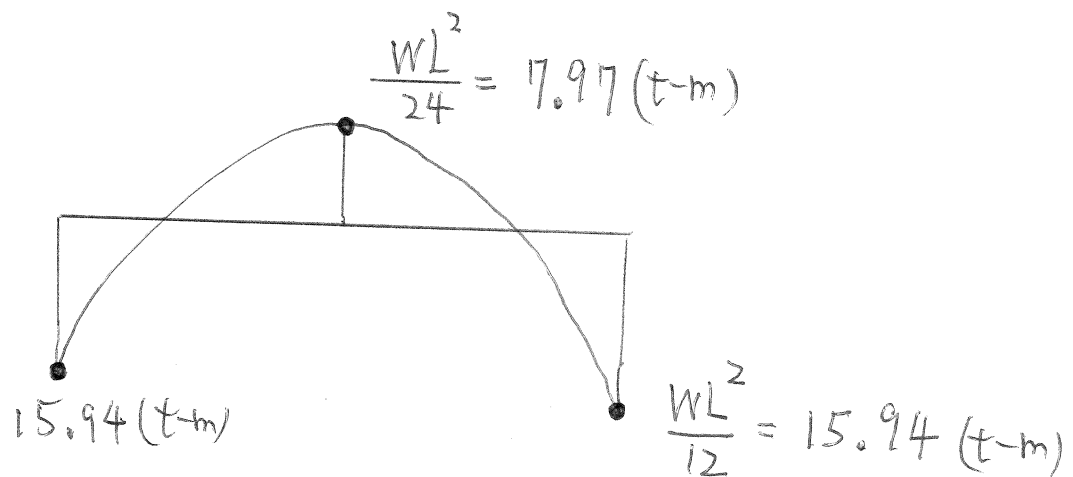


(1) 載重分析 ($1.2D + 1.0L + 1.0E$)

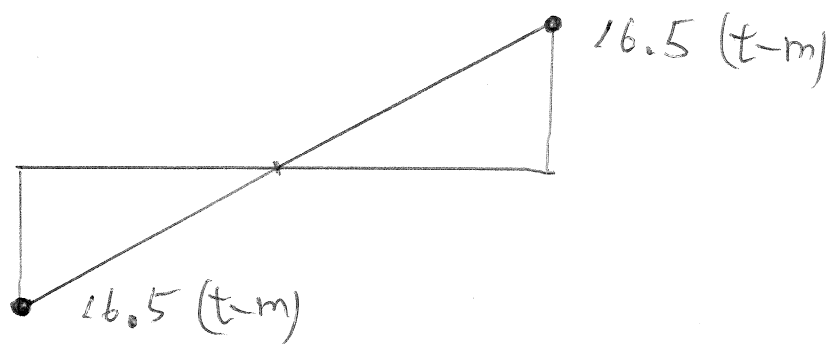
$$W_u = 1.2 \times W_D + 1.0 \times W_L = 1.2 \times 2 + 1.0 \times 1$$

$$= 3.4 \text{ (t/m)}$$

垂直力造成的彎矩圖：



地震力引起的彎矩圖：



註：地震力彎矩圖有可能左右反向（地震力往覆作用），但設計結果一樣。

$$\Rightarrow M_u^+ = 7.97 + 16.5 = 24.47 \text{ (t-m)}$$

$$M_u^- = 15.94 + 16.5 = 32.44 \text{ (t-m)}$$

註：皆取極大值相加。

(2) 抵抗正負彎矩之主筋量 (分別以單筋矩形斷面計算之)

① 正彎矩：

$$m = \frac{f_y}{0.85 f_c'} = \frac{4200}{0.85 \times 280} = 17.65$$

$$R_n = \frac{M_u}{\phi b d^2} = \frac{24.47 \times 10^5}{0.9 \times 35 \times 63^2} = 19.57$$

$$\rho = \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2 m R_n}{f_y}} \right)$$

$$= \frac{1}{17.65} \times \left(1 - \sqrt{1 - \frac{2 \times 17.65 \times 19.57}{4200}} \right)$$

$$= 0.00487$$

$$A_s^+ = \rho \times b \times d = 0.00487 \times 35 \times 63 = 10.74 \text{ (cm}^2\text{)}$$

② 負彎矩：

$$m = 17.65, R_n = 25.94$$

$$\rho = \frac{1}{17.65} \times \left(1 - \sqrt{1 - \frac{2 \times 17.65 \times 25.94}{4200}} \right) = 0.00656$$

$$A_s^- = 0.00656 \times 35 \times 63 = 14.46 \text{ (cm}^2\text{)}$$

(3) 鋼筋量檢核

$$\textcircled{1} A_{s, \min} = \max\left(\frac{14}{f_y}, \frac{0.8\sqrt{f'_c}}{f_y}\right) \times b \times d$$

$$= \frac{14}{4200} \times 35 \times 63 = 7.35 \text{ (cm}^2\text{)}$$

② 本題有地震力，須考量“耐震設計特別規定”。

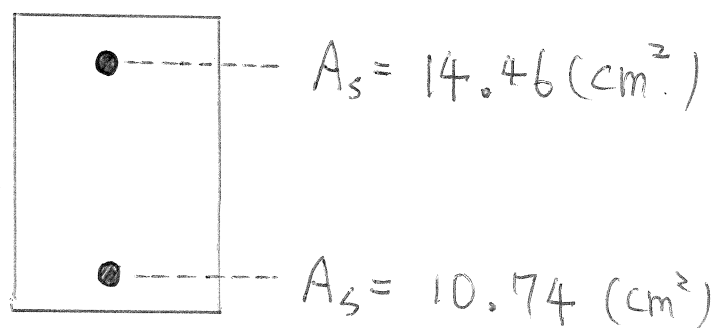
$$A_{s, \max} = \min\left(0.025, \frac{100 + f'_c}{4f_y}\right) \times b \times d$$

$$= 0.0226 \times 35 \times 63 = 49.88 \text{ (cm}^2\text{)}$$

③ 壓力筋量不少於拉力筋量之半。

(4) 設計結果

(3) 的要求皆符合，設計結果圖示如下：



二、

(1) 計算 M_{pr} (取 $\phi = 1.0$, $f_s = 1.25 f_y$)

① M_{pr}^- :

$$a = \frac{1.25 A_s \times f_y}{0.85 f'_c \times b} = \frac{1.25 \times 3 \times 6.47 \times 4200}{0.85 \times 280 \times 35} = 12.23 (\text{cm})$$

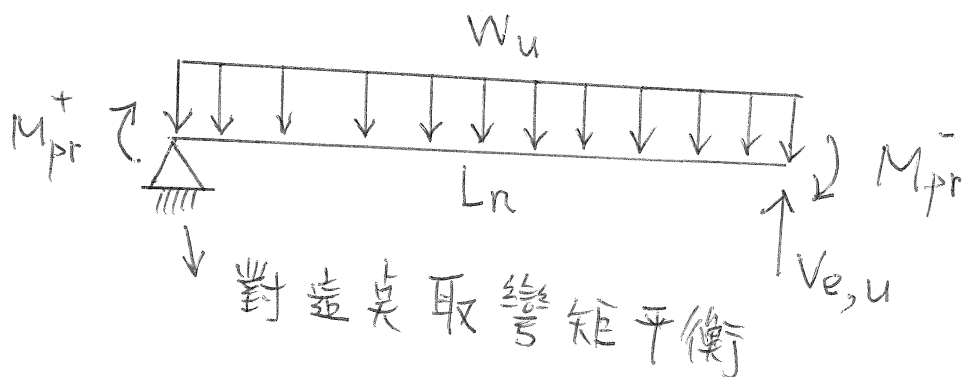
$$M_{pr}^- = 1.25 \times 3 \times 6.47 \times 4200 \times \left(63 - \frac{12.23}{2}\right) \times 10^{-5} \\ = 57.97 (\text{t-m})$$

② M_{pr}^+ :

$$a = 7.32 (\text{cm}), \quad M_{pr}^+ = 36.17 (\text{t-m})$$

(2) 計算 $V_{e,u}$

$$W_u = 3.4 \left(\frac{t}{m} \right), \quad L_n = 7.5 \text{ (m)}$$



$$\Rightarrow V_{e,u} \times L_n = \frac{W_u \times L_n^2}{2} + M_{pr}^+ + M_{pr}^-$$

$$\Rightarrow V_{e,u} = \frac{W_u \times L_n}{2} + \frac{M_{pr}^+ + M_{pr}^-}{L_n}$$

$$= \frac{3.4 \times 7.5}{2} + \frac{57.97 + 36.17}{7.5}$$

$$= \underline{12.75} + \underline{12.55} = 25.3 \text{ (t)}$$

此處 12.55 未超過總剪力之半， V_c 不必為零。

(3) 設計箍筋間距

$$\phi V_c = 0.75 \times 0.53 \sqrt{280} \times 35 \times 63 = 14666 \text{ (kgf)}$$

$$\phi V_s = 0.75 \times 3 \times 0.71 \times 4200 \times \frac{63}{s} = \frac{422700}{s}$$

$$V_{e,u} \leq \phi V_n = \phi V_c + \phi V_s \Rightarrow s \leq 39.75 \text{ (cm)}$$

$$S_{\max} = \min\left(\frac{d}{4}, 30\text{cm}, 8d_{\text{主筋}}, 24d_{\text{抗壓筋}}\right)$$

$$= \min\left(\frac{63}{4}, 30, 8 \times 2.22, 24 \times 0.95\right) = 15.75\text{ (cm)}$$

$$\Rightarrow \text{取 } S = 15\text{ (cm)}$$

檢核 $S = 15\text{ cm}$ 形成的 \bar{V}_s 是否合於上下限

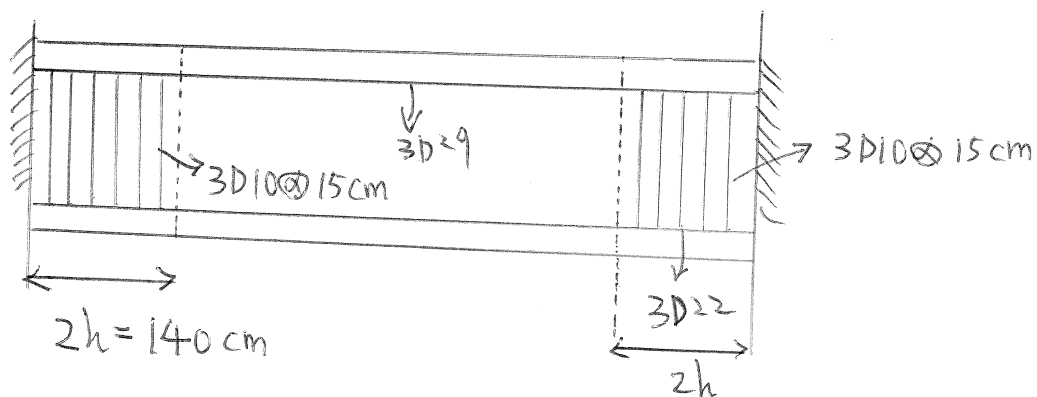
$$\bar{V}_s = \frac{3 \times 0.71 \times 4200}{15 \times 35} = 17.04\text{ (kgf/cm}^2\text{)}$$

$$\bar{V}_{s, \min} = \max(3.5, 0.2\sqrt{280}) = 3.5\text{ (kgf/cm}^2\text{)}$$

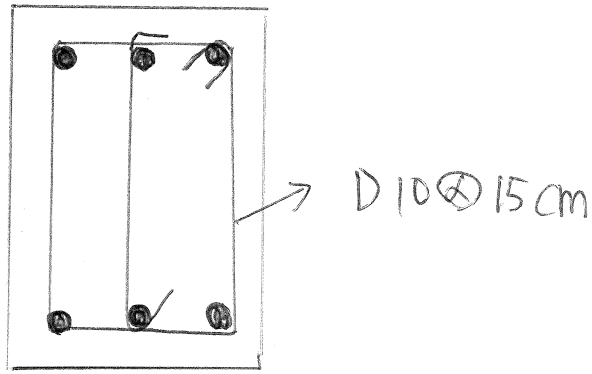
$$\bar{V}_{s, \max} = 2.12\sqrt{280} = 35.47\text{ (kgf/cm}^2\text{)}$$

$$\Rightarrow S = 15\text{ (cm)}$$

(4) 配筋圖：梁端塑鉸區緊密橫筋



※ 第一組剪力筋距柱面 5 cm 。



* 中間繫筋 90-135 彎鉤在縱向交替排置。

三、

(1) 判定此柱是否為細長柱

$$L_u = 800 \text{ cm}, \quad r = 0.3h = 0.3 \times 40 = 12 \text{ cm}$$

$$\text{柱的細長比} = \frac{kL_u}{r} = \frac{0.9 \times 800}{12} = 60$$

無側移柱細長比分界值

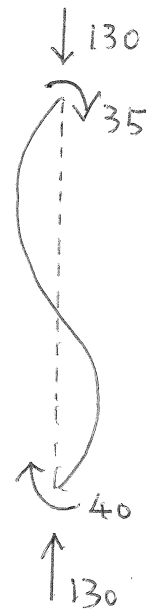
$$= 34 \pm 12 \times \frac{M_1}{M_2}$$

$$= 34 + 12 \times \frac{35}{40} \quad (\text{雙曲度})$$

$$= 44.5 > 40 \Rightarrow \text{取 } 40$$

$$40 < \frac{kL_u}{r} = 60 < 100$$

\Rightarrow 本柱為細長柱且適用彎矩放大法



(2) 計算放大彎矩

$$I_g = \frac{1}{12} \times b h^3 = 213333 \text{ (cm}^4\text{)}$$

$$\begin{aligned} EI &= 0.25 E_c I_g = 0.25 \times 15000 \sqrt{280} \times 213333 \\ &= 1.34 \times 10^{10} \text{ (kgf-cm}^2\text{)} \end{aligned}$$

$$P_{cr} = \frac{\pi^2 EI}{(k L_u)^2} = \frac{\pi^2 \times 1.34 \times 10^{10}}{(0.9 \times 800)^2} \times 10^{-3} = 255 \text{ (t)}$$

$$\begin{aligned} C_m &= 0.6 \pm 0.4 \times \frac{M_1}{M_2} = 0.6 - 0.4 \times \frac{35}{40} \\ &= 0.25 < 0.4 \Rightarrow C_m = 0.4 \end{aligned}$$

$$\delta_{ns} = \frac{0.4}{1 - \frac{130}{0.75 \times 255}} = 1.25 > 1 \quad \text{ok!}$$

$$M_2 = 40 > P_u \times (1.5 \text{ cm} + 0.03h) = 3.51 \text{ (t-m)} \quad \text{ok!}$$

$$M_c = \delta_{ns} \times M_2 = 50 \text{ (t-m)}$$

(3) 柱設計用外力

$$P_u = 130 \text{ (t)}$$

$$M_u = 50 \text{ (t-m)}$$