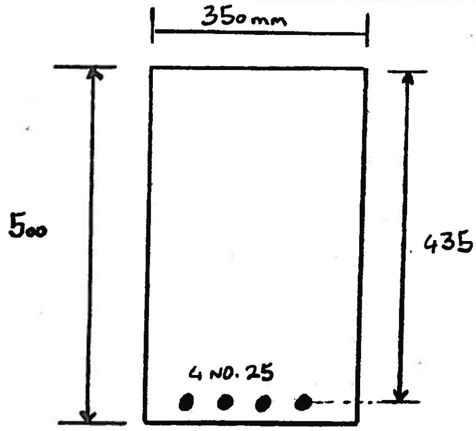
BCEE 345 Assignment #2

1)



Solution:

Step 1: $T_s = \phi_s f_s A_s$, Assume $\varepsilon_s \geq \varepsilon_y$, then $f_s = f_y$

$\therefore T_s = \phi_s (f_y A_s)$

Step 2: $C_c = \phi_c (\alpha_1 f'_c)(a \times b)$

Step 3: $T_s = C_c$, $\phi_c \alpha_1 f'_c (a \times b) = \phi_s A_s f_y$

$\Rightarrow \alpha_1 = 0.85 - 0.0015 f'_c = 0.81 \Rightarrow \alpha_1 = 0.81$

$$a = \frac{\phi_s f_y A_s}{\phi_c \alpha_1 f'_c b} = \frac{0.85 \times 400 \times (4 \times 500)}{0.65 \times 0.81 \times 30 \times 350} = 123\,mm \Rightarrow \underline{a = 123\,mm}$$

Step 4: verify $\varepsilon_s \geq \varepsilon_y \Rightarrow \frac{\varepsilon_s}{d-c} = \frac{\varepsilon_{cu}}{c}$

$$C = \frac{a}{\beta_1} = \frac{a = 123}{0.97 - 0.0025 f'_c} = 137\,mm \Rightarrow \underline{c = 137\,mm}$$

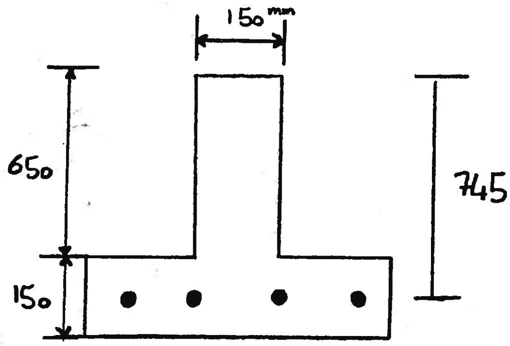
$$\varepsilon_s = \frac{\varepsilon_{cu}}{c}(d-c) = \frac{0.0035}{137}(435 - 137) \Rightarrow 0.008 > \varepsilon_y$$

Step 5: calculate M_r

$$M_r = T_s d' \Rightarrow (\phi_s f_y A_s)\left(d - \frac{a}{2}\right) \Rightarrow (0.85 \times 400 \times 4 \times 500)\left(435 - \frac{123}{2}\right)$$

$$\boxed{M_r = 253\ KN.m}$$

2)



Solution :

Step 1: Assume that the compression block lies within the web:

$$\alpha_1 \phi_c f'_c b_w a = \phi_s f_s A_s \rightarrow \text{Assume } \varepsilon_s \geq \varepsilon_y \text{ , } f_s = f_y$$

$$a = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f'_c b_w} = \frac{0.85 \times 400 \times (4 \times 700)}{0.805 \times 0.65 \times 30 \times 150} = 404 \text{ mm} \qquad \underline{a = 404 \text{ mm}}$$

Step 2: verify $\varepsilon_s \geq \varepsilon_y$

$$\frac{\varepsilon_s}{d-c} = \frac{\varepsilon_{cu}}{c} \quad , \quad c = \frac{a}{\beta_1} = \frac{404}{0.895} = 451 \text{ mm} \qquad \underline{c = 451 \text{ mm}}$$

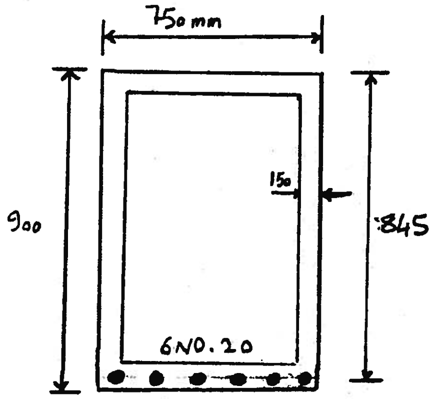
Step 3: Calculate M_r

$$M_r = T_s \left(d - \frac{a}{2}\right) \Rightarrow M_r = \phi_s A_s f_y \left(d - \frac{a}{2}\right)$$

$$M_r = 0.85(4 \times 700)(400)\left(745 - \frac{404}{2}\right)$$

$$\boxed{M_r = 517 \text{ KN.m}}$$

3)



Solution:

Step1: Assume that the compression block lies between external and internal rectangular section

$$\alpha_1 \phi_c f'_c b a = \phi_s f_s A_s \quad , \text{Assume } \varepsilon_s \geq \varepsilon_y \;, f_s = f_y$$

$$a = \frac{\phi_s f_y A_s}{\phi_c \alpha_1 f'_c b} = \frac{0.85 \times 400 \times 6 \times 300}{0.65 \times 0.805 \times 30 \times 750} = 52.2\,\text{mm} \qquad \underline{a = 52.2\,\text{mm}}$$

Step2: verify $\varepsilon_s \geq \varepsilon_y$

$$c = \frac{a}{\beta_1} = \frac{52}{0.895} = 58.3 \qquad \underline{c = 58.3}$$

$$\varepsilon_s = \frac{\varepsilon_{cu}}{c}(d-c) = \frac{0.0035}{58.3}(845-58) = 0.046 > 0.002$$

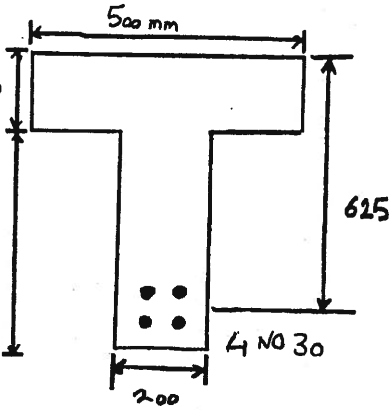
Step3: Calculate Mr

$$M_r = T_s d' \Rightarrow M_r = (\phi_s f_y A_s)\left(d - \frac{a}{2}\right)$$

$$M_r = (0.85 \times 400 \times 6 \times 300)\left(845 - \frac{52}{2}\right)$$

$$\boxed{M_r = 501 \text{ KN.m}}$$

4)



Solution:

Step 1: $\phi_c(\alpha_1 f'_c)(a\, b_f) = \phi_s f_s A_s$

Assume $\varepsilon_s \geq \varepsilon_y$, $f_s = f_y$

$$a = \frac{\phi_s f_y A_s}{\phi_c \alpha_1 f'_c b_f} = \frac{0.85 \times 400 \times 4 \times 700}{0.65 \times 0.805 \times 30 \times 500} = 121 > h_f = 100$$

Step 2:

$$a = \frac{\phi_s f_s A_s - \alpha_1 \phi_c f'_c (b_f - b_w) h_f}{\alpha_1 \phi_c f'_c b_w}$$

$$a = \frac{0.85 \times 400 \times 4 \times 700 - 0.805 \times 0.65 \times 30 \times (500-200) \times 100}{0.805 \times 0.65 \times 30 \times 200} = 153\text{mm} \qquad \underline{a = 153\text{mm}}$$

Step 3: $c = \dfrac{a}{\beta_1} = \dfrac{153}{0.895} = 171$ mm $\qquad \underline{c = 171 \text{ mm}}$

$$\varepsilon_s = \frac{\varepsilon_{cu}}{c}(d-c) = \frac{0.0035}{171}(625-171) = 0.0092 > \varepsilon_y$$

Step 4: Calculate M_r

$$M_r = C_f\left(d - \frac{h_f}{2}\right) + C_w\left(d - \frac{h_f + a}{2}\right)$$

$$C_f = \phi_c(\alpha_1 f'_c)(b_f h_f) = 0.65 \times 0.805 \times 30 \times 500 \times 100 = 785 \text{ kN}$$

$$C_w = \phi_c(\alpha_1 f'_c) b_w (a - h_f) = 0.65 \times 0.805 \times 30 \times 200 \times (153 - 100) = 166 \text{ kN}$$

$$M_r = 785 \times \left(625 - \frac{100}{2}\right) + 166 \times \left(625 - \frac{100+153}{2}\right)$$

$$\boxed{M_r = 533 \text{ kN.m}}$$