

CVG3148 - ASSIGNMENT 2 – Solutions (Summary)

Problem 1 (20marks)

a.

$$W_f = 105 \text{ kN/m}$$

$$M_f = 328.13 \text{ kN.m}$$

$$a = 124.54 \text{ mm}$$

$$M_r = 398 \text{ kN.m}$$

Compare M_r and M_f : $M_r = 398 \text{ kN.m} > M_f = 328.13 \text{ kN.m}$ OK

b.

$$\rho = 1.03 \%$$

$$k_r = 3.167$$

$M_r = 398 \text{ kN.m} \Rightarrow M_r = 329 \text{ kN.m} > M_f = 328.13 \text{ kN.m}$ OK

c.

$$A_{Smin} = 621.19 \text{ mm}^2$$

$$A_S = 2000 \text{ mm}^2 > A_{Smin} = 621.19 \text{ mm}^2$$
 OK

d.

$$s = 40 \text{ mm}$$

$$s = 40 \text{ mm} \geq \begin{cases} 1.4d_b = 35 \text{ mm} \\ 1.4a_{max} = 28 \text{ mm} \\ 30 \text{ mm} \end{cases} \quad (a_{max} = \text{aggregate size})$$
 OK

e.

$$d_s = 52.5 \text{ mm}$$

$$A_e = b(2d_s) = 31500 \text{ mm}^2$$

$$A = \frac{A_e}{N} = 7875 \text{ mm}^2$$

$$z = f_s \sqrt[3]{d_c A} = 17879 \text{ N/mm} < 30000 \text{ N/mm}$$
 OK.

f.

For $f_y=400\text{MPa} \Rightarrow \frac{c}{d} = 0.636 \Rightarrow c = 411.81 \text{ mm}$

$$A_{sb} = \frac{\alpha_1 \beta_1 \phi_c f'_c b c}{\phi_s f_y} = \mathbf{5819.6 \text{ mm}^2}$$

$$A_s = 2000 \text{ mm}^2 < A_{sb} = 5819.6 \text{ mm}^2 \text{ OK}$$

$\Rightarrow A_{smin} = 621.19 \text{ mm}^2 < A_s = 2000 \text{ mm}^2 \leq A_{sb} = 5819.6 \text{ mm}^2 \rightarrow$ under-reinforced

Problem 2 (20marks)

a.

We assume $a < 150 \text{ mm}$ and we apply rectangular analysis:



$$a = \frac{\phi_s f_y A_s}{\alpha_1 \phi_c f'_c b} = \mathbf{110.35 \text{ mm}}$$

Assumption $a = 110.35 \text{ mm} < 150 \text{ mm}$ (similar to rectangular beam) OK

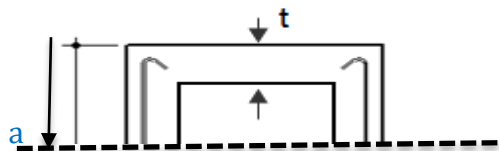
$$d = h - \left(\text{clear cover} + d_{stirrups} + \frac{d_b}{2} \right) = \mathbf{947.5 \text{ mm}}$$

Check also $\left(\frac{c}{d}\right) = 0.134 < \left(\frac{c}{d}\right)_{max} = 0.64$ OK

$$M_r = \phi_s A_s f_y \left(d - \frac{a}{2} \right) = \mathbf{1213.6 \text{ kN.m}}$$

b.

We assume $a > 100 \text{ mm}$



$$A_{con,comp} = 66212 \text{ mm}^2$$

$$\Rightarrow a = 131 \text{ mm} > 100 \text{ mm} \quad \text{OK}$$

$$\bar{a} = \frac{\sum \bar{y}_{ci} * A_i}{\sum A_i} = 56.1 \text{ mm}$$

$$M_r = \phi_s A_s f_y Z = 1212.3 \text{ kN.m}$$

$$\left(\frac{c}{d}\right) < \left(\frac{c}{d}\right)_{max} \Rightarrow 0.159 < 0.64 \quad \text{OK}$$

C.

$$b_t h = (600 * 1000) - (300 * 700) = 390000 \text{ mm}^2 \text{ (Total area of concrete section)}$$

$$A_{Smin} = 1233.3 \text{ mm}^2$$

$$A_{Smin} = 1233.3 \text{ mm}^2 < A_s = 4000 \text{ mm}^2 \quad \text{OK}$$

$$s = 45.7 \text{ mm}$$

$$s = 45.7 \text{ mm} \geq \begin{cases} 1.4d_b = 35 \text{ mm} \\ 1.4a_{max} = 28 \text{ mm} \\ 30 \text{ mm} \end{cases} \quad (a_{max} = \text{aggregate size}) \quad \text{OK}$$

$$d_s = 52.5 \text{ mm}$$

$$A_e = b(2d_s) = 63000 \text{ mm}^2$$

$$A = \frac{A_e}{N} = 7875 \text{ mm}^2$$

$$z = f_s \sqrt[3]{d_c A} = 17879 \text{ N/mm} < 25000 \text{ N/mm} \quad \text{OK.}$$

Problem 3 (20marks)

a.

$$M_f = 243.4 \text{ kN.m}$$

$$\text{rebars} \Rightarrow 4 - 25M (A_s = 2000 \text{ mm}^2)$$

Verify design

$$d_{actual} = 547.5 \text{ mm}$$

$$\alpha_{actual} = 144.4 \text{ mm}$$

$$\left(\frac{c}{d}\right) = 0.295 < \left(\frac{c}{d}\right)_{max} = 0.64 \quad \text{OK}$$

$$M_{r,actual} = 323.2 \text{ kN.m} \circ M_f \quad \text{OK}$$

$$A_{smin} = 493 \text{ mm}^2 \circ A_s \quad \text{OK}$$

Bar spacing

$$s = 40 \text{ mm}$$

$$s = 40 \text{ mm} \geq \begin{cases} 1.4d_b = 35 \text{ mm} \\ 1.4a_{max} = 28 \text{ mm} \\ 30 \text{ mm} \end{cases} \quad (a_{max} = \text{aggregate size}) \quad \text{OK}$$

b.

$$A = 12.27$$

$$B = -180200$$

$$C = 243.4 * 10^6$$

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} \Rightarrow x = 1504 \text{ mm}^2 \Rightarrow 4 - 25M (A_s = 2000 \text{ mm}^2)$$

c.

$$M_r = M_f = 234.4 \text{ kN.m}$$

$$K_{r,required} = \frac{M_r}{bd^2} \Rightarrow K_{r,min} = 2.78$$

$$\Rightarrow \text{for } (k_r = 1.83), \rho\% = 0.882$$

$$A_s = \rho bd = 1402.4 \text{ mm}^2 \Rightarrow 3 - 25M (A_s = 1500 \text{ mm}^2)$$