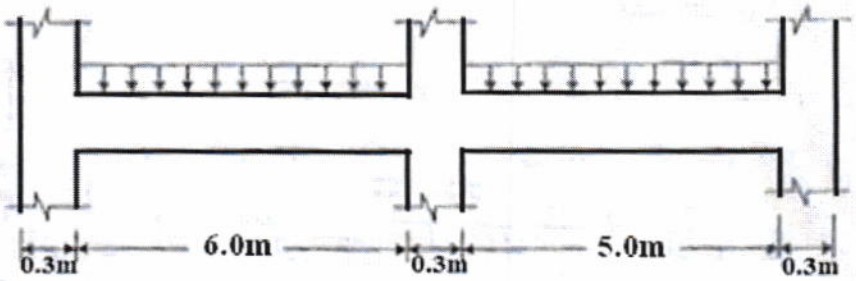
University Of Technology
Building and Construction Engineering Department
First term /Final Exam. 2013/2014

Subject : Concrete structures | **Year : 4th**
Division: Building and project management dept. | **Time : 3 hours**
Examiner : Dr. Iqbal N. Gorgis | **Date : 26/ 05 / 2014**

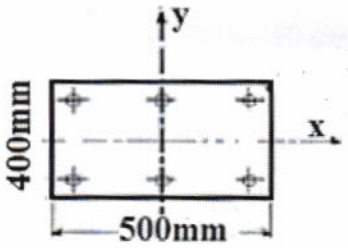
Notes: Solve only **THREE** questions

Use $f'c = 25$ MPa and $fy = 420$ MPa for solving the questions.

Q.1-a) Calculate steel required at the critical section for the beam shown below, if the beam supports service dead load including its own weight of 10kN/m and service live load of 15kN/m. Use for bending $\emptyset 25mm$ and for shear $\emptyset 10mm$ stirrups, with b = 250mm and d= $430mm$. (23%)



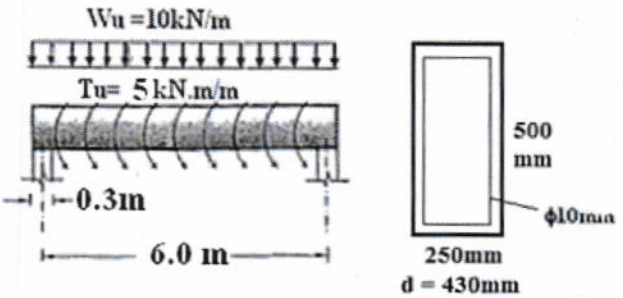
Q.1-b) A short rectangular tied column with 400x500 mm reinforced with 6 $\emptyset$ $30mm$. Estimate the axial load (Pu) of the column and design the ties required (assume 40mm cover all around) then draw the final cross section of the column. (10%)



Q.2-a) A concrete wall with 200 mm thickness supports a dead load of 40 kN/m and live load of 40 kN/m. Design a wall footing to withstand the loads and draw the section of footing so that: (16%)

1. The allowable soil capacity at depth of 0.8 m was 100 kN/m^2.
2. Density of soil is 16 kN/m^3 and concrete is 24 kN/m^3.
3. Try thickness of footing 0.25m and use bars with diameter of 12mm (cover 70mm).

Q.2-b) A concrete beam is subjected to uniform distributed load of 10 kN/m and uniform distributed torsional moment of 5 kN.m/m along its span. Check the section adequacy to withstand the loading.



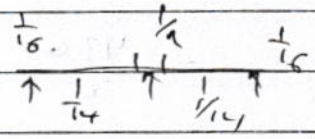
(17%)

Concrete Structures 2014

(دور اول)

Q.1 a//

$W_u = 1.2(10) + 1.6(15) = 36$ kN/m



$M_u = \frac{1}{9}(36)\left(6+\frac{5}{2}\right)^2 = 121$ kN.m

$R_u = \frac{121 \times 10^6}{0.9 * 250 (430)^2} = 2.908$

$m = \frac{420}{0.85 \times 25} = 19.76$

$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2 R_u m}{f_y}}\right] = 0.00748$

$\rho_{max} = 0.75 (0.85)^2 \frac{25}{420} \left(\frac{600}{600+420}\right) = 0.01897$

$\rho_{min} = \frac{1.4}{f_y} \geq \frac{\sqrt{f'_c}}{4 f_y} \leq \frac{1.4}{420} \geq \frac{\sqrt{25}}{4*420} = 0.00333 \geq 0.00298$

$\rho_{min} < \rho_{req} < \rho_{max}$

$A_s = 0.00748 * 250 * 430 = 804.1$ mm²

use $\phi 25$ mm $A_{bar} = 490.87$ mm² no. of bars $2\phi 25$

$V_u = \frac{1.15(36)(6)}{2} = 124.2$ KN

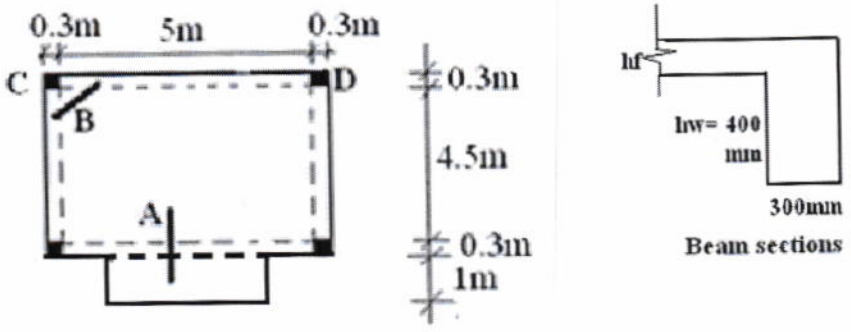
$V_{u,d} = 124.2 - 36(0.43) = 108.72$ kN

$\phi V_c = 0.75 \frac{\sqrt{25}}{6} * 250 * 430/1000 = 67.187$ kN

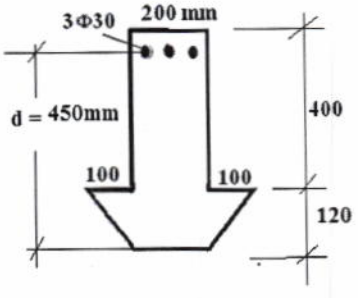
$\phi V_s = 108.72 - 67.187 = 41.53$ kN $< 2\phi V_c$

Q.3-a) Determine the **thickness** for the two way concrete slab and **service live load** if the steel area used at points A and B was $\emptyset 12 @ 150mm\ C/C$. The slab supports a service dead load of 7 kN/m^2 **including its own weight**, then estimate Load on beam CD (for slab thickness use either 100,125 or 150).

(20%)



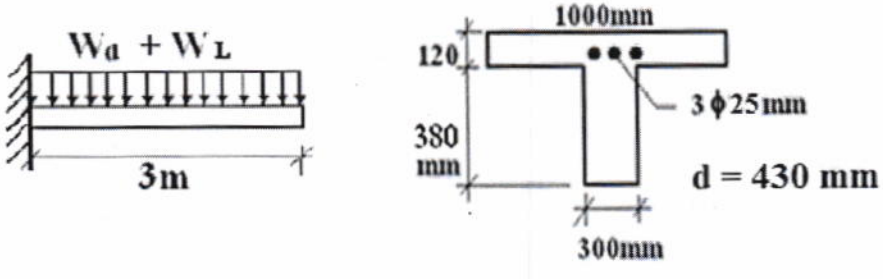
Q.3-b) Find ultimate moment capacity for the section shown below: (13%)



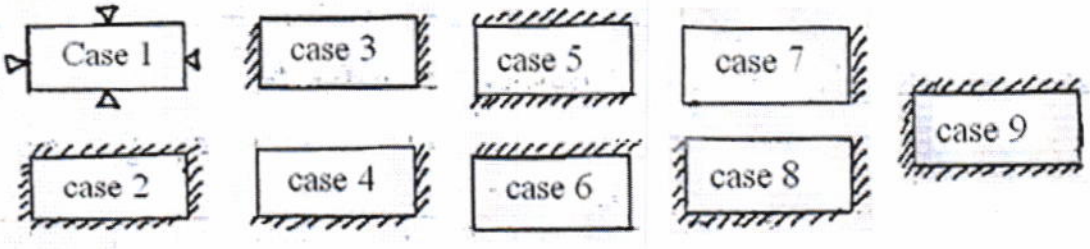
Q.4): The ~~simply supported~~ cantilever beam is a part of flat roofs not supporting or attached to non-structural elements likely to be damaged by large deflection. Check the deflection with the limit of ACI-Code 318-11. The beam supports service distributed dead load including its own weight of 15 kN/m and live load of 20 kN/m.

$$\Delta_{\text{free end}} = \frac{W*L^4}{8*E*I_{eff}}$$

(34%)



Slab cases:



$S_{req} = \frac{0.75 * 157 * 420 * 430}{41.51 * 1000} = 512.055$ mm

$S_{max} = \frac{d}{2} < 600 < \frac{3 A_v f_y}{b_w} < \frac{16 A_b f_y}{b_w \sqrt{f_{ck}}}$

$= \frac{430}{2} = 215 < 600 < \frac{3 * 157 * 420}{250} = 791.3$ mm $< \frac{16 * 157 * 420}{250 * \sqrt{25}} = 844$ mm

Use $\phi 10 @ 210$

Q.1 b) $6 \phi 30 = 4241.15$ mm^2

$P_u = 0.8 * 0.65 [0.85 * 25 (400 * 500 - 4241.15) + 4241.15 * 420] / 1000$

$= 3089.5$ kN.

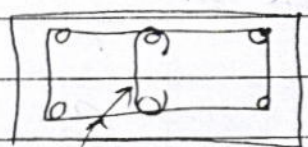
Use $\phi 10$ mm dia ties spacing $\leq 16 * 30 = 480$ mm

$\leq 48 * 10 = 480$

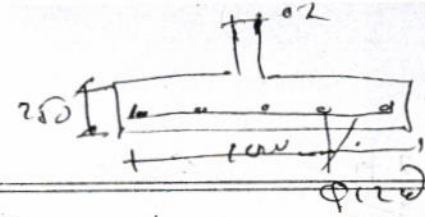
≤ 400 mm

Clear bar spacing $= \frac{500 - 2(40) - 2(10) - 3 * 30}{2}$

$= 155$ mm



2 set $\phi 10 @ 400$ mm



Q.2 a

$q_{ult} = 100 - 0.8\left(\frac{16+24}{2}\right) = 84 \text{ kN/m}^2$

$b = \frac{40+40}{84} = 0.95 \text{ m} \approx 1.0 \text{ m}$

$h = 250 \text{ mm} \quad d = 250 - 70 - 6 = 174 \text{ mm}$

$q_{ult} = \frac{1.2(40) + 1.6(40)}{1.0} = 112 \text{ kN/m}^2$

$V_{ult} = 112\left(\frac{1-0.2}{2} - 0.174\right) = 25.312 \text{ kN}$

$\phi V_c = 0.75 \frac{\sqrt{25}}{6} * 1000 * \frac{174}{1000} = 108.75 \text{ kN} >$ ok.

thickness (inadequate depth)

$M_u = \frac{112(1-0.2)^2}{8} = 8.96 \text{ kN.m}$

$R_n = \frac{8.96 * 10^6}{0.9 * 1000 (174)^2} = 0.3288$

$f = 19.72 \quad \rho = 0.000789 < \rho_{min} = 0.0018$

use ρ_{min} both directions

$A_s = 0.0018 * 1000 * 250 = 450 \text{ mm}^2/\text{m}$

$Spacing = \frac{113 * 1000}{450} = 251.1 \text{ mm}$ use 250 mm

Φ12 @ 250 mm c/c both directions

$L_{d\,provided} = (1000 - 200)/2 = 70 = 330 \text{ mm}$

$L_{d\,req} = \frac{18 * 12 * 420}{25\sqrt{25}} = 725.76 \text{ mm}$

we have $= \frac{400(12)}{4\sqrt{25}} = 240 \text{ mm} \quad 8 d_b \geq 150 \text{ mm}$

$8 * 12 = 96 \text{ mm}$

$252 \text{ mm} < 330 \text{ mm}$ ok. we have

Q.2b $6 - 0.3 = 5.7$ m

Vu at face of support $= 5.7 * \frac{10}{2} = 28.5$ kN

Tu at face $= 5.7 * \frac{5}{2} = 14.25$ kN-m

$V_{ud} = 28.5 - 0.43 * 10 = 24.2$ kN

$T_{ud} = 14.25 - 0.43 * 5 = 12.1$ kN-m

$T_{cr} = 0.75 \frac{\sqrt{25}}{12} \left\{ \frac{(250 + 500)^2}{2(250 + 500) 10^6} \right\} = 3.255$ kN-m

< 14.25 we need torsional reinf

$X_0 = 250 - 2(40) - 10 = 160$ mm

$y_0 = 500 - 2(40) - 10 = 410$ mm

$A_{ch} = 160 * 410 = 65600$ mm^2

$P_{ch} = 2(160 + 410) = 1140$ mm

$$\sqrt{\left(\frac{242000}{250 * 430}\right)^2 + \left(\frac{12.1 * 10^6 * 1140}{1.7 (65600)^2}\right)^2} \leq 0.75 \frac{5}{6} \sqrt{25}$$

$0.05067 + 3.55 < 226 \leq 3.125$

$1.8989 \leq 3.125$

$\therefore$ section is adequate

Q.3-a

$h_{min} = \frac{2(4.5+5)}{180} \times 100 = 105 \geq 100$ mm

$= 120$ mm

$= 125$ mm

$m = \frac{4.5}{5} = 0.9$ case 6

$d = 120 - 20 - 12 = 88$ mm

$= 125 - 20 - 12 = 93$ mm

Span $= \frac{113 \times 100}{A_s} \Rightarrow A_s = \frac{113000}{150} = 753.33$ mm²

$\rho = \frac{753.33}{100 \times (88)^2}$ or $(93)^2$ $= 0.00856 > \rho_{min}$

$0.0081 > \rho_{min}$

$M_n = 0.9 \times 0.00856 \times 100 \times (88)^2 \times 420 \left(1 - 0.59 \times 0.00856 \frac{420}{25}\right) / 10^6$

$= 22.93$ kN.m/m

$M_{a-ve} = 0.079 (W_u)(4.5)^2 = 22.93$

$W_u = 14.33 = 1.2(7) + 1.6(W_L)$

$W_L = 3.706$ kN/m² ← govern. الأكبر

$M_{a+ve} = [1.2(7)(0.039) + 1.6(W_L)(0.042)] 4.5^2 = 14.33$

$W_L = 5.655$ kN/m²

$14.33 = \frac{W_u (1)^2}{2}$ $W_L = 28.33 = 1.2(7) + 1.6 W_L$

$W_L = 12.45$ kN/m² ✓

$W_u = 1.2(7) + 1.6(3.7) = 14.32$ kN/m

wt. on beam on CD. $= \frac{5 \times 4.5 \times 14.32}{2 \times 5} \times 0.79 = 25.45$ kN

wt. of beam $= 1.2 \times 0.3 \times 0.4 \times 24 = 3.46$ kN/m

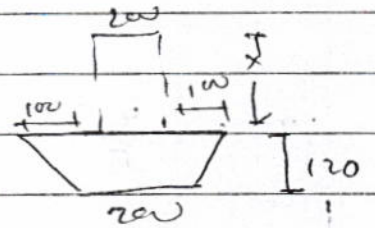
$\Sigma = 28.91$ kN/m

Q.3b $3930 = 2121 \text{ mm}^2$

$C = T$

$0.85 f_c A_{comp} = A_s f_y$

$A_{comp} = 41920.94 \text{ mm}^2$

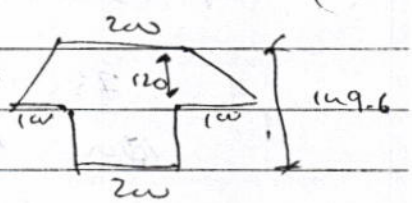


$A_{\square} = 2w * 120 + 2 * \frac{1}{2} * 1w * 120$

$= 36000 \text{ mm}^2$

$41920.94 = 36w + x(2w)$

$x = \frac{41920.94 - 36w}{2w} = 29.6 \text{ mm}$



$\bar{y} = \frac{2w(149.6)^2}{2} + \frac{1}{2} * 1w * 120 * \frac{2}{3} * 120$

41920.94

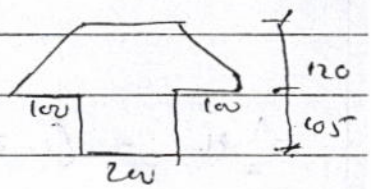
$= 118.22 \text{ mm}$

$M_u = 0.9 * 2121 * 420 (450 - 118.22) / 10^6$

$= 266 \text{ kN.m}$

$C_b = \frac{6w(450)}{6w + 420} = 264.7 \text{ mm}$

$a_b = 0.85 * 264.7 = 225 \text{ mm}$



$(A_{comp}) = 36w + 2w * 105 = 57000 \text{ mm}^2$

$A_{s\,b} = \frac{0.85 * 25 * 57000}{420} = 2883.93 \text{ mm}^2$

$A_{s\,bmax} = 0.75 * 2883.93 = 2162.9 > 2121$

ok.

under reinf.

Q. 4

$$I_g = \frac{300 \times (500)^3}{12} = 3.125 \times 10^9 \text{ mm}^4$$

$$M_{cr} = \frac{0.62\sqrt{25} \times 3.125 \times 10^9}{250 \times 10^6} = 38.75 \text{ kN.m}$$

$$M_d = \frac{15(3)^2}{2} = 67.5 \text{ kN.m} \qquad n = \frac{200000}{4700\sqrt{25}} = 9$$

$$M_{d+L} = \frac{35(3)^2}{2} = 157.5 \text{ kN.m}$$

$$\frac{300x^2}{2} = 9 \times 1473(430 - x)$$

$$150x^2 = 5700510 - 13257x$$

$$x^2 + 88.38x - 38003.4 = 0$$

$$x = 155.7 \text{ mm}$$

$$I_{cr} = \frac{300(155.7)^3}{3} + 9 \times 1473(430 - 155.7)^2 = 1.375 \times 10^9 \text{ mm}^4$$

$$(I_e)_d = \left(\frac{38.75}{67.5}\right)^3 \left[3.125 \times 10^9 - 1.375 \times 10^9\right] + 1.375 \times 10^9 = 1.706 \times 10^9 \text{ mm}^4$$

$$(I_e)_{d+L} = \left(\frac{38.75}{157.5}\right)^3 \left[(3.125 - 1.375)10^9\right] + 1.375 \times 10^9 = 1.401 \times 10^9 \text{ mm}^4$$

$$\Delta_{im_d} = \frac{15(3000)^4}{8 \times 4700\sqrt{25}(1.706 \times 10^9)} = 3.788 \text{ mm}$$

$$\Delta_{im_{d+L}} = \frac{35(3000)^4}{8 \times 4700\sqrt{25}(1.401 \times 10^9)} = 10.764 \text{ mm}$$

$$\Delta_{im\,L.L} = 10.764 - 3.788 = 6.976 \text{ mm}$$

$$\frac{L}{180} = \frac{3000}{180} = 16.67 > 6.976 \text{ mm}$$

ok adequate.