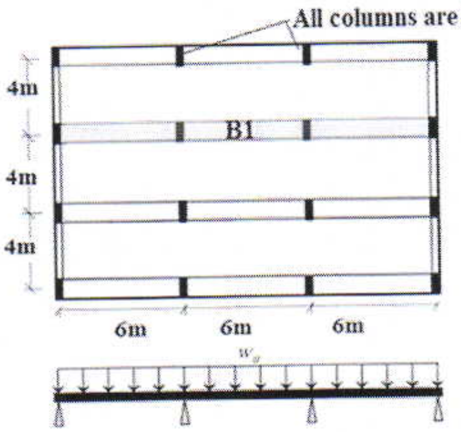
University Of Technology
Building and Construction Engineering Department
First attempt Exam. / 2015-2016

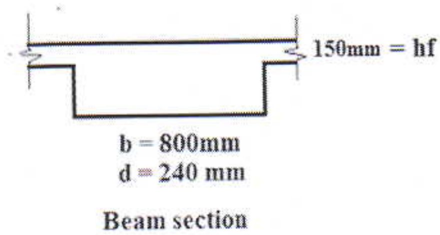
Subject : ***Concrete Structures***
Division: ***Building and Project Management Dept.***
Examiner : ***Asst. Prof. Dr. Iqbal N. Gorgis***

Stage : 4th
Time : 3 hours
Date : 5 / 6 / 2016

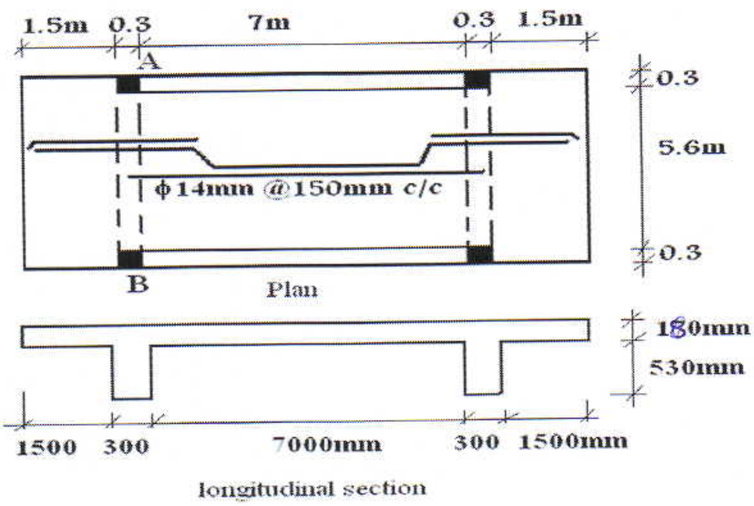
Solve only **three** questions &Use $\boldsymbol{f'c = 25}$ MPa , $\boldsymbol{fy = 420}$ MPa.

Q-1: The rectangular beam B1 shown in the figure has b = 800mm and h = 300mm supports a 150mm slab. The factored distributed load (including slab weight) over the slab is Wu =14 kN/m^2. Find area of steel required for the critical section of beam B1 using bars with 20mm diameter, then find spacing required for 10mm diameter stirrups at critical section only.





Q.2- A) A reinforced concrete slab with 180mm thickness supports service dead load of 3kN/m^2 and service live load of 5 kN/m^2. The reinforcement **at supports** and **at mid span** are $\emptyset 14mm\ at\ 150mm\ ^{c}/_{c}$ as shown in the figure below. Check the adequacy of steel area?

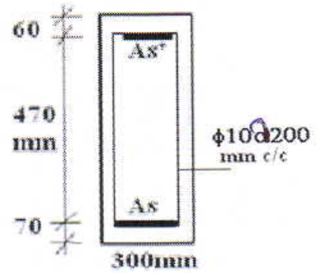


Make use of these:

$\rho_b = 0.85 * \beta_1 * \frac{f'c}{fy} * \frac{0.003}{0.003+\varepsilon_t}$ $Try\ \varepsilon_t = 0.005$ for $\emptyset = 0.9$ $\quad c = \frac{a}{\beta_1}$ $\quad and \quad \varepsilon_t = \frac{0.003\,(d-c)}{c} \geq 0.005$

$\emptyset = 0.48 + 83 * \varepsilon_t$ for $\varepsilon_t < 0.005$

B) Determine allowable and maximum **pure torque** that the beam shown below could withstand using bars with 10mm diameter, (no need for torsion design).



circular

Q.3: A) Design a short, spirally reinforced column to support a service dead load of 800 kN and a service live load of 400 kN. $(Try\ \rho_g = 1\%)$. Use longitudinal bars of 16mm diameter.

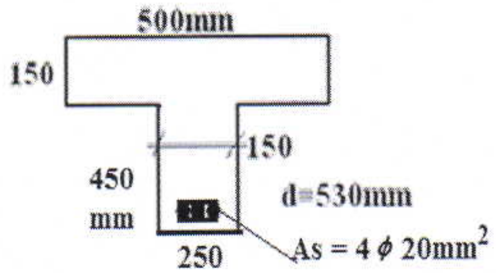
B) A brick wall with 240 mm thickness supports a dead load of 28 kN/m and live load of 40 kN/m. Design a concrete wall footing to withstand the loads so that:

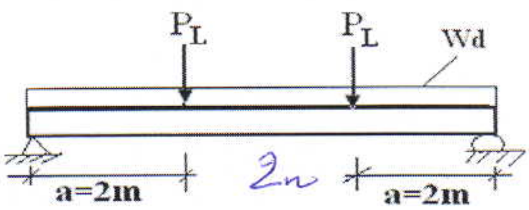
1. The allowable soil capacity at depth of 0.75 m was 100 kN/m^2.
2. Density of soil is 16 kN/m^3 and concrete is 24 kN/m^3.
3. Try using total thickness of footing 0.20m.
4. Use bar with diameter of 10mm.

Q.4: A simply supported beam with 6m length, support 20kN/m service dead load including its own weight and two concentrated sevice live load each one 40kN. Check (As= 4$\emptyset 20mm\ and$ n = 9) :

1- The deflection if the beam is part of floor attached to nonstructural element not likely to be damaged by large deflection , and if the 30% of live load is to sustained for 24 months. ($\sum \Delta sus + \Delta im_{L.L.} \le \frac{L}{240}$)

2- The crack width if the beam is interior one .





$\Delta_{CL.d} = \frac{5W_d L^4}{384EI}$ $\qquad \Delta_{CL.L} = \frac{Pa}{24EI}(3L^2 - 4a^2)$

Building and Project management Dept.

Concrete Structures . 4th Stage 5/6/2016

Use $f'_c = 25$ MPa $f_y = 420$ MPa.

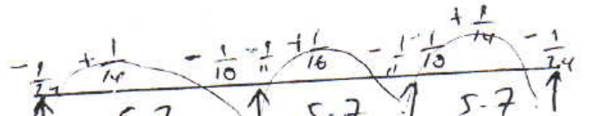
Q.1

$W_u = 1.2(24 * 0.8 * 0.15) = 3.456$ kN/m beam weight

Load from slab $= (14 * 1.15 * \frac{4}{2} + 14 * \frac{4}{2}) = 60.2$ kN/m

$\Sigma = 63.656$ kN/m

at critical Section:



$$M = \frac{63.656(5.7)^2}{10}$$

$= 206.318$ kN.m (-ve moment) rectangular section

$$R_n = \frac{206.318 * 10^6}{0.9 * 800(240)^2} = 4.987 \quad \text{Try } \phi = 0.9 \,//$$

$$m = \frac{420}{0.85 * 25} = 19.764$$

$$\rho = \frac{1}{19.764}\left[1 - \sqrt{1 - \frac{2 * 4.987 * 19.764}{420}}\right] = 0.01373$$

$$\rho_{max} = 0.85\beta\frac{f'_c}{f_y}\frac{0.003}{0.003 + \varepsilon_t} = 0.85^2 \frac{25}{420}\left(\frac{0.003}{0.008}\right) = 0.0161$$

$$\rho_{min} = \frac{1.4}{420} \geq \frac{\sqrt{25}}{4 * 420} \Rightarrow \boxed{0.0033} \geq 0.00297$$

$\therefore \rho_{max} > \rho_{req} > \rho_{min}$ o.k. under reinforced beam.

for ϕ 20mm A_s bar $= 314$ mm²

$$\text{no. of bars} = \frac{0.01373 * 800 * 240}{314} = \frac{2636.4}{314} = 8.3$$

9ϕ 20 mm $\Rightarrow A_s = 2826$ mm²

$$a = \frac{2826 * 420}{0.85 * 25 * 800} = 69.818 \text{ mm} \Rightarrow c = \frac{a}{\beta} = 82.14 \text{ mm.}$$

$$\varepsilon_t = \frac{d-c}{c} * 0.003 = \frac{240-82.14}{82.14} * 0.003 = 0.00576 > 0.005$$

$\therefore \Phi = 0.9$ ok Tension case

For shear spacing:

$R_u = V_u = 1.15 * 63.656 * 5.7/2 = 208.63$ kN.

$V_{ud} = 208.63 - 63.656(0.24) = 193.355$ kN.

$\Phi V_c = 0.75 \frac{\sqrt{25}}{6} * 800 * 240/1000 = 120$ kN.

$\Phi V_s = 193.355 - 120 = 73.355$ kN $< 4\Phi V_c$ المقطع آمن

$< 2\Phi V_c$ استخدم القصوى

$S_{max} \le \frac{d}{2} = \frac{240}{2} = \boxed{120 \text{ mm}}$ govern.

≤ 600 mm

$\le \frac{3A_v f_y}{b_w} = \frac{3(157)420}{800} = 247.275$ mm

$\le \frac{16(157)420}{\sqrt{25}} = 211.008$ mm

use $\Phi 10$ @ 120 mm c/c

Q.2(A)

$W_u = 1.2(3 + 24*0.18) + 1.6*5 = 8.784 + 8 = 16.784 \ \frac{kN \cdot m}{m}$

Slab is Case 3 $m = \frac{5.6}{7} = 0.8$

$d_{av} = 180 - 20 - 14 = 146mm$

At support $M =$ from cantilever $= \frac{wl^2}{2} = \frac{16.784(1.5)^2}{2} = 18.882 \ \frac{kN \cdot m}{m}$

$M^-_{slab} = 0.061 * 16.784 * (7)^2 = \underline{\underline{50.167}} \ \frac{kN \cdot m}{m}$ controls.

table (1)

At mid span: $M^+ = (0.02 * 8.784 + 0.022 * 8)(7)^2$

$= 17.232 \ \frac{kN \cdot m}{m}$

Mu	Rn	ρ	As	Spacing	Notes.
50.167	2.615	0.00667	973.82	Φ14 → 158.8	$As_{min} = 0.0018 * 1000 * 180$ $= 324 \ mm^2/m$
17.232	0.898	0.00218	318.78 ↑ use As_{min}	Φ14 → 475	Spacing $= \frac{324 * 1000}{153.94}$ Φ14

$\frac{153.94 * 1000}{324} = \underline{\underline{475mm}}$ $\leq 5h$

$R_n = \frac{M_u * 10^6}{0.9 * 1000 (146)^2} =$

$\mu = \frac{420}{0.85(25)} = 19.765$

$\rho = \frac{1}{\mu}\left[1 - \sqrt{1 - \frac{2 R_n \mu}{f_y}}\right]$

$A_s = \rho * 1000 * 146$

الموجود Φ14 → 150 ∴ مناسب
adequate

Q.2 (B)

$$T_{cr\ \text{allowable}} = 0.75\ \frac{\sqrt{25}}{12}\ \frac{(300*600)^2}{2(300+600)} \Big/ 10^6 = 5.625\ \text{kN.m}$$

$x = 300 - 80 - 10 = 210$ mm

$y = 600 - 80 - 10 = 510$ mm

$A_{cp} = 107100\ \text{mm}^2$

$P_{cp} = 1440$ mm

$$T_{u\,max} = 0.75\ \frac{5}{6}\sqrt{f_c'}\ \frac{1.7\,(A_{cp})^2}{P_{cp}}$$

$$= 0.75 * \frac{5}{6}\sqrt{25}\ \frac{1.7\,[107100)^2}{1440 * 10^6}$$

$= 42.317$ kN.m

Q.3 (A) $\rho = \frac{A_s}{A_g} \Rightarrow A_s = 0.01 A_g$

$P_u = 1.2(800) + 1.6(400) = 1600$ kN.

$P_u = 0.75 * 0.85 [0.85 f'_c (A_g - A_{st}) + A_{st} f_y]$

$1600*10^3 = 0.6375 [0.85*25 [A_g - 0.01 A_g] + 0.01 A_g * 420]$

$A_g = 99447.406 \text{ mm}^2 \Rightarrow \frac{\pi D^2}{4}$

$D = 355.8$ mm use 360 mm. //

for As :

$1600*10^3 = 0.6375 [21.25 [\frac{\pi (360)^2}{4} - A_{st}) + A_{st} (420)]$

$2509803.922 = 2162986.54 - 21.25 A_{st} + 420 A_{st}$

$346817.38 = 398.75 A_{st}$

$\therefore A_{st} = 869.76 \text{ mm}^2$

$\phi 16$ $A_s = 201 \text{ mm}^2$ no. of bar $= 4.3$

$\therefore$ use min of $\boxed{6 \phi 16 \text{ mm}}$ as ACI - Code 318-14 //

$D_{cor} = 360 - 80 = 280$ mm

$\rho_{sp} = 0.45 \left(\left(\frac{D_g}{D_{cor}} \right)^2 - 1 \right) \frac{f'_c}{f_y}$

$= 0.45 \left(\left(\frac{360}{280} \right)^2 - 1 \right) \frac{25}{420} = 0.0175$ //

Spacing $\phi 10$ mm spiral $= \frac{4(78.5)(280-10)}{0.0175*(280)^2} = 61.79$

use 60 mm > 25 mm, < 75 mm

$\therefore$ spiral $\phi 10$ @ 60 mm c/c. (pitch) //

P.3 (B) $q_{net} = 100 - 0.75\left(\frac{16+24}{2}\right) = 85 \text{ kN/m}^2$

$b = \frac{28+40}{85} = 0.8 \text{ m}$

$d = 200 - 70 - 5 = 125 \text{ mm}$

$q_{ult} = \frac{1.2(28)+1.6(40)}{0.8 * 1} = 122 \text{ kN/m}^2$

$V_u = 122\left(\frac{0.8-0.24}{2} - 0.125\right) = 18.91 \text{ kN}$

$\phi V_c = 0.75 \frac{\sqrt{25}}{6} * 1000 \left(\frac{125}{1000}\right) = 78.125 \text{ kN} > V_u$ ok.

$\therefore h = 200$ mm adequate.

$M_u = \frac{122(2*0.8-0.24)^2}{32} = 7.0516 \text{ kN-m/m}$

$R_u = \frac{7.0516 * 10^6}{0.9 * 1000 (125)^2} = 0.5015$ $\qquad M = 19.765$

$\rho = 0.0012 < \rho_{min} = 0.0018$ use.

$A_{s\,min} = 0.0018 * 1000 * 200 = 360 \text{ mm}^2/\text{m}$

use $\phi 10$ $\therefore$ Spacing $= \frac{78.5 * 1000}{360} = 218.05$ mm $< 3h$ ok.
600 mm

use $\phi 10$ @ 210 mm c/c

$L_{d\,req} = \frac{18 * 10 * 420}{25 \sqrt{25}} = 345.6$ mm

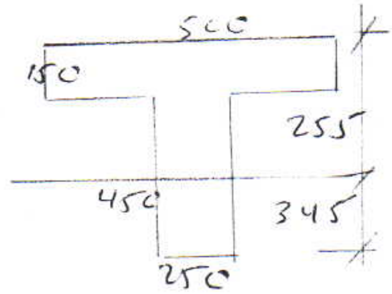
$L_{d\,provided} = \frac{800-240}{2} - 70 = 210$ mm < required

use hook: $L_{dh} = \frac{420 * 10}{4\sqrt{25}} = 210$ mm ok provided

Q.4

$$\bar{y} = \frac{500*150*75 + 250*450(225+150)}{500*150 + 250*450}$$

$$= 255 \text{ mm}$$



$$I_g = \frac{500(255)^3}{3} - \frac{250(105)^3}{3} + \frac{250(345)^3}{3}$$

$$= 6.0891*10^9 \text{ mm}^4$$

$$M_{cr} = \frac{0.62\sqrt{25}*6.0891*10^9}{345*10^6} = 54.714 \text{ kN.m}$$

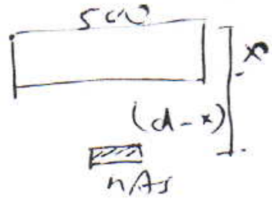
$$M_{a(d.l)} = \frac{20(6)^2}{8} = 90 \text{ kN.m}$$

$$M_{a(d+L)} = 90 + 40*2 = 170 \text{ kN.m}$$

$$A = 500*150*75 = 5625000 \text{ mm}^3$$

$$B = 9*4*314(530-150) = 4,295,520 \text{ mm}^3$$

$\Big\}$ ∴ section



$$500\frac{x^2}{2} = 9*4*314(530-x)$$

$$250x^2 = 11304(530-x)$$

$$x^2 + 45.216x - 23964.48 = 0$$

$$x = 133.84 \text{ mm}$$

$$I_{cr} = \frac{500(133.84)^3}{3} + 11304(530-133.84)^2 = 2.1737*10^9 \text{ mm}^4$$

$$I_{eff\,d.l} = \left(\frac{54.714}{90}\right)^3\left[6.0891*10^9 - 2.1737*10^9\right] + 2.1737*10^9$$

$$= 3.0534*10^9 \text{ mm}^4$$

$$\Delta_{d.l} = \frac{5*20(6000)^4}{384*4700\sqrt{25}*3.0534*10^9} = 4.704 \text{ mm.}$$

$$I_{eff\,(d+L)} = \left(\frac{54.714}{170}\right)^3 \left[6.0891 - 2.1737\right] * 10^9 + 2.1737 * 10^9$$

$$= 2.304 * 10^9 \text{ mm}^4$$

$$\Delta_{d+L} = \frac{5 * 20 * (6000)^4}{384 * 4700\sqrt{25} * 2.304 * 10^9} + \frac{40000\,(2000)(3(6000)^2 - 4(2000)^2)}{24 * 4700\sqrt{25} * 2.304 * 10^9}$$

$$= 6.233 + 5.664 = 11.897 \text{ mm}$$

$$\Delta im_{LL} = 11.897 - 4.704 = 7.193 \text{ mm}$$

$$30\%\,LL = 0.3 * 7.193 = 2.1579 \text{ mm}$$

$$\lambda_{24} = 1.7 \qquad \Delta sus = 1.7\,(4.704 + 2.1579)$$
$$= 11.665 \text{ mm}$$

$$\text{Total} = 11.665 + 7.193 = 18.858 \text{ mm} \leq \frac{6000}{240}$$
$$\leq 25 \text{ mm}$$

ok