University Of Technology
Building and Construction Eng. Dept.
Final Exam – First Attempt – 2014/2015

Subject :Concrete structures — Class: Fourth
Branch :Building and Construction Management Engineering — Time : 3 Hours
Examiner :Dr. Iqbal N. Gorgis — Date : 7 / 6 / 2015

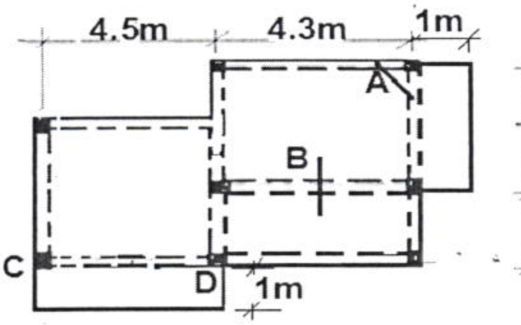
Note: Use **f 'c = 25 MPa and fy = 420 MPa** for solving all the questions.

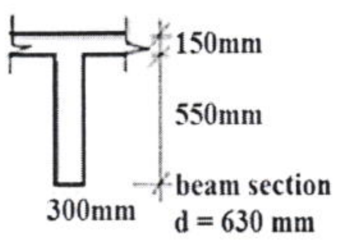
Solve only **four** questions.

Q.1: A concrete slab with 150 mm thickness supports service dead load of 6 kN/m^2 including its own weight and service live loads of 3 kN/m^2, find:

1- Area of steel reinforcement required for the slab at point A, and B using Φ12mm.

2- Total loads on beam CD? (the spans are c/c)



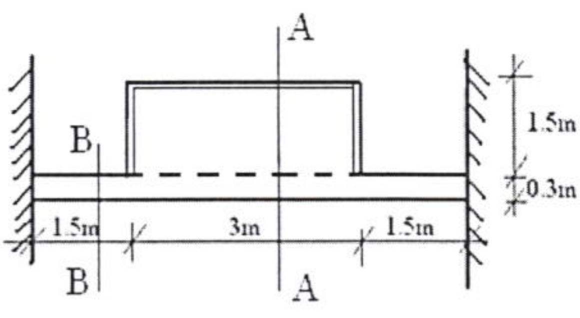


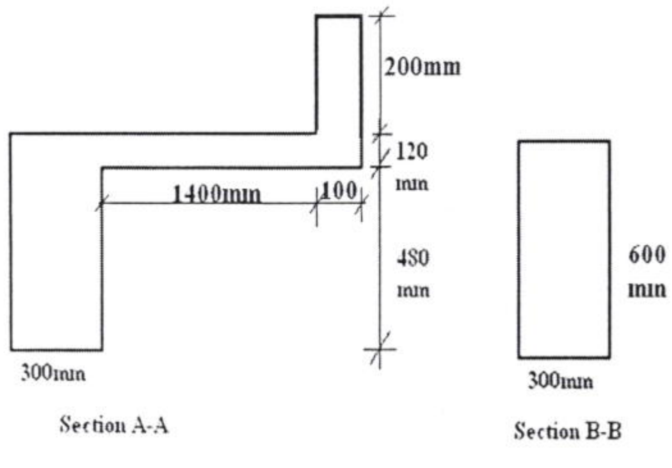
All beams are 300mm in width and all columns are 300*300mm

Q.2: Answer **either A or B** :

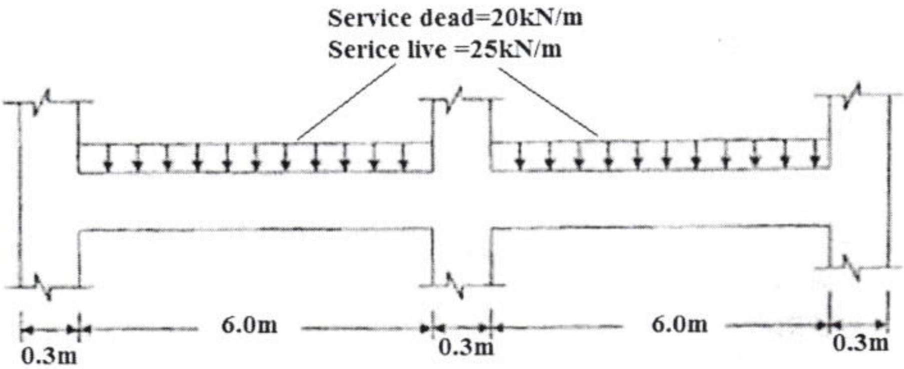
A) A circular short spirally reinforced column with 400mm diameter supports a factored load of 800kN. The load is applied with eccentricities of $\mathbf{e_y}$ = 130 mm and $\mathbf{e_x}$ = 152mm, find the steel area required using bars with 30 mm diameter for longitudinal and 10mm for spiral (use d' = 60mm)?

B) A concrete beam with cantilever slabs as shown, check only if the critical section of the beam can with stand the torsion and shear loading. The dead load including slab dead weight is 4 kN/m^2 and live load of 3 kN/m^2 use bars with 10mm diameter (d= 530mm).





Q.3:Design the critical section of the beam for bending and shear using bars with 25mm in diameter and 10 mm stirrups, if b=250mm , $\rho = 0.5\rho_{max}$ (assume weight of beam 5kN/m) .

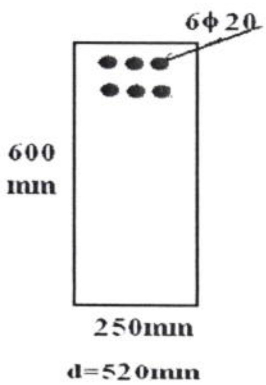


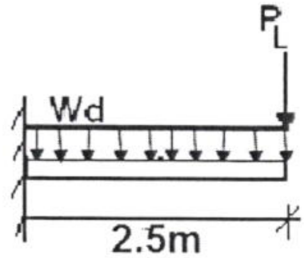
Q.4: Design a wall footing for a masonry wall with 250mm thickness, the wall supports a service live load of 60 and service dead loads of 50 kN/m. The bearing capacity of the soil is 120kN/m^2 at depth of 0.75m for γ soil = 16 kN/m^3 (try thickness of footing of 250 mm using bars with diameter of 12mm and cover of 70mm).

Q.5: Check the deflection of the free end of the beam shown if the beam is part of roof supporting or attached to nonstructural elements likely to be damaged by large deflections and 50% of live load is continued for 24 months. The distributed dead load including its own weight is 15kN/m and concentrated live load of 50kN.

$\Delta_{\text{free end}} = \frac{W_d L^4}{8EI}$, and $\Delta_{\text{free end}} = \frac{P_L L^3}{3EI}$?

$\frac{b * y^2}{2} = nAs * (d - y) \quad and \quad I_{crack} = \frac{b * y^3}{3} + nAs * (d - y)^2$





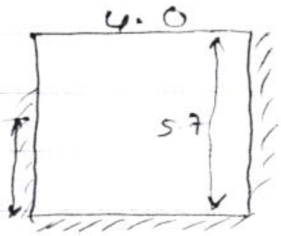
Concrete structures 2015

Set -1 $f'_c = 25$ MPa $f_y = 420$ MPa.

Solutions:

Q.1

(1) $W_u = 1.2 * 6 + 1.6 * 3 = \underset{D.L.}{7.2} + \underset{L.L.}{4.8} = 12$ kN/m



For point B,

case 9 $m = \frac{4}{5.7} = 0.7$

from oneway $= \frac{wL^2}{12} = \frac{12(2)^2}{12} = 4$ kN.m/m (< 3m)

$M_b^- = 0.011 * 12 * (5.7)^2 = 4.288$ kN.m (given) الأكبر

For point A,

$M^+_a = (0.033 * 7.2 + 0.05 * 4.8)(4)^2 = 7.64$ kN.m/m.

$d_{av} = 150 - 20 - 12 = 118$ mm.

$A_{s\,min} = 0.0018 * 1000 * 150 = 270$ mm²/m

$\mu = \frac{f_y}{0.85 f'_c} = 19.764$

Mu	Ru	ρ	As	Spacing
7.64	0.6096	0.00147 < 0.0018	270	$\frac{113 \times 1000}{270} = 418$; 2h = 300
4.288	0.342			

both directions.

Noted: $R_u = \frac{M_u \times 10^6}{0.9 \times 1000 (118)^2}$

use Ø12 @ 300 mm c/c.

(2) Load on beam CD:

from cantilever $= 12 \times 1 = 12$ kN/m.

$m = \frac{4.2}{4.7}$ from slab (case 4) (m = 0.9)

$= \frac{0.4 \times 12 \times 4.2 \times 4.7}{2 \times 4.2} = 11.28$ kN/m.

wt. of beam $= 1.2 \times 24 \times 0.3 \times 0.55 = 4.752$ kN/m.

$\Sigma = 28.032$ kN/m.

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Q.2 either A or B:-

(A) $P_u = 800$ kN.

$e_{new} = \sqrt{(130)^2 + (152)^2} = 200$ mm.

$\frac{e}{D} = \frac{200}{400} = 0.5 \quad \Big\} \quad \gamma = \frac{400 - 120}{400} = 0.7$

$k = \frac{800 * 1000}{0.75 * 25 * \frac{\pi (400)^2}{4}} = 0.3395$

$\rho_g = 0.03 = \frac{A_{st}}{A_g}$

$\therefore A_{st} = 0.03 * \pi (400)^2 / 4 = 3769.91$ mm²

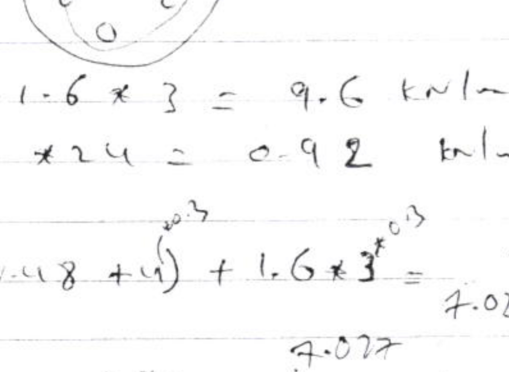
no. $\phi 30 = \frac{3769.91}{\pi (30)^2/4} = 5.3 \approx \underline{6}$ bars $\phi 30$ mm

$\phi 10$ mm

$\rho_{sp} = 0.45 \left[\left(\frac{400}{400 - 80} \right)^2 - 1 \right] \frac{25}{420} = 0.01507$

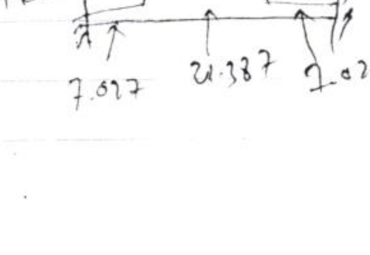
$S_p = \frac{4 * 79 (320 - 10)}{0.01507 \ (320)^2} = 63.5 \approx 60 \ \begin{matrix} > 25 \text{ mm} \\ < 75 \text{ mm} \end{matrix}$

use $\phi 10$ @ 60 mm c/c.



B/ $W_u = 1.2(4) + 1.6 * 3 = 9.6$ kN/m²

$P = 1.2 * 0.32 * 0.1 * 24 = 0.92$ kN/m



w of rectangular =

$1.2 \left[24 * 0.3 * 0.48 + 4 \right) + 1.6 * 3 * 0.3 = 7.027$ kN/m

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Σ load for shear $= 9.6 * 1.4 + 0.92 + 7.027 = 21.387$ kN/m.

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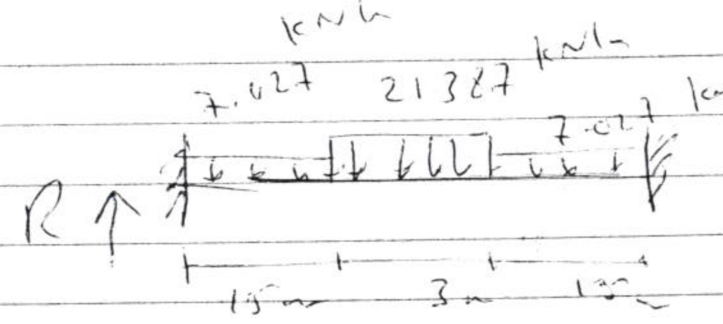


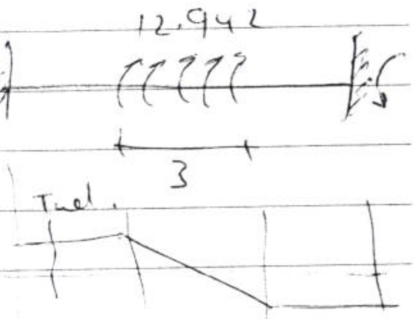
$R = (7.027 * 3 + 21.387 * 3)/2 = 42.621$ kN

$V_{ud} = 42.621 - 0.53 * 7.027 = 38.897$ kN

For Torsion =

$0.92\,(0.1 + 1.4 + 0.15) + 9.6 * 1.4\,(0.7 + 0.15)$

$= 12.942$ kN·m



$T_{ud} = 12.943 * \frac{3}{2} = 19.443$

$x = 300 - 2(40) - 10 = 210$ mm

$y = 600 - 2(40) - 10 = 510$ mm

$P_h = 2(210 + 510) = 1440$ mm

$A_{oh} = 210 * 510 = 107100$ mm²

$T_{cr} = 0.75 \frac{\sqrt{25}}{12} \frac{(300 * 600)^2}{2\,(300 + 600)\,10^6} = 5.625$ kN·m < 19.442 kN·m.

we need Torsion design

$\sqrt{\left(\frac{38.397 \times 10^3}{300 * 510}\right)^2 + \left(\frac{19.413 \times 10^6 * 1440}{1.7\,(107100)^2}\right)^2} \le \frac{5}{6} * 0.75 \sqrt{25}$

$1.454 \le 3.125$

ok.

The section is adequate.

Q.3

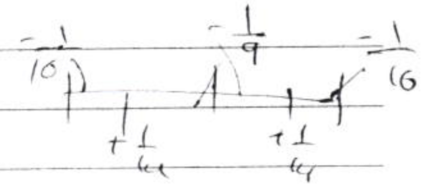
$h_{min} = \frac{L}{18.5} = \frac{6000}{18.5} = 324.3$ mm.

$\rho_{max} = 0.75 (0.85)^2 \frac{25}{420} \left(\frac{600}{600 + 420} \right) = 0.0189.$

$\rho = 0.5 * 0.0189 = 0.00995$ //.

$W_u = 1.2 (20+5) + 1.6 (25) = \underline{70}$ kN/m.

$M_{critical} = \frac{1}{9} * 70 * (6)^2 = 280$ kN.m



$280 * 10^6 = 0.9 * 0.00995 * 250 \, \underline{d}^2 * 420 \left(1 - 0.59 * 0.00995 \frac{420}{25}\right)$

$d = 574.71 \approx 580$ mm $+ 70 =$ (650 mm = h) $>$ h_{min} ok

check
wt. of beam $= 24 * 0.25 * 0.65 = 4$ kN/m < 5 kN/m ok

$A_{s\,req} = 0.00995 * 250 * 580 = 1442.75$ mm²

no. of bars $= \frac{1442.75}{491} =$ $3 \phi 25$

$V_u = 1.15 \frac{70 * 6}{2} = 241.5$ kN.

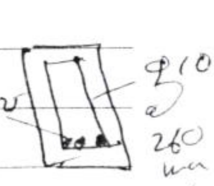
$V_{ud} = 241.5 - 70 (0.58) = 200.9$ kN

$\phi V_c = 0.75 \frac{\sqrt{25}}{6} * 250 * \frac{580}{1000} = 90.625$ kN.

$\phi V_s = 200.9 - 90.625 = 110.275 \le 2 V_c = 241.66$ kN.
$\le 4 V_c = 483.3$ kN.

$S_{req} = \frac{\phi A_v \cdot f_y \, d}{\phi V_s} = \frac{0.75 * 157 * 420 * 580}{110.275 * 1000}$

$= 260.11$ mm.



$S_{max} \le \frac{d}{2} \le 600 \text{ mm} \le \frac{3 A_v f_y}{b_w} \le \frac{16 A_v f_y}{b_w \sqrt{f'_c}}$

$290 \le 600 \le 791.3 \le 844.03$ mm.

$\therefore$ use ϕ 10 mm @ 260 mm c/c.

Q.4

$q_{net} = 120 - 0.75\left(\frac{16+24}{2}\right) = 105$ kN/m²

$b = \frac{60+50}{105} = 1.047 \approx 1.0$ m.

$q_{ult} = \frac{1.2(60)+1.6(50)}{1.0} = 152$ kN/m²

h = 250 mm d = 250 − 70 − 6 = 174 mm.

$V_u = 152\left[\frac{1-0.25}{2} - 0.174\right] = 30.552$ kN.

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

h = 250 mm adequate.

$M_u = \frac{152\,(2*1-0.25)^2}{32} = 14.55$ kN.m.

$R_u = \frac{14.55 * 10^6}{0.9*1000\,(174)^2} = 0.5339$, $m = 19.765$

$\rho = \frac{1}{19.765}\left[1-\sqrt{1-\frac{2*0.5339*19.765}{420}}\right] = 0.00128 < 0.0018$

∴ both direction use $A_{s\,min} = 0.0018 * 1000 * 250$
$= 450$ mm²/m

spacing $= \frac{113 * 1000}{450} = 251.1 < 2h = 500$ mm ok.
use Ø12 @ 250 mm c/c.

L_d provided $= \frac{1000-250}{2} - 70 = 305$ mm

$L_{dreq} = \frac{18 * 12 * 420}{25\sqrt{25}} = 725.7$ mm > 305 mm use hooks

$L_{dh} = \frac{420*12}{4\sqrt{25}} \geq 8*12 \geq 150$ mm.

$\boxed{252} \geq 96 \geq 150$ m.
< 305 ok use hooks.

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Q.5 $I_g = \frac{250(600)^3}{12} = 45 * 10^8$ mm^4

$M_{cr} = \frac{0.62\sqrt{25} * 45 * 10^8}{300 * 10^6} = 46.5$ kN.m.

$n = \frac{200000}{4700\sqrt{25}} \approx 9$

$A_s = 6 \frac{\pi(20)^2}{4} = 1884.956$ mm^2 } $nA_s = 16964.6$ mm^2

$250 \frac{y^2}{2} = 16964.6 (520 - y)$ بالحل $y = 206.3$ mm

$I_{cr} = \frac{250(206.3)^3}{3} + 16964.6(520 - 206.3)^2 = 24.011 * 10^8$ mm^4

$(M_a)_{dead} = \frac{15(2.5)^2}{2} = 46.875$ kN.m.

$(M_a)_{dead+live} = 46.875 + 50 * 2.5 = 171.875$ kN.m.

$I_{eff,dead} = \left(\frac{46.5}{46.875}\right)^3 (I_g - I_{cr}) + I_{cr} = 44.5 * 10^8$ mm^4 $< I_g$ ok

$I_{eff,d+L} = \left(\frac{46.5}{171.875}\right)^3 (45 - 24) * 10^8 + 24 * 10^8 = 24.4266 * 10^8$ mm^4 $< I_g$ ok

$\Delta_{i\,dead} = \frac{15(2500)^4}{8 * 4700\sqrt{25} * 44.5 * 10^8} = 0.7$ mm.

$\Delta_{i\,dead+live} = \frac{15(2500)^4}{8 * 4700\sqrt{25} * 244266 * 10^8} + \frac{50000 * (2500)^3}{3 * 4700\sqrt{25} * 244266 * 10^8}$

1.2759   4.5367

$= 5.8126$ mm

$\Delta_{i\,L.L} = 5.8126 - 0.7 = 5.112$ mm

$0.5\%\ \Delta_{i\,L.L} = 2.556$ mm

$\lambda = \frac{\xi}{1+50\rho'} = \xi = 1.7$ ($\rho' = 0$)

$\Delta_{sust} = 1.7(0.7 + 2.556) = 5.536$ mm

$\frac{L}{480} \geq 5.536 + 2.556$

$\frac{2500}{480} = 5.208 \not\geq 8.09$ not adequate