University Of Technology
Building and Construction Engineering Department
Final Exam. / 2012/2013

Subject : *Concrete structures*
Division: *Building and project management dept.*
Examiner : *Asst. Prof. Dr. Iqbal N. Gorgis*

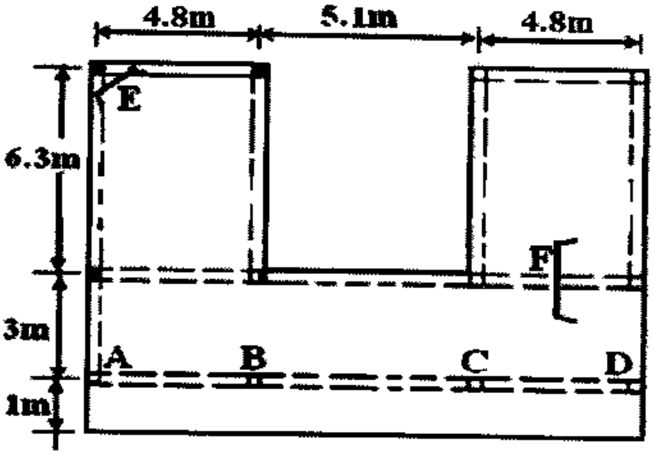
Year : 4^{th}
Time : 3 hours
Date : 8/6/ 2010

Notes: Solve only **THREE** questions

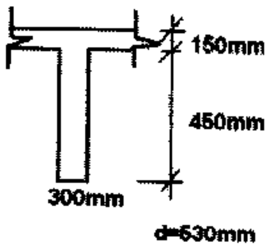
Use $f'c = 25$ MPa and $fy = 420$ MPa for solving the questions.

Q.1): Two way concrete slab with thickness of 150mm support a service dead load of 4 kN/m^2 and service live load of 2.5 kN/m^2, determine:

1. Load on beam ABCD. (5%)
2. Area of steel required for continuous beam ABCD at critical section only. (13%)
3. Area of steel required for points E and F using bars with 12mm diameter. (15%)

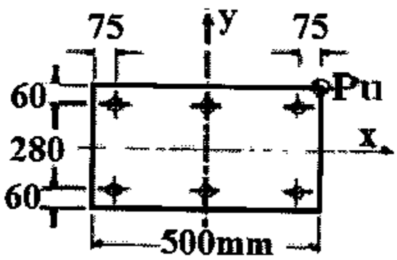


Notes: All columns are 0.3x 0.3m
All beam's width are 0.3 m
All dimensions are center to center.



Beam Section

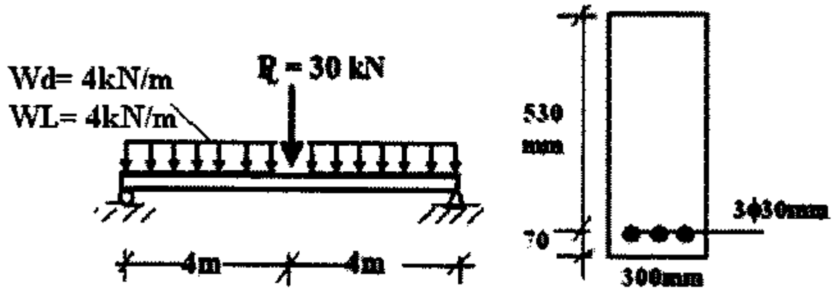
Q.2-a) A short rectangular tied column with 400x500 mm reinforced with 6 Ø $30mm$ arranged as shown. Estimate the axial load Pu loaded at the corner of column as shown. (17%)



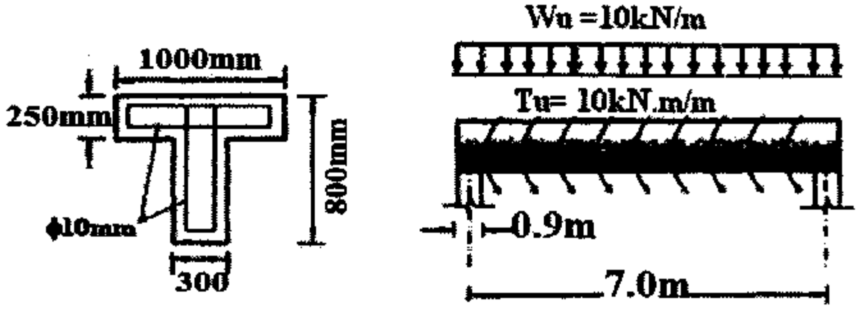
Q.2-b) A brick wall with 240 mm thickness supports a dead load of 45 kN/m and live load of 40 kN/m. Design a wall footing to withstand the loads and draw the section of footing so that: (16%)

1. The allowable soil capacity at depth of 0.8 m was 120 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).

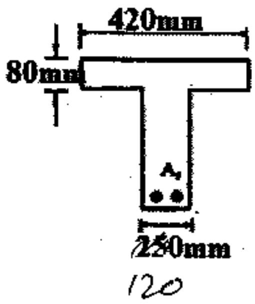
Q.3): The simply supported beam is a part of floor not supporting or attached to non-structural elements likely to be damaged by large deflection. Check the deflection of $(\Delta_{im})_{L.L.}$ to not exceed the limit of ACI-Code 318. The beam supports service distributed (dead load including its own weight of 4 kN/m and live load of 4 kN/m) with a concentrated service live load of 30 kN. $\Delta_{im} = \frac{5W_d L^4}{384EI}$ $\Delta_{im} = \frac{P_L L^3}{48EI}$ (34%)



Q.4-a): The beam shown is subjected to uniform distributed load of 10 kN/m and uniform distributed torsional moment of 10 kN.m along its span. Check the section adequacy to withstand the loading considering the contribution of flanges (d = 730mm). (18%)



Q.4-b) Compute the area of steel required for the T- beam shown in figure if it is subjected to ultimate moment of 280 kN.m (d = 370mm). (15%)



Set 1

« $f'_c = 25$ MPa $f_y = 420$ MPa »

Q.1 ① Load on beam ABCD:

$W_u = 1.2 * 4 + 1.6(2.5) = 4.8 + 4 = 8.8$ kN/m²

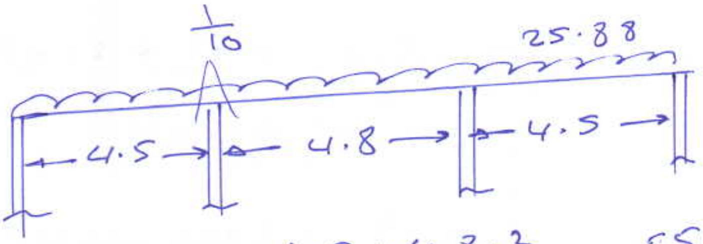
Cantilever $= 1 * 8.8 = 8.8$ kN/m

one way slab, $\frac{3 * 8.8}{2} = 13.2$ kN/m

wt. of beam $= 1.2 * 0.3 * 0.45 * 24 = 3.88$ kN/m

$\Sigma = 25.88$ kN/m

②



$M_u = \frac{1}{10}(25.88)\left(\frac{4.5 + 4.8}{2}\right)^2 = 55.96$ kN.m

$R_n = \frac{55.96 * 10^6}{0.9 * 300 * (530)^2} = 0.738$

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

$\rho = \frac{1}{19.76}\left[1 - \sqrt{1 - \frac{2 * 19.76 * 0.738}{420}}\right] = 0.001788$

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

∴ use $A_{s\,min} = 0.0033 * 300 * 530 = 524.7$ mm²

③ Point F $m = \frac{4.5}{6} = 0.75$ case 7

$(M\text{-ve})_b = 0.044 * 8.8 * 6^2 = \boxed{13.94 \text{ kN.m/m}}$ govern.

$(M\text{-ve})_{oneway} = \frac{8.8(3)^2}{12} = 6.6$ kN.m/m

Point E case 7 $m = 0.75$

$M_{+ve} = (0.051 * 4.8 + 0.056 * 4)(4.5)^2 = 9.49$ kN.m

Point	M_u	R_n	ρ	A_s
F	13.94	1.1124	0.0027	318.6
E	9.49	0.757	0.0018	270 mm²

notes:-

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

$A_{s\,min} = 0.0018 * 150000 = 270$ mm²/m

$m = 19.76$

Q.2 a

moment about y = $e_x = 250$ mm | about x $e_y = 200$ mm

$\frac{e}{h} = 0.5$ | $\frac{e}{h} = 0.5$

$\gamma = \frac{500 - 2(75)}{500} = 0.7$ | $\gamma = \frac{400 - 2(60)}{400} = 0.7$

$\rho = \frac{4 * (\frac{\pi (30)^2}{4})}{500 * 400} = 0.014$ | $\rho = \frac{6 * \pi (30)^2/4}{500 * 400} = 0.0212$

from graph: $k = 0.35$ | $k = 0.41$

$P_{noy} = \frac{0.35 * 25 * 500 * 400}{1000}$
$= 1750$ kN.

$P_{onx} = \frac{0.41 * 25 * 500 * 400}{1000}$
$= 2050$ kN

$P_n = 0.85 * 25 (200000 - 4242) + 4242 * 420) / 1000$
$= 5941.497$ kN.

$\frac{1}{P_u} = \frac{1}{1750} + \frac{1}{2050} - \frac{1}{5941.497}$

$P_u = 1122.46 \underset{ok}{>} 0.1 * 5941.497 * 0.65 = 386.197$ kN

Q.2-b $q_{net} = 120 - 0.8 (\frac{24+16}{2}) = 104$ kN/m²

$b = \frac{45+40}{104} = 0.81$ m use 1.0 m.

$q_{ult} = \frac{1.2 (45) + 1.6 (40)}{1 * 1} = 118$ kN/m²

$h = 250 - 70 - 6 = 174$ mm

$V_{ud} = 118 (\frac{1 - 0.24}{2} - 0.174) = 24.308$ kN

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

$M_u = \frac{118 (2*1 - 0.24)^2}{32} = 11.42$ kN.m

$R_n = \frac{11.42 * 10^6}{0.9 * 1000 (174)^2} = 0.419$ $m = 19.76$

$\rho = 0.001$ use $\rho_{min} = 0.0018$ $As_{min} = 450$ mm²/m

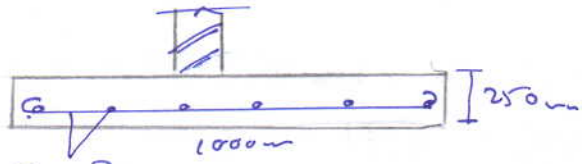
spacing $= \frac{113000}{450} = 251.11$ mm use $\phi 12$ @ 250 mm c/c

$L_d = \frac{18 * 12 * 420}{25 \sqrt{25}} = 725.76$ mm.

$L_d\ provided = \frac{1000-240}{2} - 70 = 310\ mm$

use $L_{d\,hook} = \frac{420 * 12}{4\sqrt{25}} = \boxed{252\ mm} > 8*12 = 96\ mm > 150\ mm$

ok.



$\Phi 12 @ 250\ mm\ c/c.$

Q.3 $I_g = \frac{300(600)^3}{12} = 54 * 10^8\ mm^4$

$M_{cr} = \frac{0.62\sqrt{25} * 54 * 10^8}{300 * 10^6} = 55.8\ kN.m$

$(M_a)_d = \frac{4(8)^2}{8} = 32\ kN.m < M_{cr}\quad (I_{eff})_D = I_g$

$(M_a)_{d+L} = 32 + \frac{30(8)}{4} = 92\ kN.m$

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

$\frac{300\,y^2}{2} = 9 * 2121\,(530 - y)$

$150\,y^2 + 19089\,y - 10117170 = 0$

$y = 203.76\ mm$

$I_{cr} = \frac{300\,(203.76)^3}{3} + 9 * 2121\,(530 - 203.76)^2 = 28.777 * 10^8\ mm^4$

$(I_{eff})_{D+L} = \left(\frac{55.8}{92}\right)^3 * 54 * 10^8 + \left(1 - \left(\frac{55.8}{92}\right)^3\right) 28.777 * 10^8 = 34.405 * 10^8\ mm^4$

$(\Delta i_m)_D = \frac{5 * 4 * (8000)^4}{384 * 4700\sqrt{25} * 54 * 10^8} = 1.681\ mm$

$(\Delta i_m)_{D+L} = \frac{5 * 8\,(8000)^4}{384 * 4700\sqrt{25} * 34.405 * 10^8} + \frac{30000\,(8000)^3}{48 * 4700\sqrt{25} * 34.405 * 10^8}$

$5.27715 + 3.9579$

$= 9.235\ mm$

$(\Delta i)_{L.L} = 9.235 - 1.681 = 7.554\ mm$

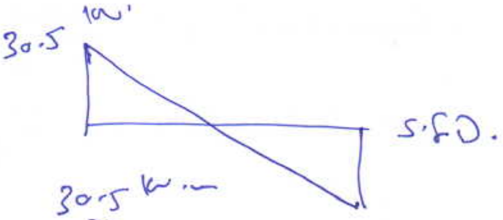
$7.554 \le \frac{8000}{360} = 22.22\ mm$

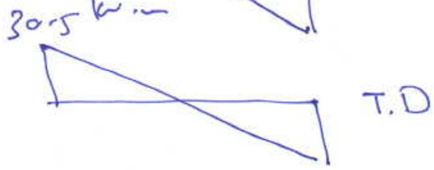
ok

Q.4 a

$7 - 0.9 = 6.1\ m$

$\frac{10 * 6.1}{2} = 30.5\ kN$





$V_{ud} = 30.5 - 0.73 * 10 = 23.2\ kN.$

$T_{ud} = 30.5 - 0.73 * 10 = 23.2\ kN.m.$

$x = 300 - 2 * 40 - 10 = 210\ mm,\ y = 800 - 20 - 40 - 10 = 730\ mm$

$x_1 = 250 - 2(20) - (10) = 200\ mm,\ y_1 = 1000 - 80 - 10 = 910\ mm$

$A_{oh} = 210 * 730 + 910 * 200 - 210 * 200 = 293300\ mm^2$

$P_{oh} = 2(910 + 730) = 3280\ mm$

$$\sqrt{\left(\frac{23.2 * 10^3}{300 * 730}\right)^2 + \left(\frac{23.2 * 10^6 * 3280}{1.7(293300)^2}\right)^2} \le 0.75 * \frac{5}{6}\sqrt{25}$$

$$0.531 \le 3.125 \text{ o.k.}$$

Q.4 b

Try $a = h_f = 80\ mm$

$M_{uf} = 0.9 * 0.85 * 25 * 420 * 80 (370 - \frac{80}{2}) / 10^6 = 212.06\ kN.m$

T-section

$M_{web} = 280 - 212.06 = 67.94\ kN.m$

$67.94 * 10^6 = 0.9 * 0.85 * 25 * 250 x (370 - 80 - \frac{x}{2})$

$14209.67 = 290x - 0.5x^2$

$x^2 - 580x + 28419.35 = 0$

$x = 54.03\ mm.$

$A_s = \frac{0.85 * 25 (250 * 54.03 + 80 * 420)}{420} = 2383.4\ mm^2$

$A_{sf} = \frac{0.85 * 25 (420 - 250) 80}{420} = 688.09\ mm^2$

$\rho''_{max} = 0.75 \left[(0.85)^2 \frac{25}{420} \frac{600}{600 + 420} + \frac{688.09}{250 * 370}\right] = 0.0246$

$A_{smax} = 0.0246 * 250 * 370 = 2275.5\ mm^2$

Use work.