University Of Technology

Building and Construction Eng. Dept.

Final Exam –2013/2014

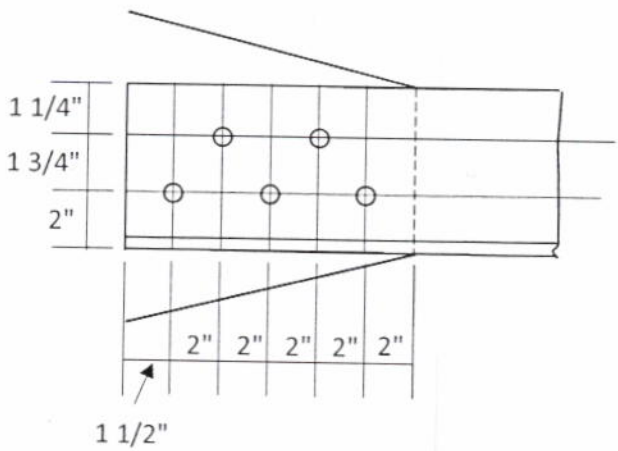
Subject : Structural Design | **Class: Fourth year**

Branch : Water and Dams Eng. | **Time : 3 Hours**

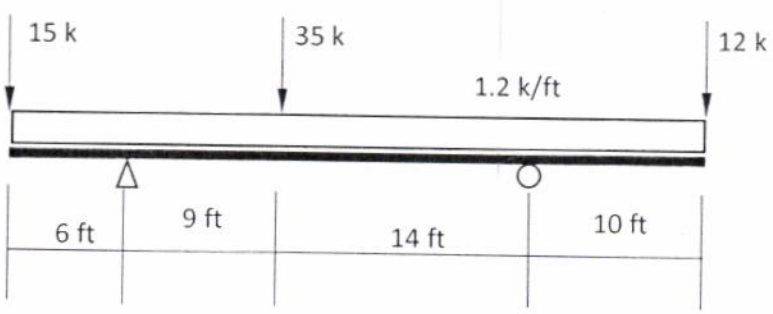
Examiners : | **Date: 28/5/2014**

Part 1: Steel Structures

Q1: Compute the tensile capacity for the double-angle member L5 × 3 1/2 × 1/2 shown in the figure. The bolts are 3/4-in. diameter and the steel is A36.



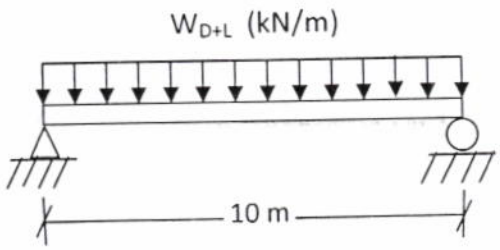
Q2: Select the lightest W shape for the beam shown in the figure. Lateral support exists at the reactions and at the concentrated loads. Assume A36 steel. Consider moment and shear only. The distributed load shown does not include the beam weight.

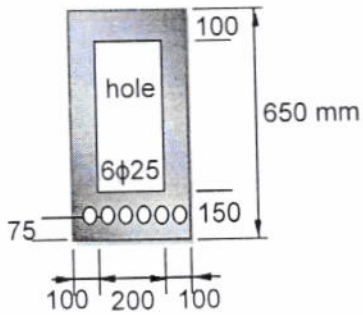


Part 2: Reinforced Concrete Structures: Answer Two questions only.

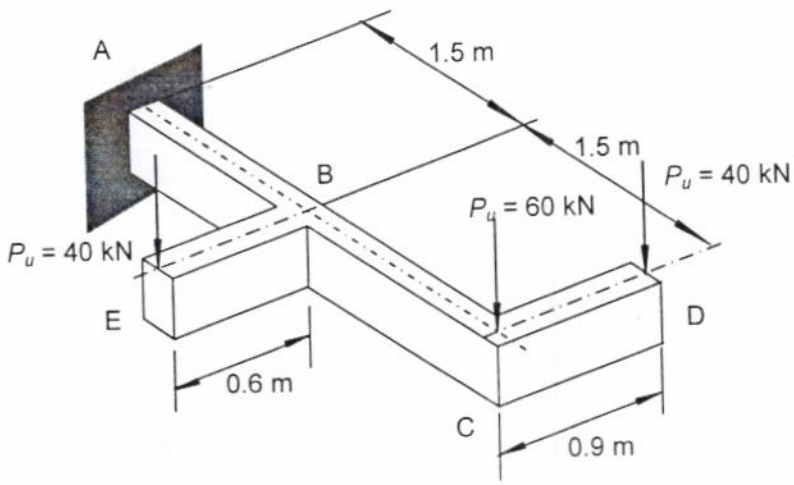
(Use $f_c' = 22\ \text{N/mm}^2$ and $f_y = 420\ \text{N/mm}^2$)

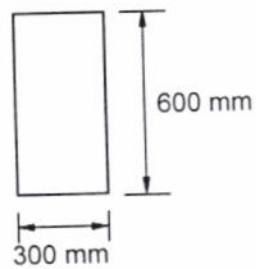
Q1: The simply supported beam shown in the figure carries a service distributed dead load of (20 kN/m) (beam weight is not included) and a service distributed live load (W_L). Find the maximum value of (W_L (kN/m)) that the beam can carry.



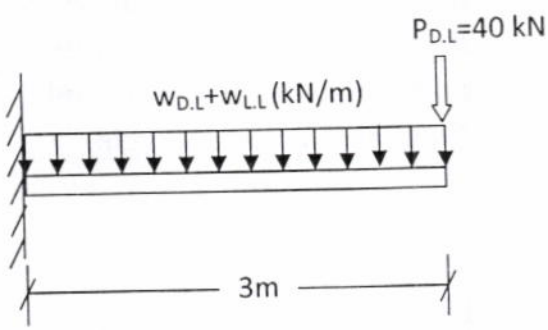


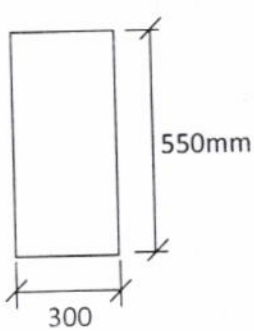
Q2: Check only if the beam section (size) for segment BC can withstand the shear and torsion loading shown in the figure. Neglect the beam weight. Use stirrups of 12 mm diameter.





Q3: Design the flexural reinforcement for the cantilever beam shown in the figure. The beam must carry a dead load of (20kN/m) (beam weight is not included) and a concentrated dead load of (40 kN) at its end in addition to a live load of (30 kN/m). Allow (70mm) to the center of the nearest longitudinal bars from the compression or tension face of the beam. Use (10mm) diameter stirrups in your final design sketch.





حلول أسئلة تصاميم كونكريتية
المرحلة الرابعة - ستود

Q_1: $N_T = A_s f_y = (6*490)*420*10^{-3} = 1234.8^{KN}$ (2940)

$N_c = 0.85 f_c' h_f b = 0.85(22)(100)(400)10^{-3} = 748^{KN}$

$N_T > N_c \Rightarrow a > h_f$

$$a = \frac{N_T - N_c}{0.85 f_c' b_w} + h_f = \left(\frac{1234.8-748}{0.85*22*200}\right)10^3 + h_f = 130.16 + 100 = 230.16$$

$$\rho = \frac{1.4}{420} = 0.0033 \quad , \quad \rho_{act} = \frac{2940}{400*575} = 0.01278$$

$$\varepsilon_t = 0.003\left(\frac{575(0.85)}{230.16} - 1\right) = 0.00337$$

$$\Rightarrow \phi = 0.48 + 83*0.00337 = 0.76$$

$$\bar{y} = \frac{\Sigma A y}{\Sigma A} \quad , \quad A_1 = 100*400 = 40000 \quad , \quad \bar{y} = 50$$

$$A_2 = 200*130.16 = 26032 \quad , \quad \bar{y} = 100 + 65.08 = 165.08$$

$$\bar{y} = \frac{40000(50) + 26032(165.08)}{40000 + 26032} \quad (4297362.56) = 95.368$$

$$\Rightarrow z = d - \bar{y} = 575 - 95.368 = 479.632$$

$$M_n = N_T z = 1234.8*479.632 = 592.25^{KN.m}$$

$$M_R = 592.25*0.76 = 450.11^{KN.m}$$

$$450.11 = 1.2\left(\frac{24.32(100)}{8}\right) + 1.6\left(\frac{w_L(100)}{8}\right)$$

$$\Rightarrow w_L = 4.266^{KN.m}.$$

Q2: T_u at c = 40 (0.9 − 0.15) = 30 kN.m

T_u at B = 40 (0.6 + 0.15) = 30 kN.m

V_u at A = 140 kN

V_u at C = 100 kN.

$$T_u \le \phi \frac{\sqrt{f_c'}}{12}\left(\frac{A_{cp}^2}{P_{cp}}\right)$$

$A_{cp} = 300 * 600 = 180\,000 \text{ mm}^2$

$P_{cp} = (300 + 600)2 = 1800 \text{ mm}$

$$T_u \le \frac{0.75\sqrt{22}}{12}\left(\frac{(180000)^2}{1800} * \frac{1}{10^6}\right) \Rightarrow T_u \not\geq 5.27 \text{ kN.m}$$

$$\sqrt{\left(\frac{V_u}{b_w d}\right)^2 + \left(\frac{T_u P_h}{1.7 A_{oh}^2}\right)^2} \le \phi\left(\frac{V_c}{b_w d} + \frac{2}{3}\sqrt{f_c'}\right), \quad \frac{V_c}{b_w d} = \frac{5}{6}\sqrt{f_c'}$$

$X_1 = 300 - (40*2) - 12 = 208$, $y_1 = 600 - 2(40+6) = 508$

$A_{oh} = 208 * 508 = 105664 \text{ mm}^2$

$P_h = (208 + 508) * 2 = 1432 \text{ mm}$

$A_b = 0.85 A_{oh} = 0.85 (105664) = 89814.4 \text{ mm}^2$

$$\sqrt{\left(\frac{100 * 10^3}{300 * 530}\right)^2 + \left(\frac{30 * 10^6 * 1432}{1.7 (105664)^2}\right)^2} \overset{?}{\le} 0.75\left(\frac{5}{6}\sqrt{f_c'}\right)$$

$0.396 + 5.1229 \not\le 2.93$

$2.35 \not\le 2.93$ (n.k).

If $d = 510$ ⇒ $0.427 + 5.1229 \not\le 2.93$

$2.36 \not\le 2.93$ (n.k).

3: $w_u = 1.2(20+3.96)+1.6*30 = 76.75$ kN/m

$P_D = 1.2*40 = 48$ kN

$M_u = 76.75*\frac{3}{2}^2 + 48*3 = 345.375+144 = 489.375$ kN.m

$\rho_{td} = 0.31875 * \frac{22*0.85}{420} = 0.01419$

$A_{s_{max}} = 0.01419*300*480 = 2043.36\ mm^2$

$a = \frac{2043.36*420}{0.85(22)(300)} = 153$ mm

$M_u = 2043.36*420\left(480-\frac{153}{2}\right)10^{-6} = 346.288$ kN.m

$M_{R_{max}} = 0.9(346.288) = 311.66$ kN.m

$489.375 > 311.66 \Rightarrow$ Doubly Reinf. Sect.

$A_{s1} = A_{s_{max}} = 2043.36\ mm^2$

$M_{R_1} = M_{R_{max}} = 311.66$ kN.m

$M_{R_2} = M_u - M_{R_1} = 489.375 - 311.66 = 177.72$ kN.m

$M_{R_2} = \phi N_c (d-d')$

$N_{c2} = \frac{177.72*10^6}{0.9(480-70)} = 481.626$ kN

$c = 153/0.85 = 180$

$\varepsilon_s' = 0.003\left(\frac{180-70}{180}\right) = 0.00183$

$\varepsilon_y = 420/200000 = 0.0021 > \varepsilon_s'$

$f_s' = 200000*0.00183 = 366.6$ N/mm²

$A_s' = \frac{481.626}{366.66} = 1313.55\ mm^2$ Use $3\phi25 = 1470\ mm^2$

OR

$A_{s2} = 1313.55*\frac{366.66}{420} = 1146.73\ mm^2$

$A_s = A_{s1} + A_{s2} = 2043.36+1146.73 = 3190.1\ mm^2$

(Alternative: $7\phi25 = 3430\ mm^2$)