University of Technology
Building and Construction Eng. Dept.
Final Exam. 2015/2016

Subject: Structural Design
Branch: Geomatic Eng.

Fourth Class
Time : 3 Hrs.

Examiners: Dr. Hussein Al-Quraishi
M.Sc. Ghzwan Ghanim

Note: Open books and notes examination

Concrete Design (Answer Two Questions)

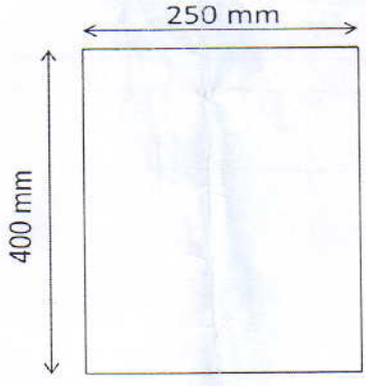
Q.1) Design a smallest possible reinforced rectangular beam section for a simple span of 5m. Uniform service dead load are 11.5 kN/m and 20 kN/m live load. Use fc=21 Mpa ,fy=420 Mpa and d=1.5b, Sketch your design.

(25 Marks)

Q.2) Design a simply supported one-way reinforced concrete floor slab to span 3m and carry a service live load of 8.3 kN/m2 and a service dead load of 1.2 kN/m2. Use fc=21 MPa and fy=420 MPa.

(25 Marks)

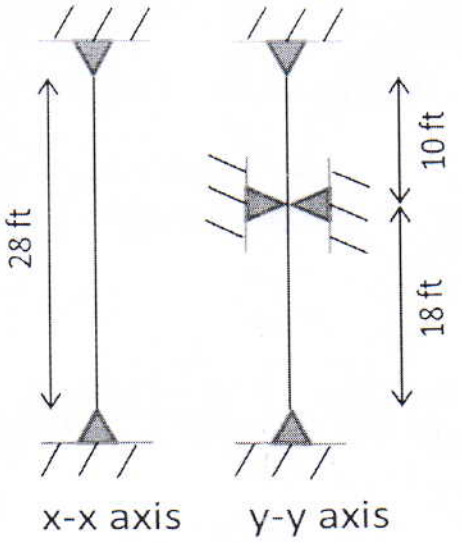
Q.3) Calculate the cracking moment (M_{cr}) for the plain concrete beam shown in figure below. Assume fc=28 MPa. Solve using flexural formula.



(25 Marks)

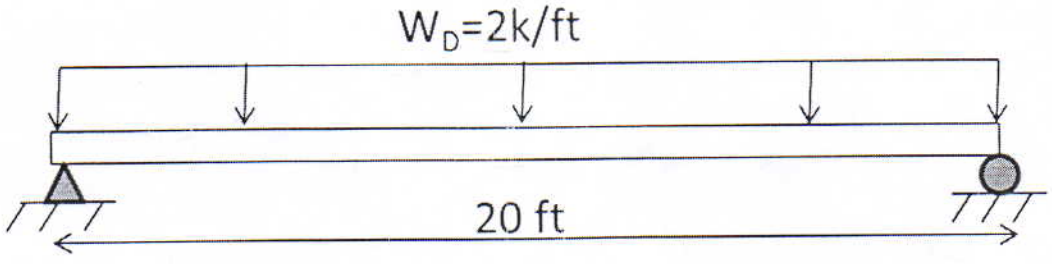
Steel Design (Aswer Two Questions)

Q.1) For 28 ft axially loaded W12x96 column that has the bracing and end support conditions shown in figure below, determine the LRFD design strength $\phi c P_n$ and the ASD allowable design strength P_n/Ω_c .E=29000ksi and fy=50 ksi.



(25 Marks)

Q.2) Select W section for the beam shown below using ASD method. Assuming full lateral support is provided for the compression flange by the floor slab above (Lb=0) and fy=50ksi.



(25 Marks)

Q.3) Select the lightest W10 section that will safety support the service tensile loads P_D=175k and P_L=210k. The member is to be 25 ft long and is assumed to have two lines of holes in each flange and two lines of holes in the web. Assume there are four bolts in each line 3 in center to center. All holes are for 7/8 in diamter bolts. Use f_y= 50ksi, U=0.8 and f_u=65ksi

(25 Marks)

w10 x 60

(1) Steel

Q1) / steel

W 12×96 → (A = 28.2, rx = 5.44, ry = 3.09)

$K_x L_x = 1.0 \times 28 = 28$

$K_y L_y = 1.0 \times 18 = 18$

$K_{cy} L_{cy} = 1.0 \times 10 = 10$ } $\Rightarrow$ 18 (B)

$\left(\frac{KL}{r}\right)_x = \frac{12 \times 28}{5.44} = 61.7$

$\left(\frac{KL}{r}\right)_y = \frac{12 \times 18}{3.09} = 69.9$ ⟵ So (B)

$69.9 = \frac{KL}{r} \leq 4.71\sqrt{\frac{29000}{50}} = 113.4$ / $f_e = \frac{\pi^2 E}{\left(\frac{L}{r}\right)^2}$

$= \frac{\pi^2 \times 29000}{69.92}$

$= 58.5$ (B)

$f_{cr} = (0.658)^{\frac{50}{58.5}} \times 50 = 34.9$

LRFD $\phi = 0.9$

$\phi_c P_c = 28.2 \times 34.9 \times 0.9$

$= 885.7$ k

ASD $\Omega = 1.67$

$\frac{P_n}{\Omega} = \frac{34.9 \times 28.2}{1.67}$

$= 589.3$ k (7)

(2)

Q2/ Steel

LRFD

$W_u = 1.2 + 2 = 2.4$

$M_u = \frac{2.4 * 20^2}{8} = 120$

ASD

$W_a = 2$ (6)

$M_a = \frac{2 * 20^2}{8} = 100$ (6)

$M_n = \frac{f_y * Z}{12}$

$100 = \frac{50 * Z}{12} \Rightarrow Z = 24$ (6)

W 12 X 22 $\Rightarrow Z_x = 25.4$ (4)

Q3/ steel / Q.3 (4)

LRFD

$P_u = 1.2*175 + 1.6*210 = 546$

ASD (4) (1)

$P_a = 175 + 210 = 385$

$A_{g\,min}$ (1)

(4)

$$A_g = \frac{P_u}{\phi_t f_y} = \frac{546}{0.9 * 50} = 12.1$$

W10×45 ($A = 13.3$) + f =

$$A_g = \frac{546}{0.75 * 65 * 0.8} + 4 * \left(\frac{7}{8} + \frac{1}{8}\right) * 0.62 + 2\left(\frac{7}{8} * \frac{1}{8}\right) * 0.35$$

$= 14 + 3.18 = 17.18$

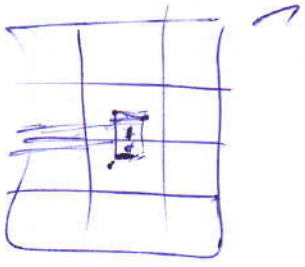
(2)

(4)

$$r = \frac{L}{300} = \frac{25 * 12}{300} = 1$$

$r = 1$, $A = 17.18$

Try = W12 * 60 ($A = 17.6$, $r = 2.57$



check (3)

a) yielding

$P_n = 50 \times 17.6 = 880$

LRFD

$\phi_t P_n = 0.9 \times 880 = 792 > 546$

OK

ASD

$\frac{P_n}{\Omega} = \frac{880}{1.67} = 526 > 385$

OK (4)

b) rupture

$A_n = 17.6 - 4\left(\frac{7}{8} + \frac{1}{8}\right) \times 0.68 - 2\left(\frac{7}{8} + \frac{1}{8}\right) \times 0.42$

$= 14.04$

$A_e = 0.8 \times 14.04 = 11.23$

$P_n = 11.23 \times 65 = 730.08$

LRFD

$\phi_t P_n = 730 \times 0.75 = 547$

ASD

$\frac{P_n}{\Omega} = \frac{730}{2} = 365 < 385$

(5)

Not OK

c) Slenderness ratio

$\frac{L_y}{r_y} = \frac{12 \times 25}{2.57} = 116 < 300$

OK

LRFD → W12x60

ASD → W12x68 (5)

(1)

Concrete Design

Q.1 / concrete

Mu حساب (1)

$$W_u = 1.2\,W_{D.L} + 1.6\,W_{L.L}$$
$$= 1.2 \times 11.5 + 1.6 \times 20 = 45.8$$

4

$$M_u = \frac{w_u \ell^2}{8} = \frac{45.8 \times 15^2}{8} = 143.1$$

ρ_{max} (2)

$$\rho = \rho_{max} = 0.85\,\beta_1 \frac{f'_c}{f_y} \frac{0.003}{0.003 + 0.004}$$
$$= 0.85 \times 0.85 \times \frac{21}{420} \times \frac{0.003}{0.003 + 0.004}$$
$$= 0.01548$$

3

$d = 1.5b$

d بدلالة b (3)

$$M_u = \phi\, b d^2 f_y \rho \left(1 - 0.59 \rho \frac{f_y}{f'_c}\right)$$

3

$$143.1 \times 10^6 = 0.9\, b \times (1.5b)^2 \times 0.01548 \left(1 - 0.59 \times 0.01548 \times \frac{420}{21}\right) \times 420$$

$$b = \sqrt[3]{\frac{824.4 \times 10^6}{10.76}} = 237 \approx 240$$

$$d = 360$$

$b = 240$, $d = 360$

حساب D.L (4)

$$W_{D.L} = 24 \times (0.24 \times 0.36) = 2.0 \ \frac{KN}{m}$$

3

$\therefore M_u = 150.6$ KN.m

6

3

(2)

$Mu = 150.6 \times 10^6 = 0.9 * 240 * d^2 * 420 * 0.0154 (1 - 0.59 * 0.0154 * \frac{420}{21})$

$d = \sqrt{\frac{150.6 \times 10^6}{1,147.8}} = 362.2$

use $b = 240$, $d = 370$

(1) حساب As

$As = \rho b d = 0.0154 * 240 * 370 = 1374.6 \ mm^2$ 3pts

(2) حساب Asmin

$Asmin = 0.25 \sqrt{\frac{21}{420}} * 240 * 370$ ، $\frac{1.4 * 240 * 370}{420}$

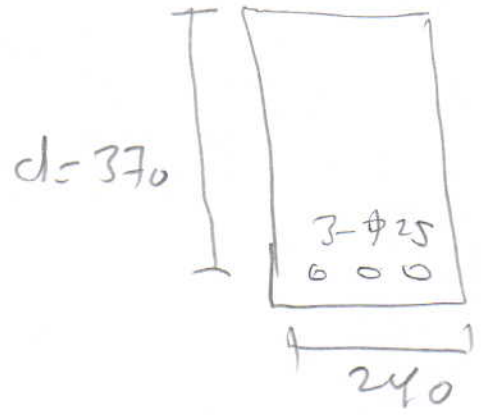
$= 242.2$ ، 296

$Asmin = 296$

$As = 1374.6 > 296$ ∴ OK

(3) عدد القضبان

no of bar $= \frac{1374.6}{\frac{\pi}{4} 25^2} = 2.8 \simeq 3$ 3pts



(3.)

Q.2 / Concrete

$$h = \frac{l}{20} = \frac{3000}{20} = 150$$ 3½ (1)

(1)

$$W.D.L = 24 * 0.15 = 3.6$$ 3½

$$W_u = 1.2 * (3.6 + 1.2) + 1.6 * 8.3 = 19.04$$

ب) ص: M_u 3½

$$Mu = \frac{w_u l^2}{8} = \frac{19.04 * 3^2}{8} = 21.37$$

ج) ص: d

$$d = h - 20 - \frac{\phi}{2} = 150 - 20 - \frac{12}{2} = 124$$ 3½

د) ص: أ

$$a = 1$$

$$b = -1.7 \frac{21 * 1000 * 124}{420} = -10540$$ 5½

$$c = 1.7 * \frac{21 * 1000}{0.9 * 420^2} * 21.37 * 10^6 = 4789682.5$$

$$x = \frac{-(-10540) \mp \sqrt{10540^2 - 4 * 1 * 4789682.5}}{2 * 1}$$ 9588.1

A_s ⟵ 475.9

⟶ 10064

(4) ← As = 475.9

(6) ب) s

$$s = \frac{\frac{\pi}{4} 12^2 \times 1000}{475.9} = 237.6 \simeq 230 \text{ mm}$$ 3/4

$s = 230$ ← $s_{max} = 3 \times 150 = 450$

$s_{max} = 500$

← o.k

(7) حدید (رنگی)

$As = 0.0018 \times 1000 \times 150 = 270$ 5/4

$$s' = \frac{\frac{\pi}{4} \times 12^2 \times 1000}{270} = 418 \simeq 410$$

$s = 410$ ← $s'_{max} = 5 \times 150 = 750$

500

← o.k

Q3/ concrete

$f_r = 0.62\sqrt{28} = 3.28$ 10

$\sigma = \frac{M \cdot c}{I} \Rightarrow M_{cr} = \frac{3.28 * \frac{750 * 400^3}{12}}{200}$

$M_{cr} = 21.8\ kN.m$ 15