SET-X

University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2012
Program: B. Sc Engineering (Civil)

Course Title: Design of Concrete Structures I | Course Code: CE 315
Time: 3.00 Hours | Full Marks: 120

Section A

(Answer **any 3 (three)** of the following 4 questions)

Full Marks: 36 [=3×(6+6)]

1. (i) Derive the expression for the ultimate moment capacity of a beam which is over reinforced.

   (ii) What do you mean by balanced steel ratio in USD? Derive the expression for balanced steel ratio of a beam for USD.

2. (i) Explain the terms Web-Shear Crack and Flexure-Shear Crack. Also explain why the Web-Shear Stress is greater than Flexure-Shear Stress.

   (ii) Draw a neat sketch showing diagonal crack in a beam with vertical stirrups. Show the forces acting at the crack and discuss them. Using the sketches and following ACI code recommendations derive the following equation for the spacing of stirrups:

$$S = A_v f_v d/(V_{ext} - V_{cr})$$

   The symbols carry their usual meaning.

3. (i) Explain the differences between flexural stress distribution over T- and rectangular beams (and their effects).

   (ii) Write down the ACI code requirements for clear cover of beam and slab, and minimum clear spacing of bars of beam and maximum spacing of bars in slab.

4. (i) What is one-way slab? Explain with reference to support conditions and slab span ratios. Explain temperature and shrinkage reinforcements and discuss their necessity in reinforced concrete design with reference to slabs.

   (ii) What is development length? Mention the factors influencing development length of deformed tension bars. Briefly compare between the development lengths of (a) bottom and top bars, (b) epoxy-coated and uncoated bars.

Section B

(Answer **any 7 (seven)** of the following 10 questions)

Full Marks: 84 [=7×12]

[Given: $f_c' = 4$ ksi, $f_y = 60$ ksi, $f_s = 24$ ksi for all questions]

5. (a) Identify the beam sections shown in Figure 1(a) as under-reinforced, balanced and over-reinforced by USD.

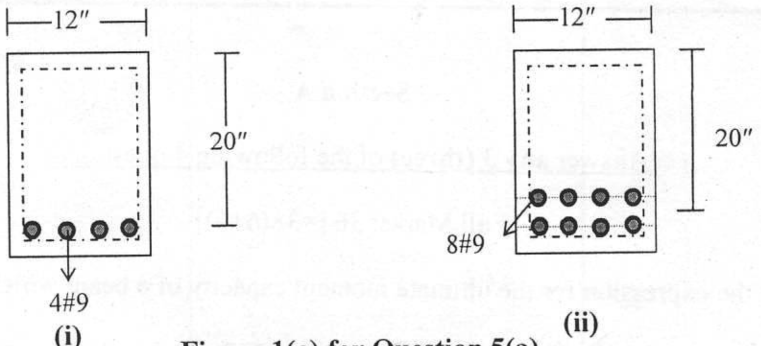


Figure 1(a) for Question 5(a)

(b) Calculate the ultimate and allowable moment capacity of the beam section shown in Figure 1(b).

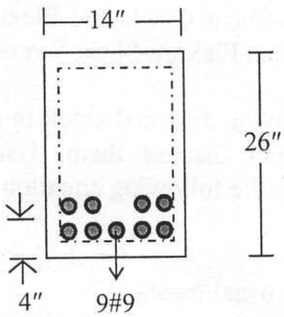


Figure 1(b) for Question 5(b)

6. Design and detail a singly reinforced beam section at mid-span with a simple span of 30′ to support a dead load of 1.00 k/ft (excluding self weight) and a live load of 2.0 k/ft(see Figure 2). Width of the beam = 12 inch (architectural requirement). **Use ACI/USD method.**

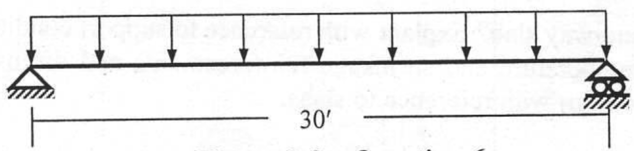


Figure 2 for Question 6

7. A rectangular concrete beam 12″ wide has an effective depth of 18″. Compression steel consisting of 2#8 bars is located 2.5 inch from the compression face of the beam. Find the ultimate moment capacity of the beam, according to ACI Code for the following alternative area of tensile steel:

(i) A_s= 3# 10 bars in one layer
(ii) A_s= 4#10 bars in two layers
(iii) A_s= 6#10 bars in two layers.

Figure 5 for Question 10

8. A beam of size 10"×20" is chosen due to architectural reasons to support a dead load of 1 k/ft (excluding self weight) and live load of 2 k/ft on a cantilever span of 10 '(Figure 3). Is it singly reinforced or doubly reinforced? Design and detail the beam section at support. Use **ACI/USD** method.

w_D = 1 k/ft (excluding self weight) w_L = 2 k/ft

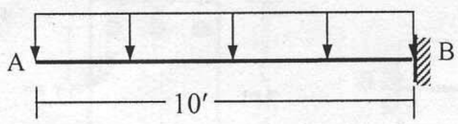
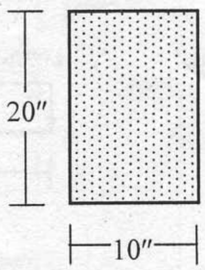


Figure: 3 for Question 8



beam cross-section at support

9. Determine design moment for the "T" beam as shown in Figure 4 and then determine the allowable live load on the slab. FF= 20 psf, Random Wall Loads= 30 psf. Use either **WSD or USD.**

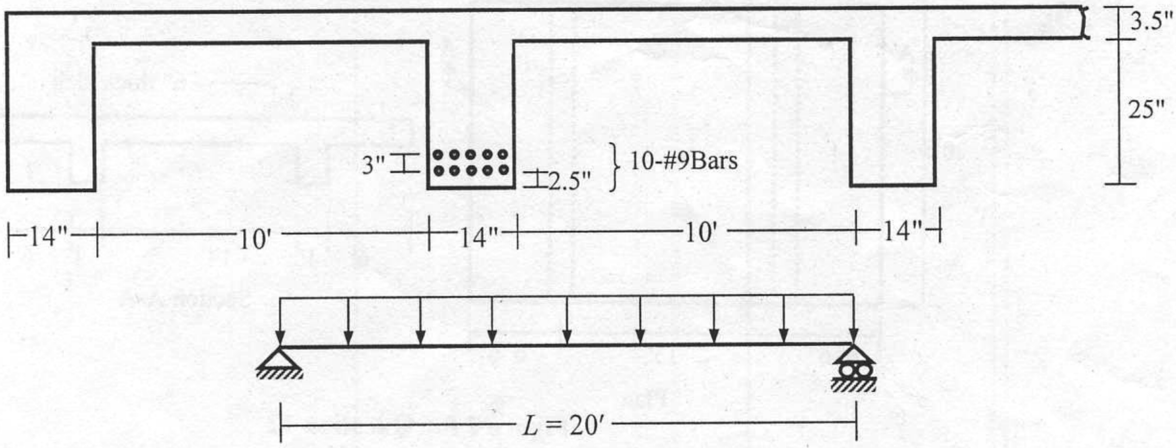
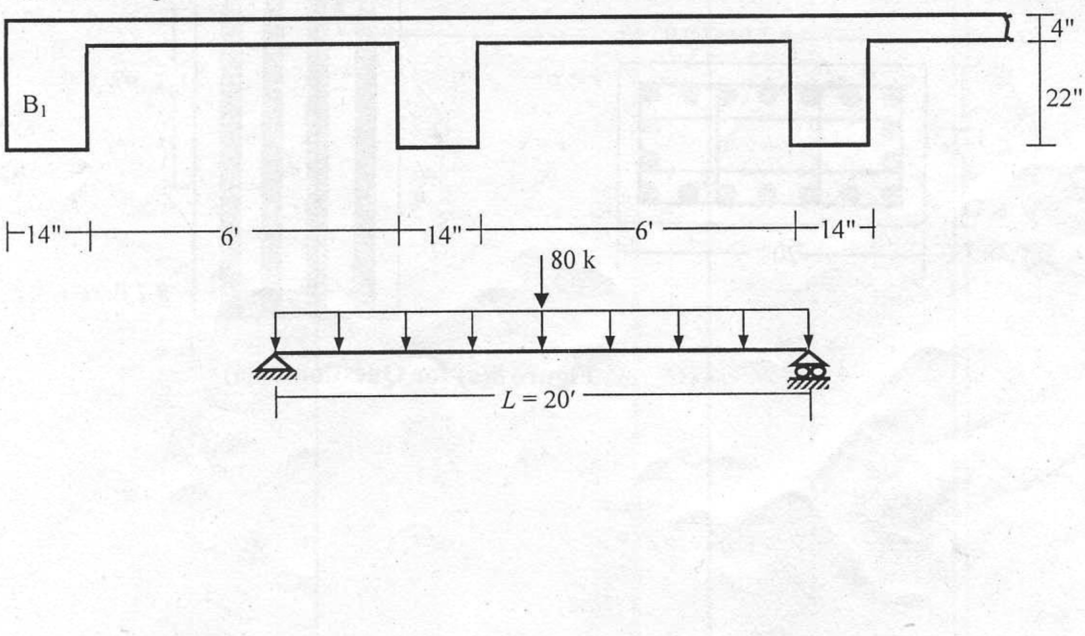


Figure 4 for Question 9

10. A floor slab 4 inch thick is supported by reinforced concrete beams, 7 ft c/c, which together with slab act as T-beams (see Figure 5). The slab supports a service live load of 200 psf and a superimposed dead load of 100 psf. Moreover each of the beams supports a concentrated live load of 80 k at midspan in addition to the load from slab. Design and detail the L-beam 'B1' as shown in Figure 5. Use **ACI/USD** method.



11. If the beam as shown in Figure 6 carries a total factored load of 5.0 k/ft, determine the region for which web reinforcement is required. If #3 rebar is selected as web reinforcement what will be the spacing of U stirrup for maximum shear to be considered for design? Also compare your calculated spacing with the value suggested by the ACI code.

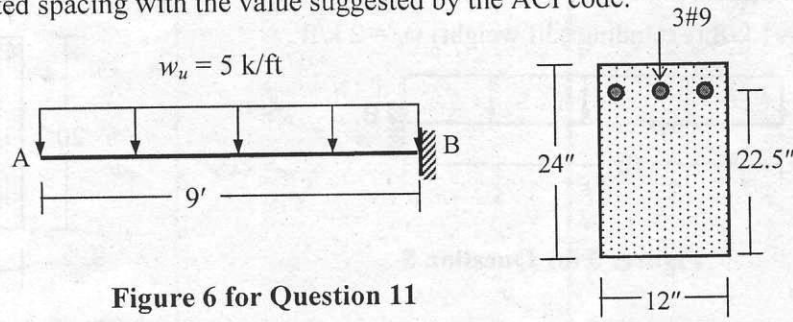


Figure 6 for Question 11

12. A 6 in. thick slab (one way) is supported on RC beams as shown in Figure 7. The calculated total dead load on the slab is 100 psf and the slab is subjected to a working live load of 80 psf. The live load can occupy any portion or any position on the slab. Calculate the critical design moments and show the necessary reinforcements in sketches. Use either **WSD or USD.**

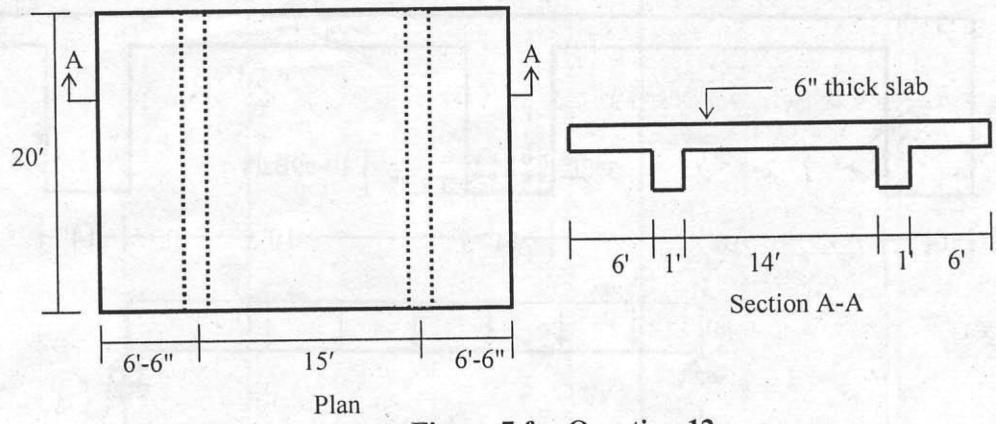


Figure 7 for Question 12

13. **(a)** If # 6 bars are to be spliced to #7 bars, for the tied column (see Figure 8a), what will be the minimum required lap length (l_{splice}) for the splice.

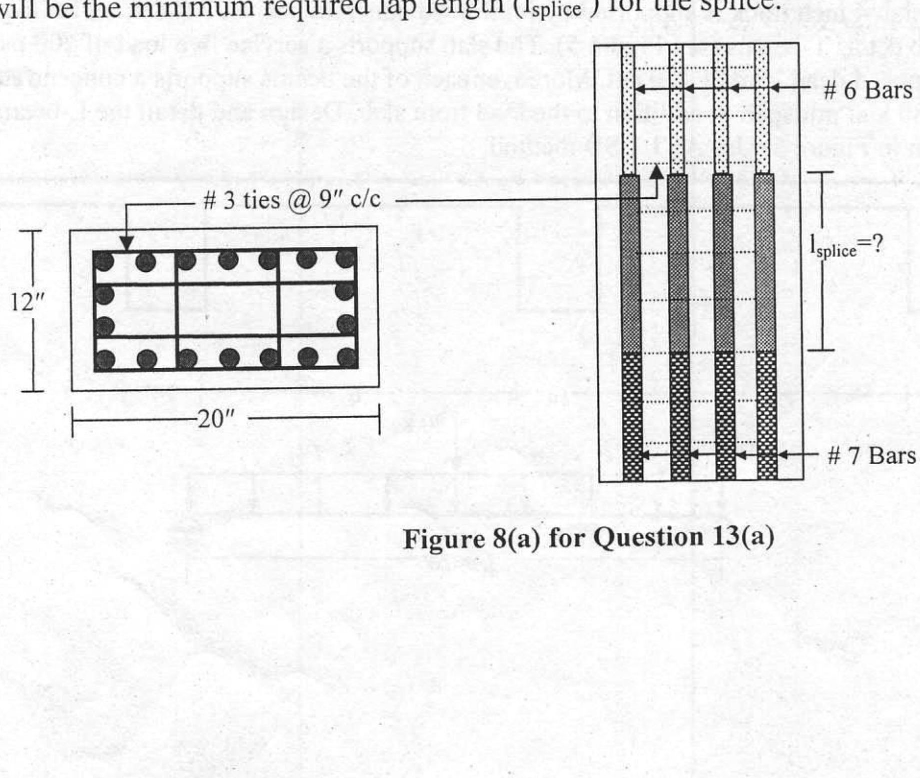
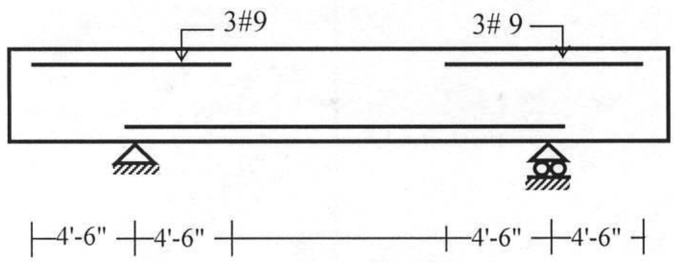


Figure 8(a) for Question 13(a)

b. The required top or negative steel area for the normal weight concrete beam of Figure 8(b) is 2.76 in.^{2}. Three #9 bars (uncoated) have been selected. Are the 4'-6" development lengths shown satisfactory?



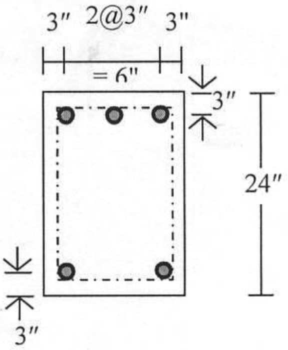


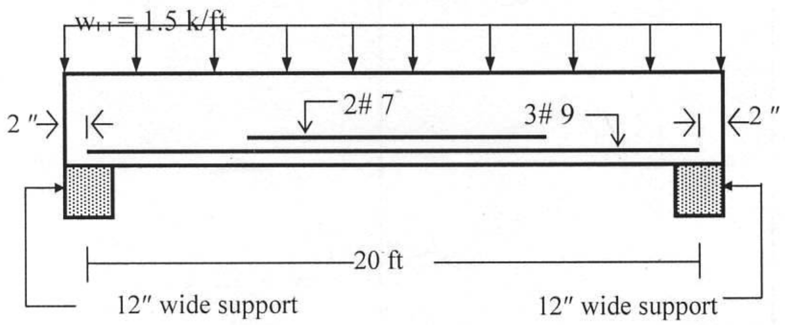
Figure 8(b) for Question 13(b) Beam section at support

14. **(a)** The beam (simple span=20 ft) shown in the Figure 9 is to carry a dead load of 1 kip/ft (excluding self weight) and a live load of 1.5 kip/ft. The reinforcement consist of 3#9 bars and 2#7 bars. Given: $A_{s\,(supplied)} = A_{s\,(required)}$.

(i) Calculate the point where the upper 2 #7 bars can be discontinued.
(ii) Check whether adequate embedment length is provided for continued and discontinued rebars. Follow ACI/USD method.

(b) In reference to Question 14(a), check the shear at cut-off point in accordance with ACI code and redesign the stirrup spacing if necessary
[Given: Stirrup provided at cut-off point is #3, 2Legged @7 inch c/c].

w_{DL}= 1.00 k/ft **(excluding self weight)**



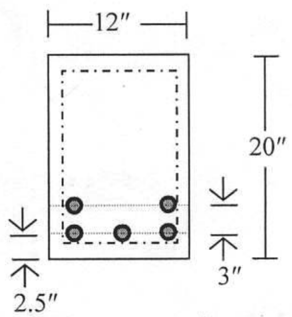


Figure 9 for Question 14

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Course Title: Design of Concrete Structures I | Credit Hours: 3.0 | Course Code: CE 315

Time: 3 hours | Full Marks: 100 (= 10 × 10)

PART A

[Answer **any 7 (seven)** of the following 10 questions]

Full Marks: 70 [= 7 × 10]

[Given: $f_c' = 3$ ksi, $f_y = 50$ ksi for all questions]

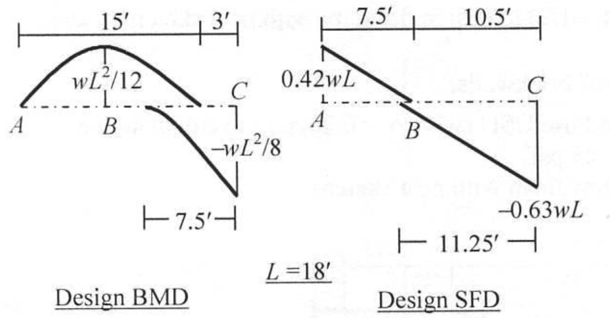

Fig. 1

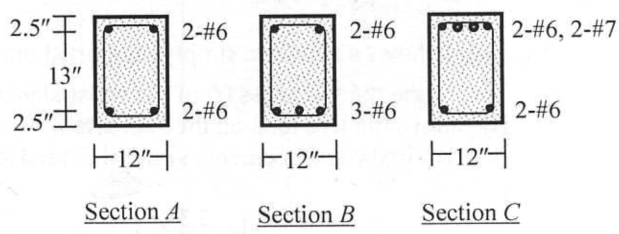

Fig. 2

1. Use the design BMD of beam ABC (Fig. 1) to calculate the maximum allowable load (w) for the Section C to remain 'uncracked', considering it is reinforced
   (i) as shown in Section C of Fig. 2, (ii) by only the tension bars in Section C of Fig. 2.

2. Use the design BMD of beam ABC (Fig. 1) to
   (i) calculate the total load (w_u) for Section B (Fig. 2) to reach its ultimate moment capacity, and
   (ii) compare it with the w_u ignoring compression bars (i.e., assuming Section B is singly reinforced).

3. Use WSD to design (with neat sketches) rectangular sections ($b = 12''$, $h = 18''$) at B and C for the design BMD of ABC (Fig. 1), considering allowable load w to keep section B singly reinforced.

4. Use USD to design (with neat sketches) rectangular sections ($b = 12''$, $h = 18''$) at B and C for the design BMD of ABC (Fig. 1), considering ultimate load w_u to keep section B singly reinforced.

5. Use WSD to design (with neat sketch of longitudinal profile) inclined stirrups ($\alpha = 45°$) for rectangular sections ($b = 12''$, $h = 18''$) at A and C using the design SFD of ABC (Fig. 1), if w is the maximum load the beam can carry in shear [Assume 12″ square columns at A and C].

6. Use USD to design vertical stirrups for section C of beam ABC (with $b = 12''$, $h = 18''$) using the design SFD (Fig. 1), if w_u is the ultimate load the beam can carry in shear, and it is also subjected to (i) compressive force of 50 k, (ii) tensile force of 50 k [Assume 12″ square columns at A and C].

7. Fig. 2 shows cross-sections A, B and C of beam ABC (made of normal-weight concrete and uncoated bars) supported by 12″ square columns at A and C.

   The beam is reinforced with #3 stirrups spaced @5″c/c near A, C and @8″c/c near B.

   (i) Calculate the development lengths and lap lengths (with suitable location) of the longitudinal bars (a) with end anchorage, (b) without end anchorage.

   (ii) Use Fig. 1 to draw the longitudinal profile of the beam reinforcements, specifying points where the top and bottom bars can be cut off.

8. Use the design BMD of beam ABC (Fig. 1) to design the L-beam (by USD) and T-beam (by WSD) at section B (i.e., with design moment = $wL^2/12$, where L = 18′) of the slab-beam system (Fig. 3), if slab thickness t = 4″, floor finish = 30 psf, random wall = 60 psf and live load = 60 psf.

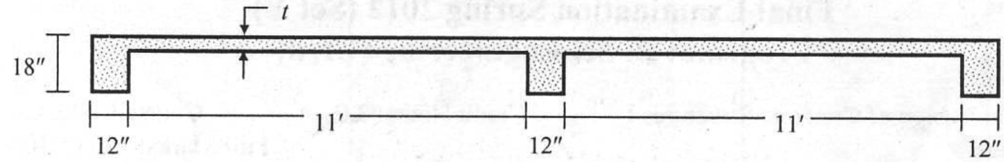

Fig. 3

9. Fig. 3 shows sectional view of a one-way slab-beam system (i.e., unsupported in the other direction). Determine the thickness (t) of the slab and use the WSD to calculate the

   (i) Live load (LL) on the slab if the T-beam carries working load of 3 k/ft, assuming the slab to carry working loads including floor finish = 30 psf, random wall = 60 psf, in addition to self-weight and LL.

   (ii) Use ACI moment coefficients (−1/24, 1/14, −1/9) to design the slab (with neat sketch of section).

10. Fig. 4 shows a staircase simply-supported on 10″ brickwalls.
Determine the thickness (t) of the waist-slab and use USD (with $\rho_s = 0.25\rho_{max}$) to calculate the
   (i) allowable live load on the staircase if FF = 25 psf,
   (ii) required reinforcements in the slab (and show them with neat sketch).

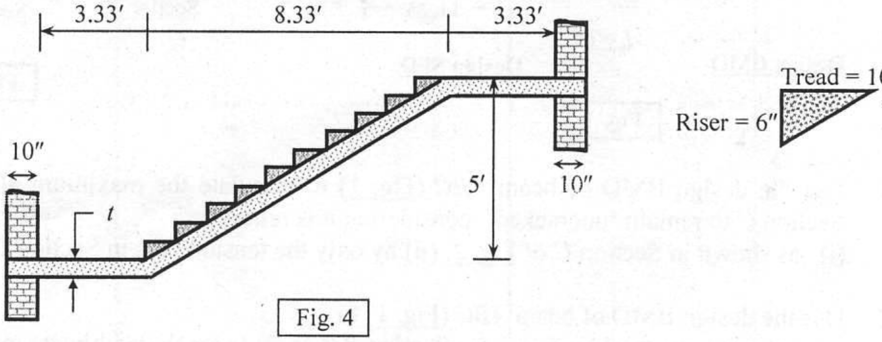

Fig. 4

PART B

[Answer **any 3 (three)** of the following 4 questions]

Full Marks: 30 [= 3 × (5 + 5)]

11. (i) What are the maximum and minimum allowable steel ratios used for RC beams?
Explain why they are used.

    (ii) Show the variations of stress and strain over a RC section as it is stressed gradually from uncracked to cracked and ultimate failure condition.

12. (i) Explain the terms Web-Shear Crack and Flexure-Shear Crack.
Also explain why the Web-Shear Stress is greater than Flexure-Shear Stress.

    (ii) Narrate the advantages and disadvantages of inclined stirrups compared to vertical stirrups.

13. (i) Mention the distinctive features of the shear design of deep beams.

    (ii) Narrate the ACI code provisions for choosing the minimum thickness of one-way slabs.
Explain why the required thickness of slabs increases with the yield strength of reinforcing steel.

14. (i) Briefly explain the effects of
(a) Reinforcement Location Factor, (b) Cover Dimension (c) Transverse Reinforcement Index on the development length of reinforcing bars.

    (ii) What are bar splices? Distinguish between lap splices in tension and compression.

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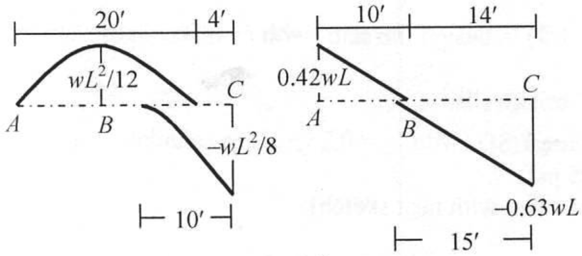
PART A

[Answer **any 7 (seven)** of the following 10 questions]

Full Marks: 70 [= 7 × 10]

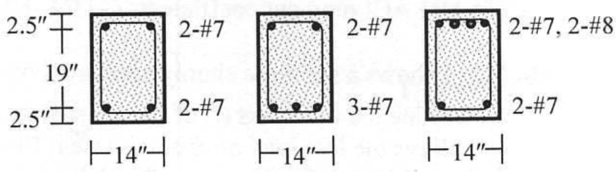
[Given: $f_c' = 4$ ksi, $f_y = 60$ ksi for all questions]



L = 24′

Design BMD   Design SFD

Fig. 1



Section A   Section B   Section C

Fig. 2

1. Use the design BMD of beam *ABC* (Fig. 1) to calculate the maximum allowable load (w) for the Section *C* to remain 'uncracked', considering it is reinforced
   (i) as shown in Section *C* of Fig. 2, (ii) by only the tension bars in Section *C* of Fig. 2.

2. Use the design BMD of beam *ABC* (Fig. 1) to
   (i) calculate the total load (w_u) for Section *B* (Fig. 2) to reach its ultimate moment capacity, and
   (ii) compare it with the w_u ignoring compression bars (i.e., assuming Section *B* is singly reinforced).

3. Use WSD to design (with neat sketches) rectangular sections (b = 14″, h = 24″) at *B* and *C* for the design BMD of *ABC* (Fig. 1), considering allowable load w to keep section B singly reinforced.

4. Use USD to design (with neat sketches) rectangular sections (b = 14″, h = 24″) at *B* and *C* for the design BMD of *ABC* (Fig. 1), considering ultimate load w_u to keep section B singly reinforced.

5. Use WSD to design (with neat sketch of longitudinal profile) inclined stirrups (α = 45°) for rectangular sections (b = 14″, h = 24″) at *A* and *C* using the design SFD of *ABC* (Fig. 1), if w is the maximum load the beam can carry in shear [Assume 14″ square columns at *A* and *C*].

6. Use USD to design vertical stirrups for section *C* of beam *ABC* (with b = 14″, h = 24″) using the design SFD (Fig. 1), if w_u is the ultimate load the beam can carry in shear, and it is also subjected to (i) compressive force of 75 k, (ii) tensile force of 75 k [Assume 14″ square columns at *A* and *C*].

7. Fig. 2 shows cross-sections *A*, *B* and *C* of beam *ABC* (made of normal-weight concrete and uncoated bars) supported by 14″ square columns at *A* and *C*.
   The beam is reinforced with #3 stirrups spaced @6″c/c near *A*, *C* and @10″c/c near *B*.
   (i) Calculate the development lengths and lap lengths (with suitable location) of the longitudinal bars (a) with end anchorage, (b) without end anchorage.
   (ii) Use Fig. 1 to draw the longitudinal profile of the beam reinforcements, specifying points where the top and bottom bars can be cut off.

8. Use the design BMD of beam *ABC* (Fig. 1) to design the L-beam (by USD) and T-beam (by WSD) at section *B* (i.e., with design moment = $wL^2/12$, where $L = 24'$) of the slab-beam system (Fig. 3), if slab thickness $t = 5''$, floor finish = 30 psf, random wall = 60 psf and live load = 60 psf.

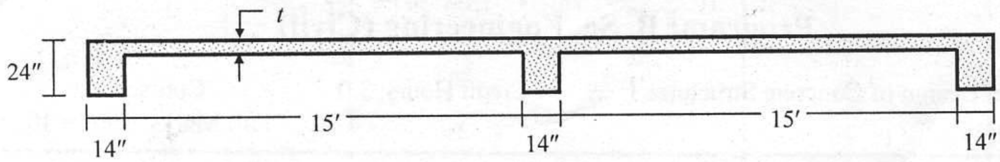


Fig. 3

9. Fig. 3 shows sectional view of a one-way slab-beam system (i.e., unsupported in the other direction). Determine the thickness (t) of the slab and use the WSD to calculate the
   (i) Live load (LL) on the slab if the T-beam carries working load of 4 k/ft, assuming the slab to carry working loads including floor finish = 30 psf, random wall = 60 psf, in addition to self-weight and LL.
   (ii) Use ACI moment coefficients (−1/24, 1/14, −1/9) to design the slab (with neat sketch of section).

10. Fig. 4 shows a staircase simply-supported on 10″ brickwalls.
    Determine the thickness (t) of the waist-slab and use USD (with $\rho_s = 0.25\rho_{max}$) to calculate the
    (i) allowable live load on the staircase if FF = 25 psf,
    (ii) required reinforcements in the slab (and show them with neat sketch).

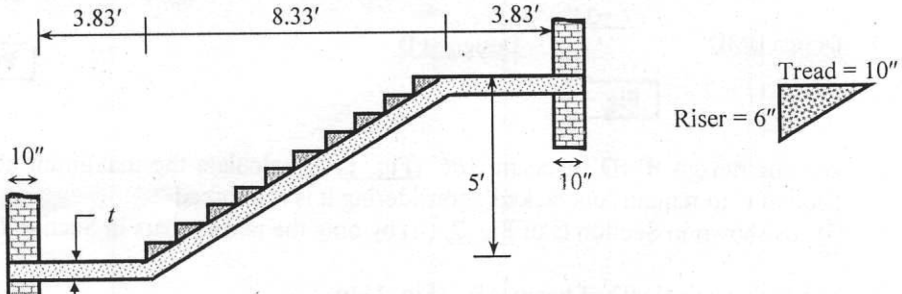


Fig. 4

PART B

[Answer **any 3 (three)** of the following 4 questions]

Full Marks: 30 [= 3 × (5 + 5)]

11. (i) What is a 'transformed' RC section? Explain with reference to cracked and uncracked sections.
    (ii) Why does the ACI recommend that in WSD, the value of compressive stress in steel (f_s') be taken as twice the value calculated from elastic analysis?

12. (i) What are the components of concrete shear resistance (V_c) of RC beams?
    (ii) Explain the effects of Web Reinforcement on the shear resistance of RC beams.

13. (i) Mention the distinctive features of the shear design of deep beams.
    (ii) Explain why shear reinforcements are usually not provided in the design of RC slabs.

14. (i) What is development length of reinforcing bars?
    Mention the factors influencing development length of deformed bars in tension.
    (ii) Explain why the development length of compression bars is smaller than that of tension bars.