(13)

B. Sc. Engg. (CEE)/ 5th Sem. 22 December, 2023 (Afternoon)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

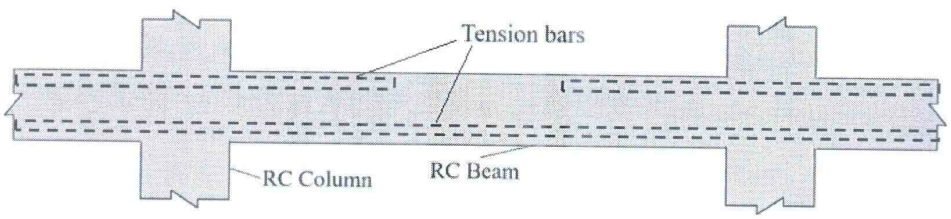
ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

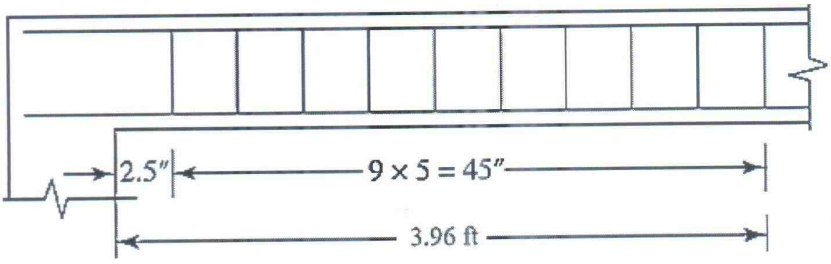
Semester Final Examination **Winter Semester: 2022 - 2023**
Course No.: CEE 4511 **Full Marks: 150**
Course Title: Design of Concrete Structures I **Time: 3 Hours**

There are **6 (SIX)** questions. **Answer all the questions.**
The symbols have their usual meaning. Assume reasonable values for any missing data. Do not write on this question paper. The figures in the right margin indicate CO, PO, and full marks.

1(a)	Justify – "For an RC beam, failure by yielding of tension reinforcement is more preferable than crushing of concrete."	**CO1 PO1**	**3**
(b)	Why is reinforcement location factor, ψ_t **(see Equation E.7 on Page 5)** less for the top bars compared to the bottom bars?	**CO1 PO1**	**3**
(c)	Discuss the advantages of designing a beam, of an RC beam-slab system, as a T-beam.	**CO1 PO1**	**3**
(d)	Why do the design codes typically allow the use of a higher capacity reduction factor (ϕ) for flexure design compared with that for shear design?	**CO1 PO1**	**3**
(e)	An RC beam is cast monolithically with two RC columns at its ends. The beam is subjected to a uniformly distributed downward load along its length. Draw neat sketches of flexure, shear, and bond cracks along the beam. Also show qualitative positioning of the web reinforcement.	**CO1 PO1**	**3**

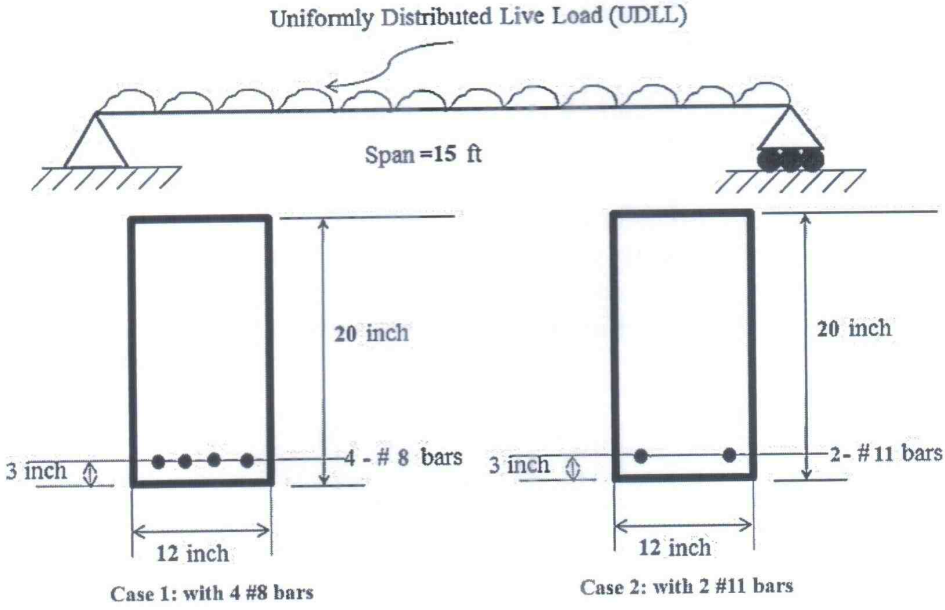


2(a)	A simply supported beam has a clear span of 16 ft and carries **factored dead and live loads** of 5.4 k/ft and 6 k/ft, respectively. **The dead load includes the self-weight of the beam**. The details of shear reinforcement for the beam are given in the following figure up to a distance of 3.96 ft from the face of the left support. Check if the detailing is adequate as per the USD method. Given, $f_c' = 3$ ksi, $f_y = 60$ ksi, width of beam = 14 in, and effective depth, $d = 22.5$ in.	**CO2 PO2**	**10**



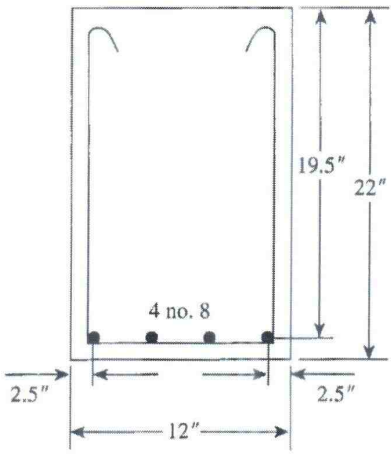
(b) Calculate the bond stresses at the critical section and at the mid-span of the simply supported beam shown in the following figure. Use the WSD method. Consider two different cases of reinforcement detailing, Case 1 and Case 2, as shown in the figure for your calculation. For both cases, assume that all the bars are continued along the length of the beam. Make a brief discussion of your results indicating the parameters that influence the bond stress. **CO2 PO2** **10**

Given, f_c' = 3500 psi, f_s = 20,000 psi, service UDLL = 1 k/ft, and service UDDL (dead load) = self-weight of the beam.



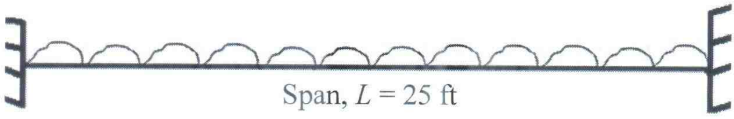
(c) The figure shows the cross section of a simply supported beam reinforced with 4 no. 8 bars that are confined with no. 3 stirrups spaced at 6 in. Check if a development length of 50 inches is adequate for the tension bars as per ACI 318 guidelines with and without the consideration of the effect of confinement. **CO2 PO2** **10**

Given, the beam is made of normal-weight concrete, bars are not coated, f_c' = 3 ksi, and f_y = 60 ksi.



3 Design the following fixed-ended RC beam for flexure by WSD and USD methods. **CO3 PO3** **45**

Given, UDLL = 0.5 k/ft, UDDL = 1.5 k/ft (**excluding self-weight**), $f_c' = 3$ ksi, $f_s = 20$ ksi, $f_y = 60$ ksi, width of beam = 14 in.



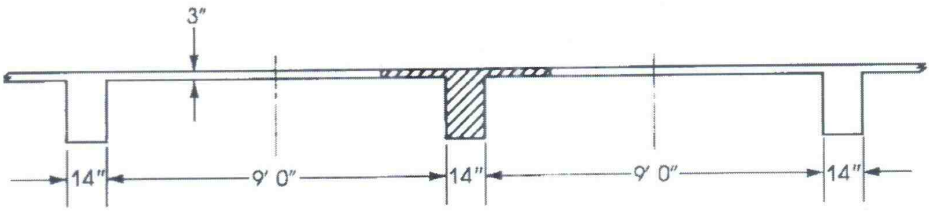
Compare the sections and steel areas obtained by using WSD and USD methods on the basis of cost and sustainability (in terms of materials consumption).

Show reinforcement details in cross-section for both WSD and USD methods.

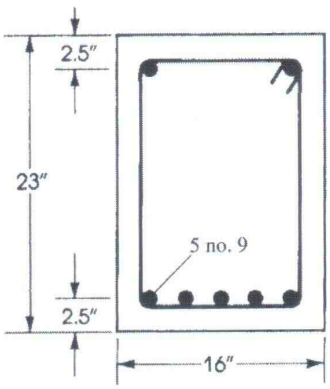
Show bar cutoff locations along the longitudinal direction of the beam for the reinforcement obtained using USD method.

4 **Consider that the beam shown in the figure of Question 3 is part of a floor system as shown in the following figure**. The floor system consists of 3-inch slab panels. The RC beams, supporting the slab panels, are spaced at a clear distance of 9 ft. Calculate the necessary reinforcement at the mid-span of a typical interior beam according to the USD method, considering the beam as a T-shaped beam, **for a factored moment at the mid-span of 5080 k-in**. Also check if the failure will be governed by the tensile yielding of reinforcement. **CO3 PO3** **20**

Use, $f_c' = 3$ ksi, $f_y = 60$ ksi, width of web = 14 in, and effective depth, d = 18.5 in.

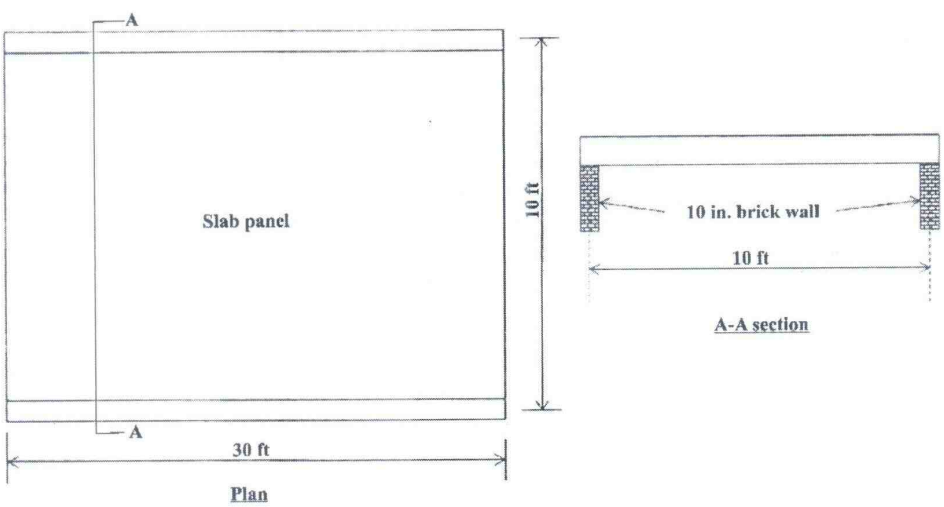


5 Determine the necessary web reinforcement for the rectangular beam section shown in the following figure. A **factored shear force** of $V_u = 48$ kips and a **factored torque** of $T_u = 360$ k-in are acting at a section located at a distance d (effective depth) from the face of the support. 5 no. 9 bars are required for the design bending moment. Assume that the concrete is a normal-weight concrete, $f_c' = 3$ ksi, and $f_y = 60$ ksi. **CO3 PO3** **20**



6 Design the slab panel, as shown in the following figure, in accordance with the USD method. Show the reinforcement details in plan and in section A-A of the panel. **CO3 PO3** **20**

Use, $f_c' = 4$ ksi, $f_y = 60$ ksi, UDLL = 100 psf, and UDDL = self-weight of the panel.



Equations

Design for torsion

$$T_u < \phi\lambda\sqrt{f'_c}\left(\frac{A_{cp}^2}{p_{cp}}\right) = \frac{1}{4}T_{cr} \quad \text{E.1}$$

$$\sqrt{\left(\frac{V_u}{b_w d}\right)^2 + \left(\frac{T_u p_h}{1.7A_{oh}^2}\right)^2} \le \phi\left(\frac{V_c}{b_w d} + 8\sqrt{f'_c}\right) \quad \text{E.2}$$

$$\frac{A_t}{s} = \frac{T_n}{2A_o f_{yt}\cot\theta} \quad \text{E.3}$$

$$A_v + 2A_t = 0.75\sqrt{f'_c}\frac{b_w s}{f_{yt}} < \frac{50 b_w s}{f_{yt}} \quad \text{E.4}$$

$$A_\ell = \frac{A_t}{s}p_h\left(\frac{f_{yt}}{f_y}\right)\cot^2\theta \quad \text{E.5}$$

$$\text{Min. } A_\ell = \frac{5\sqrt{f'_c}A_{cp}}{f_y} - \left(\frac{A_t}{s}\right)p_h\frac{f_{yt}}{f_y} \quad \text{E.6}$$

Development length

$$\ell_d = \frac{3}{40}\frac{f_y}{\lambda\sqrt{f'_c}}\ \frac{\psi_t\psi_e\psi_s}{\left(\frac{c_b + K_{tr}}{d_b}\right)}d_b \quad \text{E.7}$$

$$K_{tr} = \frac{40A_{tr}}{sn} \quad \text{E.8}$$

$$\ell_{dc} = \frac{0.02 f_y d_b}{\lambda\sqrt{f'_c}} \ge 0.0003\ f_y d_b \text{ but not less than 8 in.} \quad \text{E.9}$$