Name : Aqib Ullah

ID : 7857

SECTION : B

SEMESTER : 6^{th}

SUBJECT : PRCD I

SUBMITTED TO : ENGR. FAWAD KHAN.

MID EXAM.

QUESTION : 01

GIVEN DATA:

- Live load , L.L = 2.47 kips/ft = 2470 lb/ft
- Dead load , D.L = 1.05 kips/ft = 1050 lb/ft.
- Width , b = 10"
- Span = 18'
- f'_c = 4000 psi
- f'_y = 60,000 psi
- effective depth , d = 20 - 3 = 17

SOLUTION :

STEP 01 : Beam Self Weight per feet

$$= B \times t \times \gamma_c$$

Putting values

$$= \frac{10}{12} \times \frac{20}{12} \times 150$$

$$= 208.33 \text{ lb/ft}$$

STEP 02 : Total Factored load:

$$= 1.2(D.L) + 1.6\ (L.L)$$

$$= 1.2\ (2470 + 208.33) + 1.6\ (1050)$$

$$= 5461.996 \text{ lb/ft}$$

$$= 5.46 \text{ kip/ft}$$

Step 03 Ultimate Factored Moment:

By Formula

$$Mu = \frac{W \times L^2}{8}$$

$$Mu = \frac{5.46 \times (18)^2}{8} \times 12$$

$$Mu = 2653.56 \text{ Kip-inch}$$

Step 04 : Check the capacity of section as singly reinforced beam.

$$\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy} \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_y} \right)$$

Putting values

$$= 0.85 \times 0.85 \times \frac{4}{60} \left(\frac{0.003}{0.003 + 0.005} \right)$$

$$\rho_{max} = 0.0180$$

Step 05: Area Of Steel:

$$\rho_{max} = \frac{A_{ST}}{b \times d}$$

$$A_{ST} = \rho_{max} \times (b \times d)$$

$$= 0.0180 \times (10 \times 17)$$

$$= 3.06 \text{ in}^2$$

STEP 06 : "For Mu_2"

- $Mu_2 = \phi \times A_{ST} \times f_y \times (d - a/2)$
- But first we have to find a in order to find Mu_2.
- So, $a = \dfrac{A_s \times F_y}{0.85 \times f'_c \times b}$

$$= \frac{3.06 \times 60}{0.85 \times 4 \times 10}$$

$$= 5.4''$$

- Putting values in above equation
- $Mu_2 = 0.90 \times 3.06 \times 60 \times \left(17 - \frac{5.4}{2}\right)$

$Mu_2 = 2362.93$ kip-inch

Now

$Mu_2 = 2362.93 < Mu = 2653.56$

Design a section as doubly Reinforced.

STEP 07 For "Mu_1"

$Mu_1 = Mu - Mu_2$

$= 2653.56 - 2362.93$

$= 290.63$.

Step 08:

$Mu_1 = \phi \times A_s \times f_y \times (d - d')$

So for this we have to find A_s

$$A_s = \frac{Mu_1}{\phi \times f_y \times (d - d')}$$

$$= \frac{290.63}{0.90 \times 60 \times (17 - 2.5)}$$

$$= 0.37 \text{ in}^2$$

Putting values in above equation.

$Mu_1 = 0.90 \times 0.37 \times 60 \times (17 - 2.5)$

$= 289.71$

Step 09: Total Area Of Steel:

$A_s = A_{sT} + A_s'$

$= 3.06 + 0.37$

$= 3.43 \text{ in}^2$

Step 10: Selection Of Bars:

A. For Tensile Steel:

Let try # 8 bar having an area $= 0.785 \text{ in}^2$

No. of bars $= \dfrac{A_s}{A_b} = \dfrac{3.43}{0.785}$

$= 4.36 \approx 5$ # 8 bars

B. For Compression Steel:

let try # 6

$A_s = \frac{\pi}{4} d^2$

$d = 6/8 = 0.75$

$A_b = \frac{\pi}{4}(0.75)^2 = 0.44$

Now,

No of bars $= \frac{A_s}{A_b} = \frac{0.37}{0.44}$

$= 0.84 \simeq 1$ # 6 bar.

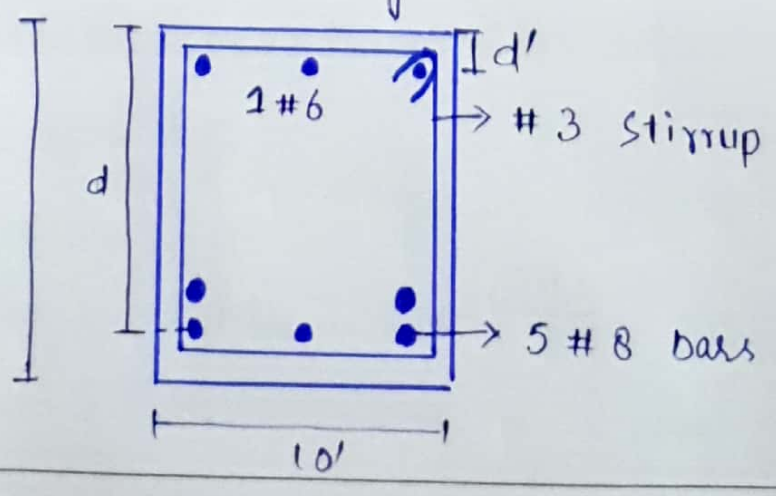
Step 11: Check Minimum width Of Beam:

bmin = 2× clear cover + 2 × diameter of stirrup + No of main bars × dia of main bar + No of spaces b/w main bars × dia of main bars.

$= 2 \times 1.5 + 2 \times 3/8 + 5 \times 8/8 + 4 \times 8/8$

bmin $= 12.75'' > 10''$

Not good in one layer, bars should be provided in two layers.



Effective Depth (d):

$20 - 1.5 - 3/8 - 8/8 - \frac{1}{2}(8/8)$

$d = 16.68''$

Effective Cover, d':

$d' = 1.5 + 3/8 + \frac{1}{2}(6/8)$

$d' = 2.25''$

STEP 12: Design Moment:

$Md = \phi\left[A_s' \times f_y \times (d-d') + (A_s - A_s') \times f_y \times (d - a/2)\right)$

where

$$a = \frac{(A_s - A_s') \times f_y}{0.85 \times f_c' \times b}$$

$$= \frac{[(5 \times 0.785) - (1 \times 0.44)] \times 60}{0.85 \times 4 \times 10}$$

$$= 6.15''$$

Putting values

$Md = 0.90\left[(1 \times 0.44) \times 60 \times (16.68 - 2.25) + (5 \times 0.785 - 1 \times 0.44) \times 60\right.$
$\times \left(16.62 - \frac{6.15}{2}\right)$

$Md = 2890.46$

$Md = 2890.46 > Mu = 2,653.56$

Design is OK.

QUESTION : 02 (a)

Briefly describe Bond stress and Development length.

BOND STRESS:

The stress which is acting on the outer interface of steel to the surrounding concrete is called bond stress. This stress helps in keeping bond between reinforcement and concrete together. Bond stress resists any force that tries to pull out the rods from the concrete.

- When you try to pull out the reinforcement bar from hardened concrete, then this bond stress resists the bar to come out.

- Different grades of concrete has different bond stress.

Classification Of Bond Stress:

Bond stress are classified into the following types.

- Anchorage bond
- Flexular bond.

DEVELOPMENT LENGTH:

The amount of reinforcement length needed to be embedded or projected into the column to established the desired bond strength between the concrete and steel is known as development length.

OR

The necessory length b/w the point of maximum stress in a bar and the end of bar.

Development length required for tension Bars:

1- $\frac{0.04 \times A_b \times f_y}{\sqrt{f'_c}}$

2. $L_d = 0.0004 \times d_b \times f_y$.

3. $L_d = 12''$

Development Length required for Compression Bars:

$$L_{dc} = \frac{0.02 \times d_b \times f_y}{f'_c} \geq 0.0003 \times d_b \times f_y.$$

Q02 b. In which conditions doubly reinforced beam can be used?

ANSWER:

Doubly reinforced beam can be used due to the following reasons. or conditions.

- When the dimensions of the beam are restricted due to any constraints like availability of head room, architectural considerations and the moment of resistance of singly reinforced section is less than the external moment.
- When the external loads may occur on either face of the member i-e the loads are alternating and may cause tension on both faces of the member.
- When the loads are eccentric.
- In case of continous beam or slab, the sections at supports are generally designed as doubly reinforced beam.
- When a beam is subjected to accidental or sudden lateral load.

Q 02 (c)

Differentiate b/w T- beam and rectangular beam analysis.

RECTANGULAR BEAM:

In case of rectangular beam, slab has been placed on the beam, so there is no connection between slab and beam.

- Most commonly used beam and has cross section in the shape of a rectangle of specific breadth (b) and depth (d). The ratio of b/d is limited based upon the code of practice.

T- BEAM:

In case of T-Beam, slab and beam are connected with one another and acts as a one member.

- This beam was developed and effectively used to reduced the cost of construction by placing the beams along with the slab during concrete placement. It has two major zones. The flange and the web.

QUESTION 02 (d):

Write short note on the effect of strength reduction factor on flexural strength.

ANSWER:

In the design of flexural strength, the strength reduction factor ϕ decreases from tension controlled sections to compression controlled sections to increase safety with decreasing ductility. This paper presents how to determine the reduction factor for flexural strength of reinforced concrete beam according to ACI code. In the reliability-based design the reliable prediction of the flexural - ~~bar~~ strength of reinforced concrete members is assured by the use of reduction factors corresponding to different target reliability index β. In this study for different β and co-efficient of variation of the flexural strength parameters, the flexural strength reduction factor has been investigated by using experimental studies. In the reliability analysis, the first order second moment approach has been used to determine the ~~random~~ reduction factor. It has also been assumed that the random variables are statistically independent.

QUESTION: 02 (e)

Briefly describe design methods, which one of them can be best used for design of different structural members and why?

DESIGN METHOD:

There are three methods of structural design i-e working stress, limit state and ultimate load method of structural design. These design method are used for reinforced concrete as well as steel structure design.

Methods Of Structural Design:

Working Stress Method:

It is based on the linear theory (elastic theory). The stresses in the materials, which are developed due to working loads are restricted given a safe design.

- The assumptions in working stress method of design are

1. The steel and concrete behaves as linear elastic material
2. The design is carried out by the factored of safety of 3 for concrete cube strength and a factor of safety 1.8 for yield strength of steel.

Ultimate Load Method:

This method is otherwise known as load factor method or ultimate strength method. This method is based on the ultimate strength. when the design member would fail. In this method factored are taken into account only on loads factors and the method of ultimate design of a structure is defined as a method which limits the structural usefulness of the material of the structure upto ultimate load.

Limit State Method:

Limit state refers to the acceptable limit for ~~s~~ safety and serviceability of structure before the failure of structure

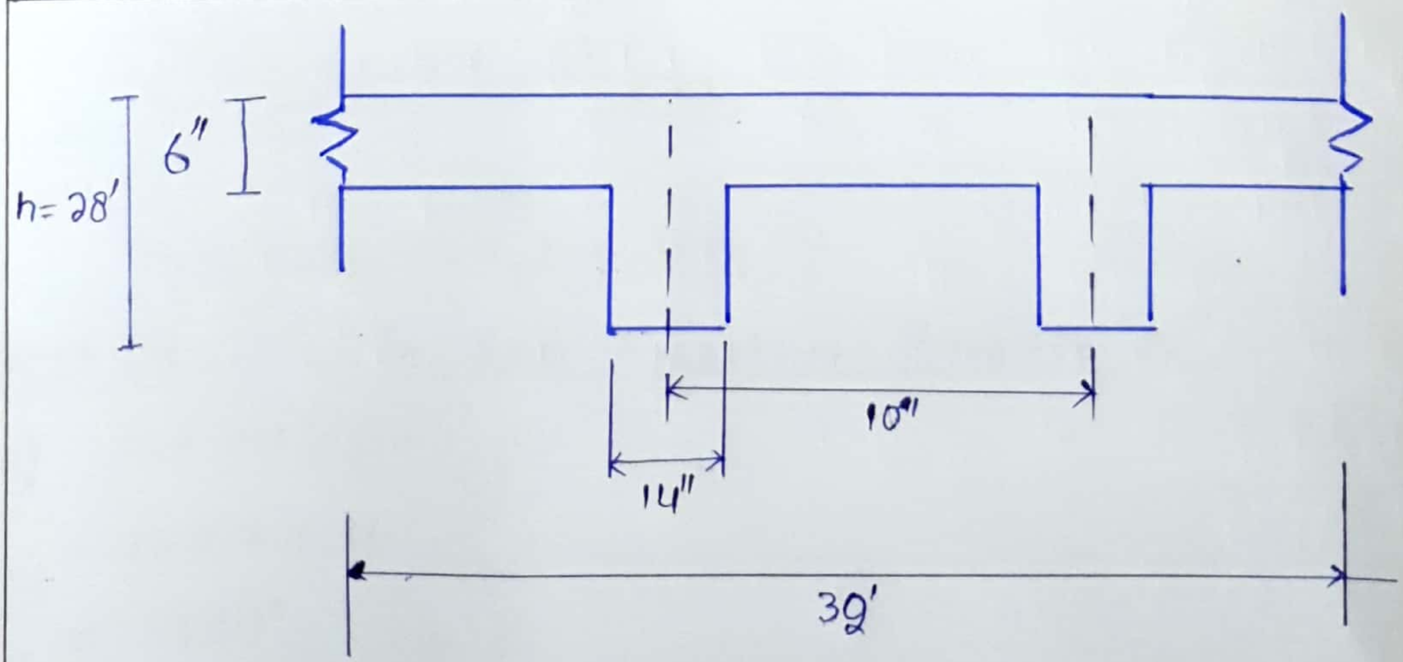
⇒ Limit State method can be best used for design of different structural member because it helps to design structure. based on both safety and serviceability. The structures are design to withstand ultimate loads or the loads at which failure occurs unlike working stress method where only service loads are considered This leads to enhanced safety.

QUESTION: 3

GIVEN DATA:

- Slab thickness = 6"
- web width, bw = 14"
- Center to center spacing = 10'
- Span length = 32'
- height, h = 28"
- effective depth, d = 28 - 3 = 25"
- Dead load, D.L = 50 psf
- Live load, L.L = 225 psf
- f_y = 60,000 psi
- f'_c = 4000 psi

SOLUTION:



STEP 01 Beam Self weight Per feet.

$$W_t = B \times t \times \gamma_c$$

$$= \frac{14}{12} \times \frac{28}{12} \times 150$$

$$= 408.33 \text{ lb/ft}$$

STEP 02 Total Factored Load:

$$= 1.2(50 + 408.33) + 1.6(225)$$

$$= 909.99 \text{ lb/ft}$$

$$= 0.909 \text{ Kip/ft}$$

STEP 03 Ultimate Factored Moment:

$$M_U = \frac{W \times L^2}{8}$$

$$= \frac{0.909 \times (32)^2}{8} \times 12$$

$$= 1396.224 \text{ Kip-inch.}$$

STEP 04 To Find Effective Breadth "be":

a) $16 \times h_f + b_w$

$= 16 \times 6 + 4$

$= 110''$

b. c/c distance = $10 \times 12 = 120''$

c. $\frac{\text{Span of beam}}{4}$

$$= \frac{32 \times 12}{4} = 96''$$

STEP 05 — Check For Rectangular Or T-Beam

let $a = h_f = 6''$

TRIAL : 01

$$A_{ST} = \frac{M_u}{\varphi \times f_y \times (d - a/2)} = \frac{1396.224}{0.90 \times 60 \times (25 - 6/2)}$$

$$A_{ST} = 1.1752 \text{ in}^2$$

TRIAL 02 :

$$a = \frac{A_s \times f_y}{0.85 \times f'c \times b_e}$$

$$= \frac{1.17 \times 60}{0.85 \times 4 \times 96} = 0.2'' < 6''$$ rectangular Beam design

$$A_{ST} = \frac{1396.224}{0.90 \times 60 \left(25 - \frac{0.2}{2}\right)} = 1.03 \text{ in}^2$$

TRIAL: ~~05~~ 03

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.18''$$

$$A_{ST} = \frac{1396.224}{0.90 \times 60 \left(25 - \frac{0.18}{2}\right)}$$

$$= 1.03 \text{ in}^2$$

STEP 06: Check ρ_{max} and ρ_{min}.

$$\rho_{max} = 0.85 \times 0.85 \times \frac{4}{60} \left(\frac{0.003}{0.003 + 0.005}\right)$$

$$\rho_{max} = 0.018$$

$$\rho_{min} = \frac{200}{f_y}$$

$$= \frac{200}{60{,}000} = 0.003$$

$$\rho = \frac{A_{ST}}{b \times d}$$

$$= \frac{1.03}{14 \times 25} = 0.0029$$

$$\rho_{min} > \rho < \rho_{max}$$

$$0.003 > 0.0029 < 0.018.$$

So ~~fma~~ ρ_{min} is greator than ρ

than

$$\rho = \frac{A_{ST}}{b \times d}$$

$$A_{ST} = \rho_{min} \times (b \times d)$$

$$= 0.003 \times (14 \times 25)$$

$$= 1.05 \text{ in}^2$$

STEP 07 SELECTION Of Bars:

Let use # 7

dia of # 7 = $7/8 = 0.875''$

$$\text{Area} = \frac{\pi}{4} d^2 = \frac{\pi}{4}(0.875)^2$$

$$= 0.601 \text{ in}^2$$

$$\text{No of bars} = \frac{A_{ST}}{A_b} = \frac{1.05}{0.601} = 1.746 \approx 2$$

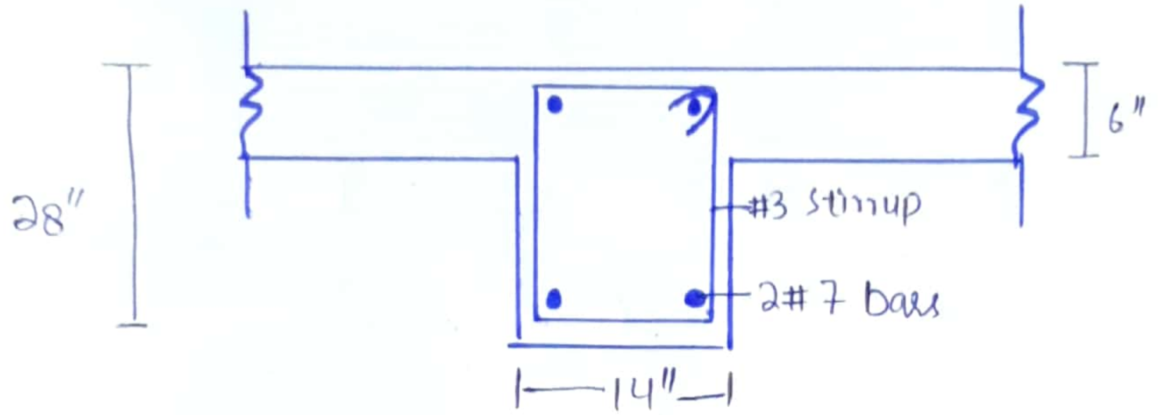
So we use 2 # 7 bars.

STEP 08 Minimum Width

$$b_{min} = (2 \times 1.5) + (2 \times 3/8) + (2 \times 7/8) + (1 \times 7/8)$$

$$= 6.375'' < 14''$$

So 2#6 bar should be provided in one layer.



STEP 09 **Design Moment.**

$$M_d = \phi \times f_y \times A_{st} \times \left(d - \frac{a}{2}\right)$$

Area of steel A_{st} = Area of Bar × No of bars

$$= 0.601 \times 2$$

$$= 1.202 \text{ in}^2$$

$$a = \frac{1.202 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.2209''$$

$$M_d = 0.95 \times 60 \times 1.202 \times \left(25 - \frac{0.2209}{2}\right)$$

$$= 1705.282 \text{ kip-inch}$$

$$M_u = 2111.02 > M_d = 1705.282$$

Design is OK.