"Mid term Exam"

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Section :: A

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Subject :: PRCD I

Attempt all the Questions:-

Q1 A rectangular beam that must carry a service live load of 2.47 Kips/ft. and a Calculated dead load of 1.05 kips/ft (without Self-weight) on an 18-ft. Simple Span is limited to 10 inches Width & 20 inches total depth for architectural reasons. if f_y = 60000 Psi, f_c = 4000 psi What Steel area must be provided. Draw Sketch of your final design.

Given data:-

Width (b) = 10", height (h) = 20"

Live load = 2.47 Kips/ft

Dead load = 1.05 kips/ft

Span = 18'

f'_c = 4000 psi ⇒ 4 ksi

f_y = 60,000 Psi ⇒ 60 ksi

Sol:-

Step # 01 Effective depth $(d) = h - 3$

$= 20 - 3 = 17''$

Effective Cover $(d') = 2.5''$

Ratio of Reinforcement:-

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

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

$$\rho_{max} = 0.0180$$

Step # 02 Finding Area of Steel

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

$$A_{st} = 0.0180 \times (10 \times 17) \Rightarrow 3.06 \text{ in}^2$$

Step # 03 Design moment formula

$$M_{u_2} = \phi \times A_{st} \times f_y \times (d - a/2)$$

Firstly

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10}$$

$$a = 5.4''$$

$$M_{u_2} = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$M_{u_2} = 2362.93 \text{ Kip-Inch}$$

[redacted] Moment due to given loads

Self Beam weight = $\frac{10}{12} \times \frac{20}{12} \times 150$

= 208.33 Lb/ft

Total Factored load = 1.2(1050 + 208.33) + 1.6(2470)

= 5461.99 Lb/ft

= 5.46 k/ft

U. F. M = $\frac{wL^2}{8}$.

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

$M_u = 2653.56$

We have

$M_{u_2} < M_u \Rightarrow 2362.92 < 2653.56$

We have to provide "Double Reinforcement"

Which is Required

Step # 4

$M_{u1} = 2653.56 - 2362.92$

= 290.64 Kip/Inch

Step # 05 "Steel area in Zone of Compression we have"

$$M_{u1} = \phi \times A_{st}' \times f_y \times (d-d')$$

$$A_{st}' = \frac{M_{u1}}{\phi \times f_y \times (d-d')}$$

$$= \frac{290.64}{0.90 \times 60 \times (17-2.5)} = 0.37 in^2$$

Step # 06 "Total Area for this extra moment"

$$A_{st} = A_{st} + A_{st}'$$

$$= 3.06 + 0.37 = 3.43 in^2$$

Step # 07 "Selection of bars"

A) for tensile Steel:-

Lets try # 8 bars, (dia = 8/8 = 1")

area = $0.785 in^2$

$$\text{No of bars} = \frac{A_{st}}{\text{Area of 1 bars}}$$

$$\frac{3.43}{0.785} = 4.36 \cong 5 \text{ bars}$$

5 # 8 bars

(B) For Compression Steel:-

Lets try #6 bars (dia = 6/8 = 0.75")

area = 0.44 in²

$$\text{No of bars} = \frac{As'}{\text{Area of 1 bar}}$$

$$= \frac{0.37}{0.44} = 0.84 \cong 1 \text{ bar}$$

1 # 6

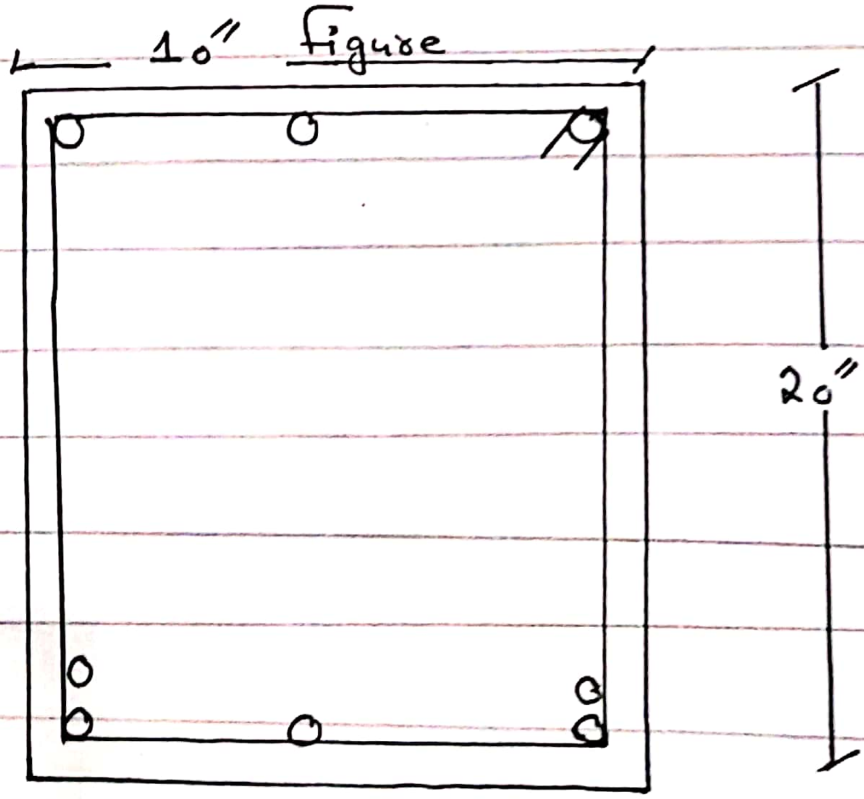
Step # 8 "Minimum Beam Width"

$$b_{min} = 2(1.5) + 2\left(\frac{3}{8}\right) + 5\left(\frac{8}{8}\right) + 4\left(\frac{8}{8}\right)$$

$$= 12.75 > 10"$$

So we provide in multiple layer

figure



Effective Cover (d') = $1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right)$
= 2.25"

Effective depth (d) = $20 - 1.5 - \frac{3}{8} - \frac{8}{8} - \frac{1}{2}\left(\frac{8}{8}\right)$
= 16.62"

Step # 09 Moment Design

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

Where

$$a = \frac{(A_{st} - A_{st}') \times f_y}{0.85 \times 4 \times b}$$

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

a = 6.15"

$$M_d = 0.90\left[(1 \times 0.44) \times 60 \times (16.62 - 2.25) + (5 \times 0.782 - 1 \times 0.44) \times 60 \times \left(16.62 - \frac{6.15}{2}\right)\right]$$

Md = 2890.46

2890.46 > 2653.56

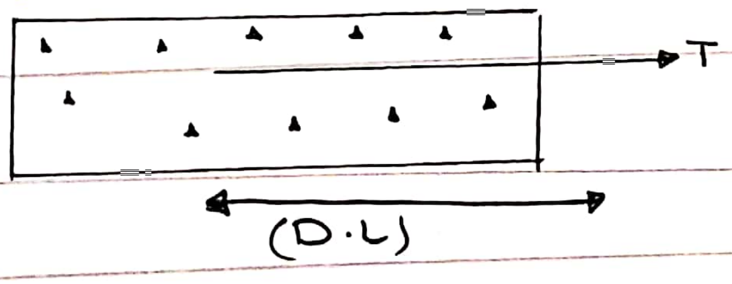
(Design is okay)

Q2(a) Briefly describe Bond Stress and development length.

Ans:- 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 b/w reinforcement & Concrete together.

Development length (D.L):- The length of bar required to transfer the force in the bar to the surrounding Concrete through bond.

Figure



(b) In which Conditions doubly reinforced beam can be used?

Ans (i) This type of beam is mainly provided when the depth of the beam is restricted. If a beam with limited depth is reinforced on the tension side only it might not have sufficent resistance to oppose the bending moment

(ii) Doubly reinforced beam is provided to increase the moment of resistant of a beam having limited dimensions.

(iii) The member is subjected to a shock or impact or accidental lateral thrust.

(iv) For safety reason we always provide doubly reinforced beam to counter wind forces, seismic forces & temp stress's.

(c) Differentiate between T-beam & rectangular beam Analysis.

Ans :- T-beam:- Slab & beam are connected with one another act as one member.

Rectangular-beam:- Slab & beam placed on the beam so there is no connection b/w slab & beam.

(1) $16 \times h_f + b_w$	$6 \times h_f + b_w$
(2) $\frac{CTS}{2} + b_w$	$\frac{CTS}{2} + b_w$
(3) $\frac{\text{Span of beam}}{4}$	$\frac{\text{Span of beam}}{12}$
(4) When $a > h_f$	When $a \leq h_f$

(d) Write short note on the effect of strength reduction factor on flexural strength:-

Ans:- In the design of flexural strength, the strength reduction, factor decreases from tension-controlled section to compression controlled section to increases safety with decreasing ductility. In the reliability based design, the reliable prediction of the flexural strength of reinforced concrete member is assured by the use of reduction factors corresponding to different target reliability Index.

(e) Briefly describe design method, Which one of them Can be used for design of different Structural member & Why?

Ans:- Design method are procedures, techniques aids, or tools of designing. They offer a number of different kinds of activities that a designer might use within process.

(1) Simple design:- This is the most Commonly used type of design. In this design it is assumed that no moment is transferred from one Connected member to the other member or the structure as a whole. This method assumes the design Structure to be pin Jointed. "Simple design method Consist of the following Assumption"

All Connection of beams, girders, & trusses are virtually flexible & proportioned for reaction shear applied at the appropriate ecentricity. The plane Sections normal to the axis remain plane after bending.

(ii) Continous Design:- In this design It is assumed that member are rigid & the moment is transferred b/w members. Continous design is way more Complex than Simple design, So various Software are used to analyze the frame. In this design, frames are capable of resisting lateral loads without relying on the addition bracing System.

" 2 Advantages Why Continous is best"

(1) Connections Perform better in load reversal Situation or earth quakes.

(2) Beams can be less deep in Comparison to beam in the Simple design method.

Problem No / 03

Given data:-

Span = 32' , c/c distance = 10'

Slab thickness = 6"

web width = 14"

Total depth (h) = 28"

Effective depth (h') = 28 - 3 = 25"

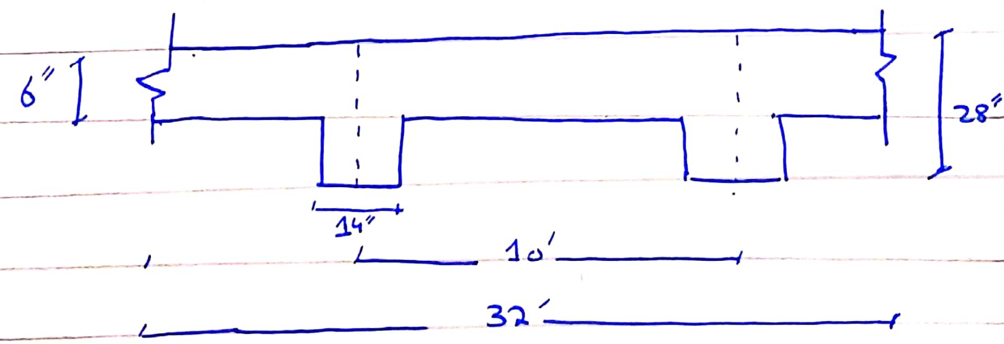
Dead load = 50 lb/ft²

S.S = 225 lb/ft²

f_c = 4000 Psi = 4 ksi

f_y = 60,000 Psi = 60 ksi

Sol:-



Step # 1 U.F.M

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

Find Self weight Per Foot:-

$w_t = b \times t \times \gamma_c$

$= \frac{14}{12} \times \frac{28}{12} \times 150 = 408.33\ lb/ft$

Total Factored load

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

$w_u = 909.96\ lb/ft$

$w_u = 0.909\ k/ft$

Moment :-

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

$M_u = 1396.22\ kips/_{Inch}$

Step # 02 Calculate Effective width

(1) $16 \times h_f + b_w = 16 \times 6 + 14 = 110''$

(2) c/c distance $= 10 \times 12 = 120''$

(3) $Span/4 = \frac{32}{4 \times} \times 12 = 96''$

So $b_e = 96''$

Step# 03 Check Rectangular or T-beam

trial #01 Let $a = h_f = 6$

$$A_{st} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.23}{0.90 \times 60 \times (25 - 6/2)}$$

$$A_{st} = 1.175 \text{ in}^2$$

Trial # 02

$$a = \frac{A_s \times f_y}{\phi \times f_c \times b_e} = \frac{1.175 \times 60}{0.85 \times 4 \times 96}$$

$$a = 0.21'' < 6''$$

So Rectangular beam of design

$$A_s = \frac{1396.23}{0.90 \times 60 \times (25 - 0.21/2)}$$

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

trial #03:- $a = \dfrac{A_s \times f_y}{0.85 \times f'_c \times b_e}$

$$a = \frac{1.03 \times 60}{0.85 \times 4 \times 96} = 0.18''$$

$$A_{st} = \frac{1396.23}{0.90 \times 60 (25 - 0.18/2)}$$

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

Step # 04 Check ρ_{max} & ρ_{min}

$$\rho_{max} = 0.85 \times \beta \times \frac{f_c'}{f_y}\left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t}\right)$$

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

$$\rho_{max} = 0.018$$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60\,000} = 0.003$$

$$\rho = \frac{A_{st}}{b \times d} = \frac{1.03}{14 \times 25} = 0.00294$$

$$\rho = 0.00294$$

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

$$0.003 > 0.00294 < 0.018$$

As "ρ" is less than "ρ_{min}"

So

$$\rho = \frac{A_{st}}{b \times d} = A_{st} = \rho \times (b \times d)$$

$$A_{st} = 0.003 \times (14 \times 25) = 1.05 in^2$$

Step # 05 Selection of bars

We try #8 main bar

area = $1.27 in^2$

No of bars = $\frac{Ast}{Avb} = \frac{1.05}{0.785} = 1.3$

$1.3 \simeq 2$

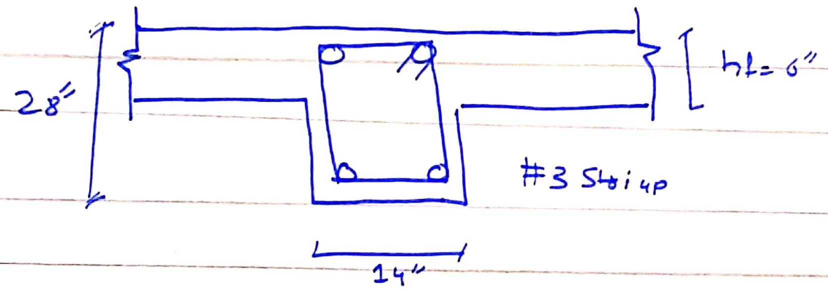
So we take 2#8 m.b

Step # 06 Check on minimum width

$b_{min} = 2 \times 1.5 + 2 \times \left(\frac{3}{8}\right) + 2\left(\frac{8}{8}\right) + 1\left(\frac{8}{8}\right)$

$b_{min} = 6.75'' < 14''$

So good in "1" layer



Step # 07 Moment design

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

where

A_{st} = Area of one bar × No of bars

$A_{st} = 0.785 \times 2 = 1.57 \, in^2$

$a = \frac{A_{st} \times f_y}{0.85 \times f_c \times b_e} = \frac{1.57 \times 60}{0.85 \times 4 \times 96}$

$a = 0.2''$

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$Md = 0.90 \times 60 \times 1.57 \times \left(28 - 0.2/2\right)$

$Md = 2111.02$ kip/Inch

$Md = 2111.02 \; 7 \; 1396.23$

" Design okay "