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Subject : PRCD I

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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 help in keeping bond b/w reinforcement and concrete together. Bond stress resists any force that tries to pull out the rods from the concrete.

=> when we try to pull out the reinforcement bar from hardened concrete, then this bond stress resists the bar to come out.

=> It is different grades of concrete has different bond stress.

Development length :-

Development length can be define as " The length of the bar required for transferring the stress into the concrete.

⇒ In other words Development length is the quantity of the rebar length that is actually required to be enclosed into the concrete to make the desired bond strength b/w two materials and furthermore to produced required stress in the steel at that area.

Why we providing Development length

we providing development length b/c of

⇒ To develop a safe bond b/w the bar surface and concrete so that no failure due to slippage of bar occure during the ultimate loading condition.

⇒ Also the extra length of the bar provided as development length is responsible for transferring the stress development in any section of the adjoing section.

Question 02

(Part b) In which condition doubly reinforcement beam can be used.

Doubly Reinforced Beam:-

Beams reinforced with steel in compression zone and tension zone are called Doubly Reinforced Beam.

Condition when Doubly Reinforced Beam used

We can used the doubly Reinforced Beam on that condition when the restriction occure in the size of beam

For example:- if some one said that the depth of the beam should not be greater then 18" and the external load on beam is very much which can not resist a beam of singly Reinforcement in that condition we used Doubly Reinforced Beam

Question = 02

(Part - c) Differentiate b/w T-Beam analysis and Rectangular Beam analysis.

T- Beam	Rectangular Beam
⇒ T- Beam having beam and slab composite section.	⇒ A Rectangular Beam is one which as generally used as compression in top fibre and tension in bottom fibre of that beam
⇒ A T- Beam is more econom-ical than Rectangular Beam	⇒ Rectangular Beam is less economical then T-Beam
⇒ T. beams are more often used for more heavy duty or larger span such as bridges. These are almost always precast using prestress reinforcement	⇒ Rectangular beams are more often used in office or commercial buildings. these can be cast in-situ using standard reinforcement.
⇒ In case of T-beam, slab are connected with one another and act as a one member.	⇒ In case of Rectangular beam slab has been placed on the beam so there is no connection b/w slab and beam.

Question = 02

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

Effect of Strength Reduction Factor on Flexural Strength :-

In the design of flexural strength, the strength reduction factor decrease from tension control section to compression controlled section to increase safty with decreasing ductility this show to determine the Reduction factor for flexural strength of reinforcement concrete.

Question = 02

(Part - e) Briefly describe design methods which one of them can be best used for design of different structure member and why?

Designing Method :- Two Methods are wordly used for the designing of concrete and different structure member.

① ASD method

② USD method

① **ASD Method** :- ASD method is also known as working stress design method. It is based on the principle that stresses developed in the structural members should not exceed a certain limit friction of elastic limit.

⇒ In this method all load are taken as service load and no factor is applied to increase these services load.

2) **USD Method** :- Ultimate strength design method is also known as load factor method. For the structural subjected to large external load the ultimate strength is determine by the inelastic analysis.

★ ⇒ USD method is best for designing different structure method b/c of the following reason.

① As the ultimate strength of of the material is considered we will get much slender section for column and beam compare to other method.

Question No = 01

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 load) on an 18 ft simple span is limited to ~~an~~ 10 inches width and 20 inches total depth for architectural reasons. If f_y = 60000 psi and f_c' = 4000 psi. What steel area must be provided? Draw sketch.

GIVEN DATA

- ★ Width (b) = 10" inch
- ★ Height (H) = 20" inch
- ★ Live load (L.L) = 2.47 kips/ft
- ★ Dead load (D.L) = 1.05 kips/ft
- ★ Span = 18 ft
- ★ f_c' = 4000 psi = 4 ksi
- ★ f_y = 60000 psi = 60 ksi
- ★ Assume Effective cover = d' = 2.5 inch

Let : $d = h - 3$

$d = 20 - 3$

$d = 17$ inch.

Solution

Step = 01 :- First check the capacity of Section As Simply Reinforcement Beam.

Reinforcement Ratio:

As we know that

$$\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy}\left[\frac{\varepsilon u}{\varepsilon u + \varepsilon y}\right]$$

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

$$\boxed{\rho_{max} = 0.0181} \rightarrow \text{Reinforcement Ratio}$$

Step = 02 :- Find Area of the steel By formula.

$$\rho_{max} = \frac{Ast}{b \times d}$$

$$Ast = \rho_{max} \times b \times d$$

$$Ast = 0.0181 \times 10 \times 17$$

$$\boxed{Ast = 3.077 \text{ inch}^2}$$

Step = 03 Design Moment

By formula

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

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b} = \frac{3.077 \times 60}{0.85 \times 4 \times 10} = \boxed{5.43''}$$

Then

$$M_{u_2} = 0.90 \times 3.077 \times 60 \left(17 - \frac{5.43''}{2}\right)$$

$$\boxed{M_{u_2} = 2373.567 \text{ kip-inch}}$$

Moment due to given loads

Beam self 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

$= 5.46$ kips/ft

Ultimate factored moment $= \frac{wl^2}{8}$

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

$$\boxed{M_u = 2653.56}$$

As, $M_{u_2} < M_u$

$2373.57 < 2653.56$

Now Doubly Reinforcement Required

Step = 04

$M_{u_1} = M_u - M_{u_2}$

$M_{u_1} = 2653.56 - 2373.57$

$M_{u_1} = 279.99$

$M_{u_1} = 280$ kip-inch

Step = 05:- Steel Area in compression zone will

$M_{u_1} = \phi \times A'_{st} \times f_y \times (d - d')$

$$A'_{st} = \frac{M_{u_1}}{\phi \times f_y \times (d-d')}$$

$$= \frac{280}{0.90 \times 60 (17 - 2.5)}$$

$A'_{st} = 0.357 \ in^2$

$\boxed{A'_{st} = 0.36 \ in^2}$

Step = 06 :

$$A_{sb} = A_{s1} + A_{s2}$$

$$A_s = 3.077 + 0.36$$

$$A_s = 3.44 \text{ in}^2$$

Step = 07 For Tensile Zone

Using #8 bar (dia = 8/8 = 1"

$$\text{Area} = 0.785 \text{ in}^2$$

$$\text{No. of bars} = \frac{A_{sT}}{\text{Area of 1 bar}}$$

$$= \frac{3.44}{0.785} = 04.38$$

No of bars = 4.38 ≅ 5 bars

So 5 #8 bars

For Compression Zone

use #6 bars. dia = $\frac{6}{8}$ = 0.75"

Area = 0.44 in²

$$\text{No of bar} = \frac{A_{s}'}{\text{Area of 1 bar}}$$

$$= \frac{0.36}{0.44} = 0.84 \cong 1$$

So 1 #6 bar in compression zone.

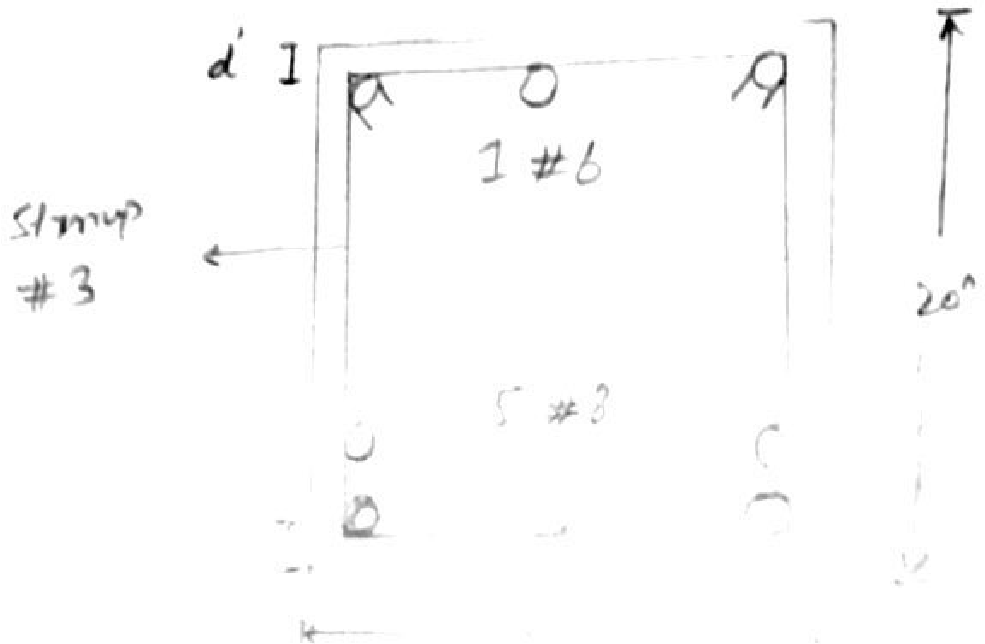
Step =02

Beam Minimum Width

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

$$= 12.75 > 10"$$

in multiple layer



⇒ Effective depth $d = 20 - 1.5 - \frac{3}{8} - \frac{8}{8} - \frac{1}{2}(8/8)$

$$\boxed{d = 16.62"}$$

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

$$\boxed{d' = 2.25"}$$

Step # 09

Design Moment is given

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

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

$$= \frac{(5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10} = \boxed{6.15''}$$

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

$$M_d = 2880.46$$

$$M_d = 2880.46 > 2653.56$$

Design is OK!

Question = 03

A concrete floor system consists of Parallel T beam spaced 10 ft on centers and spanning 32 ft. b/w supports. The 6 inch thick slab is cast monolithically with T-beam webs having width $b_w = 14$ inch and total depth measured from the top of the slab of $h = 28$" the effective depth will be take 3 inch less than the total depth. In addition to its own weight each beam must carry a superimposed D.L of 50 psf and service L.L = 225 psf Material Strengths are $f_y = 60{,}000$ psi and $f'_c = 4000$ psi Determine the required tensile steel area and select the reinforcement needed for a typical member. Draw sketch.

Given Data:

c/c distance = 10 ft

Total span = L = 32 ft

Slab Thickness = h_f = 6 inch

web width = b_w = 14 inch

depth = h = 28 inch

Dead load = D.L = 50 psf = 50 lb/ft²

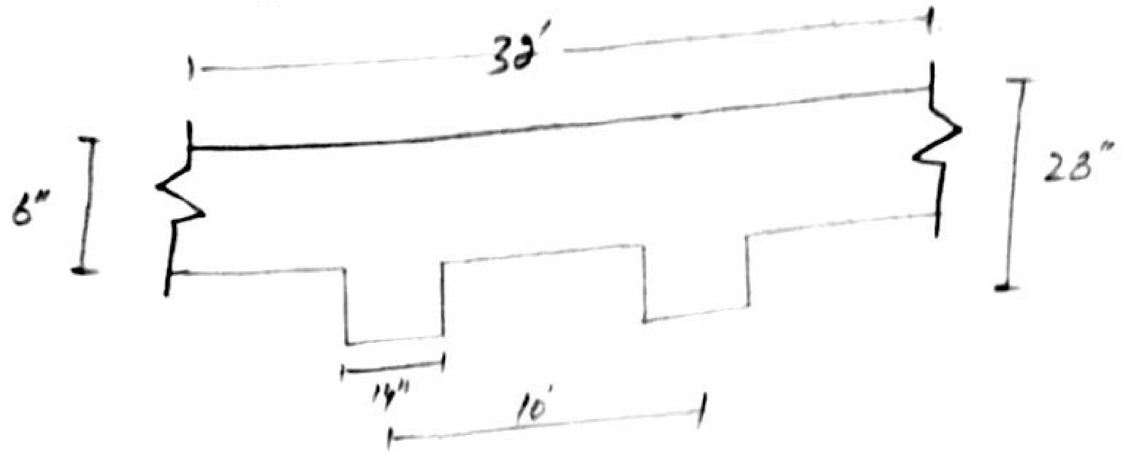
Live load = L.L = 225 psf = 225 lb/ft²

f'_c = 4000 psi = 4 ksi

f_y = 60000 psi = 60 ksi

Solution:

Effective depth = h-3 = 28-3 = 25 inch



Step=01 To Factored load

To find Beam self weight per feet.

$\Rightarrow w_t = b \times h \times \gamma_c$

$w_t = \frac{14}{12} \times \frac{28}{12} \times 150 \ lb/ft^3$

$w_t = 408.33 \ lb/ft.$

As we know that total factored load

$w_u = 1.2 \times D.L + 1.6 \ L.L$

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

$w_u = 909.996 \ lb/ft$

$w_u = 0.91 \ kip/ft$

Step=02: Ultimate factored moment

$M_u = \frac{w_u \times l^2}{8} = \frac{0.91 \times (32)^2}{8} \times 12$

$M_u = 1397.76 \ kip\text{-}inch$

Step = 03 Effective width (be)

★ 1) $16 \times hf + bw$

$16 \times 6 + 14 \Rightarrow 110$ inch

★ 2) c/c distance $= 10 \times 12 = 120$ inch

★ 3) $\frac{span}{4} = \frac{32}{4} = 8' = 8 \times 12 = 96''$

Then the $\boxed{be = 96 \text{ inch}}$

Step = 04 To check which type of analysis is Required

Trial = 01 :- let suppose $a = hf = 6''$

then $Ast = \frac{Mu}{\phi \times fy \times (d - \frac{a}{2})}$

$Ast = \frac{1397.76}{0.9 \times 60 \times (25 - \frac{6}{2})}$

$Ast = 1.177 \; in^2$

Trial = 02

$a = \frac{Ast \times fy}{0.85 \times f'c \times be} = \frac{1.177 \times 60}{0.85 \times 4 \times 96}$

$a = 0.216'' < hf = 6''$

So Design by Rectangular beam

$$A_{st} = \frac{1397.76}{0.90 \times 60 \times \left(25 - \frac{0.216}{2}\right)}$$

$$\boxed{A_{st} = 1.04 \ in^2}$$

Trial #03 :-

$$a = \frac{1.04 \times 60}{0.85 \times 4 \times 96} = 0.191 \ in$$

$$A_{st} = \frac{1387.76}{0.9 \times 60 \times \left(25 - \frac{0.191}{2}\right)}$$

$$\boxed{A_{st} = 1.04 \ in^2}$$

Step = 05 To find ρ_{max} and ρ_{min}

As we know that

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

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

$$\boxed{\rho_{max} = 0.0181}$$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60000} = 0.0033$$

As we know that

$$\rho = \frac{Ast}{b \times d} = \frac{1.04}{14 \times 25}$$

$$\boxed{\rho = 0.00297}$$

So $\rho_{min} < \rho < \rho_{max} \rightarrow$ not ok

b/c $\rho_{min} < \rho$ not satisfied here

Now $\rho_{min} = \frac{Ast}{b \times d}$

$Ast = \rho_{min} \times b \times d$

$Ast = 0.0033 \times 14 \times 25$

$Ast = 1.155 \text{ in}^2$

Step =06 Nos of bar and Bar Section.

let #8 bar use

Area of #8 is 0.785

$$\text{No of bars} = \frac{Ast}{Ab} = \frac{1.155}{0.785}$$

No. of bars = 1.47 ≃ 2

we take 2 #8 bars As main bars

Step = 07

Minimum width (b_{min})

$b_{min} = 2 \times c.c + 2 \times \text{Stirrup} + 2 \times \text{main bar} + 1 \times \text{spacing}$

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

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

So the main bars are good in one layer.

Step = 08

Design moment

As we know that

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

$M_d = 0.9 \times 60 \times 1.57 \times \left(25 - \frac{0.289}{2}\right)$

$\boxed{M_d = 2160.24}$

$M_d > M_u$

Design is OK!

$A_{st} = 0.785 \times 2$

$\boxed{A_{st} = 1.57\ in^2}$

$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b_e}$

$\boxed{a = 0.289\ in}$