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Subject PRC Design-I

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Mid Term Exam

A Rectangular Beam that must carry a Service Live load of 2.47 Kips/ft and a Calculated dead load of 1.05 Kip/ft (Without Self Weight) On an 18 ft Simple Span is Limited to 10 inches Width and 20 inches total depth for architectural reason if fy = 6000 Psi and f'c = 4000 Psi What Steel area must be provided. Draw Sketch of your final design.

Given Data:-

Beam live load (L.L) = 2.47 Kips/ft

Beam dead load (D.L) = 1.05 Kips ft

Span Of Beam = 10"

Depth of Beam = 20"

f_y = 60000 Psi = 60 Ksi

f'_c = 4000 Psi = 4 Ksi

Solution :-

Step # 01

Calculate effective depth (d)

$L - 3 = 20 - 3 = 17''$

Step 02

Calculate effective cover (d'')

Assume $d' = 2.5$

Step 03

Reinforcement Ratio

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

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

$$\rho_{max} = 0.0180625$$

Step 04 :-

Calculate area of Steal

As we know that

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

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

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

$A_{st} = 0.0180625 \times 10 \times 17$

$A_{st} = 3.070625\ in^2$

Step 05:-

By formula of Design moment.

$M_{u2} = \phi \times A_{st} \times f_y \times (d - \frac{a}{2})$

First we find the value of a

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

$$a = \frac{3.07 \times 60}{0.85 \times 4 \times 10} = 5.42''$$

$M_{u2} = 0.90 \times 3.07 \times 60 \times (17 - \frac{5.42}{2})$

$M_{u2} = 2368.99$ kips-inch

Moment due to given Load.

Beam Self Weight $= b \times t \times \gamma_c$

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

$= 208.33\ lb/ft^3$

total factored load:-

$W_I = 1.2\ D.L + 1.6\ L.L$

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

$= 5461.99\ lb/ft$

$= 5.46\ Kips/ft$

Step#06:-

ultimate factored momement

$$M_u = \frac{W \times L^3}{8} \times 12$$

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

$M_u = 2653.56$

As we have

$M_u > M_{u2}$

$2653.56 > 2368.99$

⇒ Design of Section is Doubly Reinforcement

Step 07:-

To find M_{u1}:-

$M_{u1} = M_u - M_{u2}$

$M_{u1} = 2653.56 - 2368.99$

$M_{u1} = 284.57$ Kip - inch

Step 08:-

As We Know that

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

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

$$A_s' = \frac{284.57}{0.90 \times 60 \times (17-2.5)}$$

$$A_s' = 0.36\ in^2$$

This is the steel area in Compression zone

Total Steel area:-

$$A_{st} = A_{st} + A_s' = 3.07 + 0.36$$

$$A_s = 3.43\ in^2$$

STEP 9:-

Selection of bars

(A) For tensile Steel:-

let try #8 bar having

Area $= 0.785\ in^2$

$\Rightarrow$ number of bar $= \frac{A_s}{A_b} = \frac{3.43}{0.785}$

$= 4.369 = 5$ bar

So 5 # 8 bar.

STEP 10

Design moment :-

$Md = \phi \times [As' \times fy \times (d - d') + (Ast - Ast) \times fy \times (d - a/2)]$

As we know that

$$a = \frac{(Ast - Ast) \times fy}{0.85 \times fc \times b}$$

$$a = \frac{5 \times 0.785 - ~~to~~\ 1 \times 044) \times 60}{0.85 \times 4 \times 10} = 6.15$$

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

$Md = 2890.46$

AS $Md = 2890.46 72653.56$ K"

So the design is OK

(B) **For Compression Steel:-**

lets try 6 bars having Area = 0.44 in²

number Of bar $\frac{A's}{Ab} = \frac{0.36}{0.44}$

= 0.81 = 1 bars

So 1 #6 bar in Compressin Zone

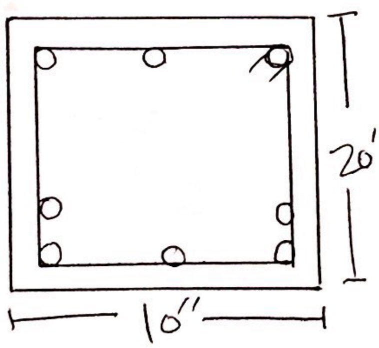
Step 09

Check on minimum width of beam

$b_{min} = 2(1.5) + 2(3/8) + 5(8/8) + 4(8/8)$

$= 12.75'' > 10''$

=> Not good in one layer.



=> Effective Depth (d) = 20 - 1.5 3/8 - 8/8 - 1/2 (8/8)

=> Effective Cover (d') = 1.5 + 3/8 + 1/2 (6/8)

Question No 3:-

(1)

A concrete floor system consist of parallel T beams spaced 10 ft. on centers and spanning 32ft. between supports. The 6-inch-thick slab is cast monolithically with T beam webs having width bw = 14-inch and total depth measured from the top of the slab, of h=28inch. The effective depth will be taken 3-inch less than total depth. In addition to its own weight, each beam must carry a superimposed D.L of 50 psf and service live load of 225 psf. Material strength are fy = 60,000 psi and fc=4000 psi. Determine the required tensile steel area and select the reinforcemen needed for a typical member. Draw sketch of your final design

Given Data:-

C/C distance = 10′

Span = 32′

Slab thickness = 6″

web width = 14″

Total depth (h) = 28″

Effective depth = 28″ - 3″

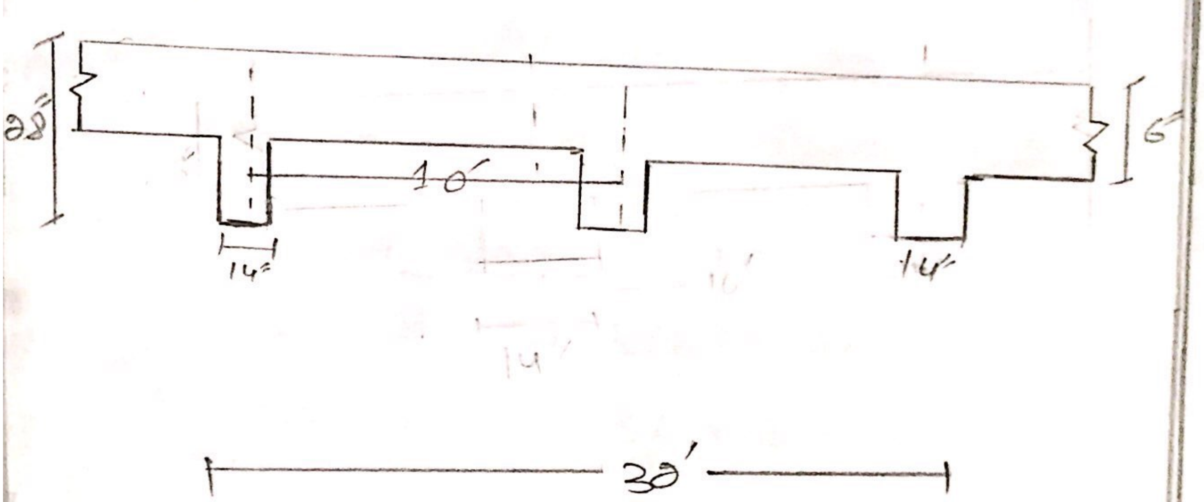
$D.L = 50 \, lb/ft^2$

$S.S = 225 \ lb/ft^2$

$f_y = 60{,}000 \ psi$

$f'_c = 4000 \ psi$

Sol:-



Step # 1

$$M_u = \frac{W_u \times L^2}{8}$$

Beam self weight per feet

$W_t = b \times t \times \gamma_c$

$= \frac{14}{12} \times \frac{28}{12} \times 15 = 408.33 \ Lb/ft$

Total Factored Load:-

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

$= 909.99\ Lb/ft = 0.909\ kip/ft$

Moment,

$\frac{wl^2}{8} = \frac{0.909 \times (32)^2 \times 12}{8} = 1396.23\ kip$

Step#02

↳ Effective Breath:-

1) $16(hf) + bw = 16(6) + 14 = 110''$

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

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

So $bc = 96''$

Step #3:-

Rectangular or T-Beam

Trial # 1

Let $a = hf = 6''$

$Ast = \frac{Mv}{0 \times fy \times (d - a/2)} = \frac{1396.23}{0.90 \times 60 (25 - 6/2)}$

$Ast = 1.17\ in^2$

Trial # 2:-

$$a = \frac{A_{st} \times f_y}{0.85 \times f_c' \times b} = \frac{1.17 \times 60}{0.85 \times 4 \times 96}$$

$$= 0.2'' < 6''$$

So Rectangular Beam design

$$A_{st} := \frac{1396.23}{0.90 \times 60 \times (25 - 0.2/2)}$$

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

Trial # 3:-

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

$$A_{st} = \frac{1396.23}{0.90 \times 60 (25 - 0.18/2)} = 1.03 \text{ in}^2$$

Step # 4:-

check ρ_{max} and ρ_{min}

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

$$\rho_{max} = 0.018$$

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

$\Rightarrow \rho = \frac{Ast}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 < 0.018$

As ρ is less than ρ_{min}

So,

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

$Ast = 0.003 \times 14 \times 25 = 1.05 \text{ in}^2$

Step # 5:-

No. and selection of Bar

Let use # 8 bar, then

dia $(8/8) = 1''$, Area $= 0.785 \text{ in}^2$

No of bars $= \frac{1.05}{0.785} = 1.3 \approx 2$

So we use 2 # 8 bars

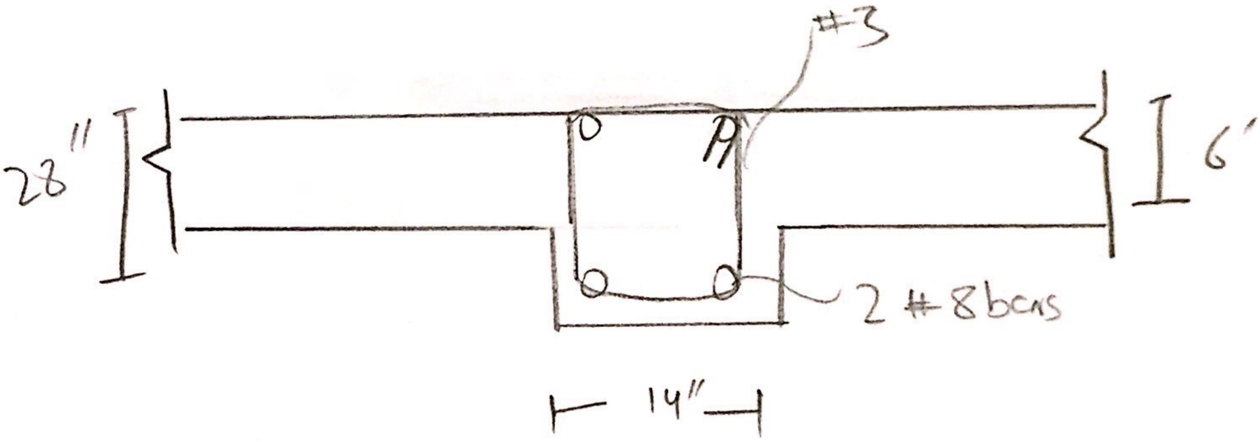
Step # 6:

Minimum Width

b_{min} $2(1.5)+2(3/8)+2(8/8)+1(8/8)$

$= 6.75'' < 14''$

So good in one layer.



Step # 7:-

Design Moment.

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

Area of steel = Area of 1 bar × No. of bars

$= 0.785 \times 2$

$= 1.57 in^2$

$$a = \frac{1.57 \times 60}{0.85 \times 4 \times 96} = 0.2''$$

$$\Rightarrow M_d = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2)$$

2111.02 kip-inch

As, 2111.02 > 1396.23

↓

Design is ok!

Question No#2

(a)

Briefly describe Bond stress and development?

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 reinforce-ment 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.

By the way different grade of concrete has different bond stress.

well, these bonds are classified into two layers.

1) Anchorage bond

2) Flexular bond.

Devolpment Length:-

A development length can be defined as the amount of reinforcement (bar) length needed to enballed or projected into the column to establish the desired bond strength between the concrete and steel.

Reason for Providing Development length:-

- The develop a safe bond b/w the bar surface and the concrete so that no failure due slippage of bar occurs during the ultimate load condition
- Also the extra length of the bar provided a development length is responsible for transfering the stress developend in any section to the adjoining section (such as a colum beam junction the extra length of bars provided from to column).

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

Ans :- Doubly reinforced beams are provided ~~beca~~ because of the following reasons.

1) Doubly reinforced beam are provided in ordered to increase the moment carrying capacity of the section we also know that we can increase the moment carrying capacity of beam by increasing its depth but it is not always possible to increase the depth of beam because of Architectural and Aesthetic Restriction.

2) Minimum compression reinforcement is provided to hold the shear reinforcment in position and for increasing ductility of beam.

3) Most important reason for providing the doubly reinforced beam is to ensure safety against reversal of stresses in the structure due to wind forces, Seismic force and temperature stresses.

(c) Differentiate between T-beam analysis and rectangular beam analysis (4)

T- Beam	Rectangular Beam
- It is more economical	- It is less economical
In case T-beam slab and beam are connected with one another and act is a one member.	- In case of rectangular beam slab has beam placed on the beam and there is no connection b/w slab and beam
- It consist of T-shaped structure	- It is used generally as compression in top fibre and tension in bottom fibre.
- Analysis is required when $a > h_f$	- Analysis is required when $a \leq h_f$.

(d) (5)

write a short note on the effect of strength reduction factor on flexural strength.

Answer:-

In the design of flexural strength. the strength reduction factor Φ decrease from tension - controlled - sections to compression- controlled section to increase safety with decreasing ductility. In the reliability based design the reliable predection of the flexural strength of reinforced concrete members is assured by the used of reduction factor corresponding to different target reliability index β.

Part (E)

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

Ans: There are three methods of structural members design. which are the following-

(i) Working Stress Method:-

This Method basically assumed that the structural material behaves as a linear elastic manner, and the adequate safety ~~ensures~~ can be ensured by suitably restricting the stresses in the material induced by the expected working loads on structure.

ii) Ultimate Load Method:-

In this method the stress condition at the site of impending collapse of the structure analyzed and the non-linear stress-strain curves of concrete and steel are made use of.

* The ultimate load method make it possible for different types of loads to be ~~used~~ assigned different load factors under combined loading conditions.

(iii) Limit State Method (7)

The Philosphy of the limit state method of design represent a definite advancement over the traditional design philosphies.