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Name = Iqrar Hussain

ID = 7877

Section = A

Mid Term Exam.

Subject =

Instrutor Name. Engr- Fawad Khan

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QNo1 ⇒ A rectangular beam that must carry a service 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 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 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_y = 60,000 = 60 ksi

f'_c = 4000 psi = 4 ksi

Sol **Step No 1** ⇒ For effective depth (d)

$h - 3$

$20 - 3 = 17''$

⇒ For effective cover (d_1) = 2.5"

⇒ **For reinforcement Ratio**

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

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

$$\boxed{\rho_{max} = 0.0180}$$

Step No 2 ⇒ For finding Steel Area.

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

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

Step No 3 Using formula of design Moment.

$$M_{o2} = \phi \times A_{st} \times F_y \times (d - a/2)$$

$$a = \frac{A_{st} \times F_y}{0.85 \times f'_c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

$$M_{o2} = 0.90 \times 3.06 \times 60 \times (17 - 5.4/2)$$

$$\boxed{M_{o2} = 2362.93 \text{ kip-inch}}$$

Moment due to given loads

Beam Self weight $= \frac{10}{12} \times \frac{20}{12} \times 150 = 208.33$ lb/ft

Total factored load $\Rightarrow$ $1.2(1050 + 208.33) + 1.6(2470)$

$= 5461.99$ lb/ft

$= 5.46$ kips/ft

Ultimate Factored Moment:

$$\frac{WL^2}{8}$$

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

$$\boxed{M_u = 2653.56}$$

Now As we know that

$$M_{u2} < M_u$$

$$2362.92 < 2653.56$$

↓

Doubly reinforcement

Step No 4

$$M_{u1} = 2653.56 - 2362.92 = \boxed{290.64 \text{ kip-inch}}$$

Step No 5 Area of steel in compression zone will be,

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

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

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

Step No 6

$$A_s = A_{st} + A'_{st}$$

$$3.06 + 0.37 = \boxed{3.43\ in^2}$$

Step No 7

We use # 8 bars, dia = 8/8 = 1")

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

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

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

So 5 # 8 bars

for tensile zone

⇒ **Compression Steel:**

Use # 6 bars

dia (6/8) = 0.75"

No of bar = $\frac{Ast}{\text{Area of 1 bar}} = \frac{0.37}{0.44} = 0.84 = 1$ bar

So 1 # 6 bars in → Compression zone

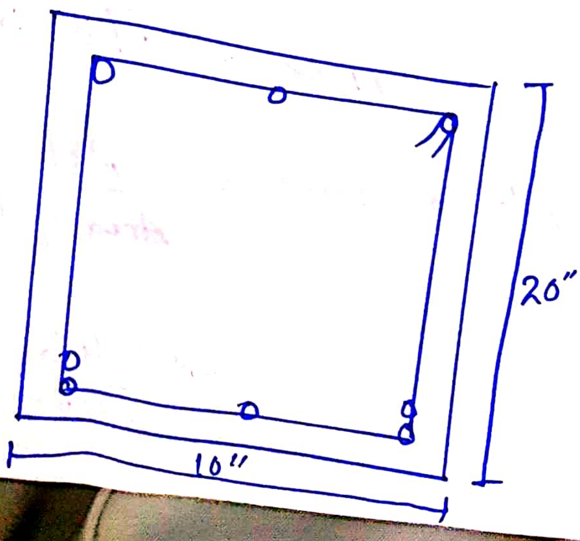
Step No 8

for Beam Minimum width.

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

$= 12.75 > 10"$

in multiple layers



⇒ Effectiv depth. (d)

$$= 20 - 1.5 - \frac{3}{8} - \frac{8}{8} - \frac{1}{2}\left(\frac{8}{8}\right)$$

$$d = 16.62''$$

⇒ Effective cover (d')

$$1.5 + \frac{3}{8} + \frac{1}{2}\left(\frac{6}{8}\right)$$

$$= 2.25''$$

Step No 9

for design Moment of given by

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

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

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

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

$$\times 60 \times 16.62 - \frac{6.15}{2})$$

$$M_d = 2890.46$$

As $M_d = 2890.46 > 2653.56$

(Design is ok)

Q No 2 A) Briefly describe Bond Stress and Development length.

Bond Stress ⇒ 1) The force of adhesion per unit area of contact between two bonded surfaces, such as between concrete and a steel reinforcing bar

2) The shear stress at the surface of a reinforcing bar which prevents relative movement between the bar and the surrounding concrete.

Development length ⇒ The check for satisfying the requirment of permissible bond stress specified in the earlier code has now been placed by the concept of development length. It is abuious that bar with sufficient embedment. In concrete cannot be pulled out. Development length is the minimum length of bar which must be embedded in concrete beyond any section to develop by bond (between concrete and Steel) a force equal to the total tensile force in the bar at that Section. Development length is represent by a symbol "Ld" and it is expressed in terms of the diameter of the bar.

Part B ⇒ In which condition doubly reinforced beam can be used?

Ans Doubly reinforced beams are provided in order to Increase the moment carrying capacity of the Section. We also know that we can increase the moment carrying capacity of beams by Increasing it's depth but it is not always possible to increase the depth of beam because of Architectural and Aesthetic restrictions.

2) Moreover increasing the depth of beam will result into the more self weight (Dead load).

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

3) Most Important reason for providing the doubly reinforced beams is to ensure safety against reversal of stresses. In the structure due to wind forces, Seismic forces and temperature stresses.

Suppose that If you haven't provided the top reinforcement, than how you will hold the stirrups on the top part of beam.

In case stirrups will shake during concreting and even may touch the formwork on one side.

Which will result in the zero required cover to the reinforcement on that side.

Part C Differentiate between T-beam ~~reinforced~~ analysics and rectangular beam analysis.

Ans ⇒ The resistance of T beam is higher for positive moment because the flange section would be in compression. But for negative moment it yields the same strength as an equivalent beam without the flange. While the rectangular section only dedepends on the location of reinforcement to yield the flexural capacity. The mean difference between the T-beam and rectangular beam in reinforced concrete is

1) Geometry

2) Flexural Capacity

3) Design procedure

1) In terms of Geometry It is vary clear one is rectangular and the other is T. But here you should not that the T beam offers more moment of Inertia.

2) The flexural capacity of T beam varies based on the sign of moment (positive or negative) The resistance of T beam is higher for positive moment because the flange section would be in compression. But for negative moment yields the same strength as an equivalent beam without the flange. While the rectangular section only depends on the location of reinforcement to yield the flexural capacity.

3) The design procedure ~~with~~ of T beam depends on the location of moment as the case of its flexural strength. for positive moment we have three cases to be checked to proceed with design one of the neutral axis is within the flange two neutral axis outside of the flange or in the web and three doubly reinforced T beam. So you need to make sure which case is your beam before proceeding to design.

Simply put, the principle difference between the T-beam and the rectangular beam in architectural use is one of functionality, or it's Intended purpose.

The T-beam more specifically the double-T beam, has been designed for flooring and roofing systems. The beam are topped with mortar-based cement or fine Concrete or more typically the concrete is added to deck panels atop the connected beam flanges.

The rectangular beam are designed to carry very heavy loads and so are Strong. and when support columns are added, become very Strong and are able to Support the T-beam.

For the T-beam and rectangular beam System, the rectangular beams run the perimeter of the Structure and the main transitional points and so are Called girders. The T-beams are tied into the rectangular beams either by fitting into Slotted receiving Channels, or are mechanically fastened to rectangular girders.

Part D ⇒ Write Short notes on the Strength reduction Factor on Flexural Strength.

Ans ⇒ Strength reduction Factor is defined as the ratio of elastic Strength to yield Strength. The importance of estimating R factor originates in the need for directly doriving inelastic Spectra.

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 ducitility. In the reliability based design the reliable prediction of the flexural Strength of reinforced Concrete members is assured by the use of redeution factors corresponding to to different target reliability index β.

The flexural strength reduction factor has been investigated by using experimental studies.

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

Design Methods

Design methods are procedures, techniques, aids or tools for designing. The offer a numbers of different kind of activities that a designer might use within an overall design process. Conventional procedures of design, such as drawing, can be regarded as design methods. but since the 1950s new procedures have been developed that are more usually grouped together under the name of design methods. Design methodology is the broader study of method in design, the study of the principles, ~~Part~~ practices and procedures of designing.

There are basically 3 method to desingn a R.C beam.

1) Limit State method.

2) Working State method.

3) Ultimate load method.

Most extensively used method is limit State method. All the codes for designing a R.C beam are based on limit State method.

Limit State method consists of 2 types.

1) <u>Limit State of Servicеabity</u> ⇒ The Servicability deals with deflections, carcking, bending ~~ect~~ etc under a given Service loads.

2) **Limit State collapse**

The resistance to bending, shear torsion and axial loads at any section shall not be less than the maximum respective values produced by most unfavorable combination of loads (dead load, live load, wind, snow earthquicks) on the structure using appropriate partial factor of safety.

Limit State method of design is more preferred as the area of cross section required is comparatively less than working stress design.

2) It considers uncertainty in loads as well as design strength of materials and takes factor of safety for both.

Besides saying that three are some advantages of working stress method over limit state method. Noticeably the reinforcement required is lesser in WSM than limit State for design of Same/equal load Carrying Structure, but that would require more volume of Concrete.

QNO3 ⇒ A Concrete floor System consists of Parallel T beams Spaced 10 ft. on Centers and Spanning 32 ft. between 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 $h = 28$ Inch. The effective depth will be 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 live load of 225 psf. Material Strength 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 of your final design.

Given data

C/c distance = 10"

Span = 30'

Slab thickness = 6"

Total depth (h) = 28"

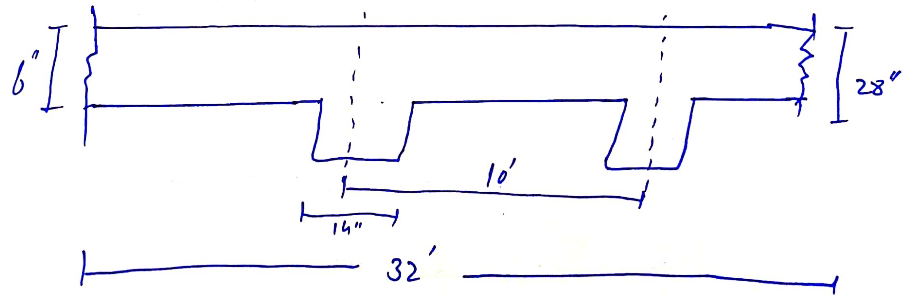
Effective depth = 28" - 3" = 25"

D.L = 50 lb/ft^2

S.S = 225 lb/ft^2

f_y = 60,000 psi

f'_c = 4000 psi



Step No 1

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

1- **Beam Self weight Per Feet**

$Wt = b \times t \times \gamma_c$

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

For Total Factored load

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

$= 909.99$ lb/ft $= 0.909$ kip/ft

Moment

$$\frac{WL^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12 = 1396.23 \text{ kip/inh}$$

⇒ **For the effective Breath**

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

⇒ C/c distance = $10(12) = 120''$

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

So be = 96"

Step No 3 for Rectangular or T-beam)

Trial 1 Let $a = h_f = 6''$

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

$$\boxed{A_{st} = 1.17 \, in^2}$$

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 the Rectangular Beam design.

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

$$\boxed{= 1.03 \, in^2}$$

Trial 3

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

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

Step No 4 ⇒ To Check the ρ_{max} and ρ_{min}

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

$\rho_{max} = 0.018$

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

⇒ $\rho = \frac{A_{st}}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 \nless 0.018$

As we know that

ρ is less than ρ_{min}

So,

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

$A_{st} = 0.003 \times 14 \times 25$

$= 1.05 \; in^2$

Step No 5 ⇒ No and Selection of Bar

let use #8 bar then

dia = (8/8) bar then dia = 8/8) = 1"

Area = $0.785 in^2$

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

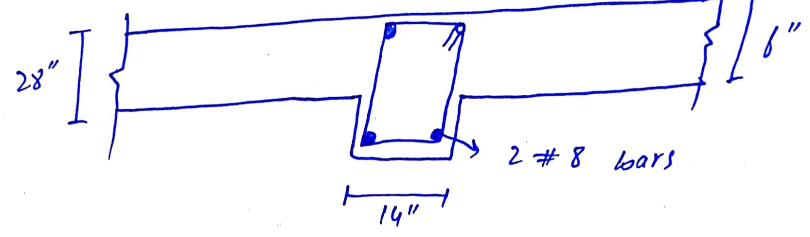
So we use 2 #8 bars.

Step No 6 For the Minimum width.

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

$$= 6.75'' < 14''$$

This is so good in one layer.



Step No 7 For design Moment.

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

Area of the Steel = Area of 1 bar × No of bars

$= 0.785 \times 2 = 1.57\ in^2$

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

$\Rightarrow M_d = 0.90 \times 60 \times 1.57 \times (25 - \frac{0.2}{2})$

As 2111.02 kip-inch

This is good for design.