Name = Shahkar

ID = 7808

Section = A

Semester = 6^{th}

Subject = Plain & reinforced concrete design I

Instructor = Engr. Fawad Khan.

MID Term Examination

Civil engineering department.

Question no 1:

A rectangular beam that must carry a service live load of 2.47 kp/ft and a calculated load of 10.5 kips/ft (without self-weight) on an 18 ft. simple span is limited to 10" width and 20" total depth for architectural reasons.

If $fy = 60{,}000$ psi => $f'c = 4000$ psi

what steel area must be provided?
Draw sketch of your final design?

<u>Given data.</u>

Height = 20"
width = 10"

dead load = 1.05 kip/ft
live load = 2.47 kip/ft

span = 18"
$fc = 4000$ psi $= 4$ ksi
$fy = 60000$ psi $= 60$ ksi

$d = h - 3 = 20 - 3 = 17"$

The effective cover $(d') = 2.5'$

Solution;

First of all to find the reinforcement ratio;

As we know that

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

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

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

Now

Step 2 ⇒ To find the total area of steel

As from the formula we have

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

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

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

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Step = 3

Now by the formula of design moment

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

$a = \frac{A_{st} \times f_y}{0.85 \times f_c \times b} = \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$

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

$= 2362.93$ kip-inch

Moment due to given load (self weight)

$= \frac{10}{12} \times \frac{20}{12} \times 150\ lb/ft^3$

$Wt = 208.33\ lb/ft$

Load = $1.2\ DL + 1.6\ (L \cdot L)$

$1.2(1.05 \times 1000) + 208.33) + 1.6(2.47 \times 1000)$

$= 5.46$ kips/ft

By formula ultimate factored moment

so we have

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

$M_u = 2653.56$ kip inch

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so $M_u > M_{u2}$

$= 2653.56 > 2369.82$

Step 4

Moments differentiate

$= 2653.56 - 2369.82$

$M_{u1} = 290.64$ kip-inch

Step 5

Now by the formula we have

$m_{u1} = \varphi \times A_{st} \times f_y \times (d - d_1)$

so as

$$A_{st} = \frac{m_{u1}}{\varphi \times f_y \times (d - d_1)}$$

$$A_{st} = \frac{290.64}{0.90 \times 60 \times (17 - 2.5)}$$

$$\boxed{A_{st} = 0.37 \text{ in}^2}$$

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Step = 6 Now to find the total steel area.

As we know that

$A_{st} + A_s'$

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

The total steel area must be provided in the tensile zone area where they applied by tension reinforcement

Step 7 selection of balls for Tensile steel.

So the 8 # having area

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

d_b = diameter of a bar

$d_b = \frac{8}{8} = 1''$

so $a_b = \frac{3.14}{4} \times (1)^2$

$a_b = 0.785\ in^2$

So the No.s of bars $= \frac{A_{st}}{\text{area of 1 Bar}}$

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So $= \frac{3.43}{0.785} = 4.36 \simeq 5$ bars

5 # 8 bars

B) for compression steel.

So try 6# bar having area of $= 0.44\ in^2$ dia $= 6/8 = 0.75$

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

So the 1 # 6 is in the compression zone which is 0.84.

Step 8# Now check the minimum depth of the bar.

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

$= 12.75'' > 10''$

As value is greater so the bar will be in multiple layer available.

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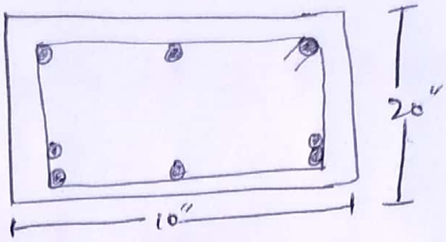

Effective depth

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

$d = 16.62''$

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

$(d') = 2.25''$

Step 9#

Design the moment

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

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

Now

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

$Md = 2890.46$

As the $Md = 2890.46 > 2653.56$.

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Question NO 02

A) Briefly described Bond stress and development length.

Bond stress:

The force of adhesion per unit area of contract b/w two bonded surfaces, such as between concrete and a steel reinforcing ball.

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

Development length:

It is the minimum length of the bar which must be embeded in concrete beyond any section to develop its full strength.

This is also called as an anchorage length in case of axial tentision or axial compression and development length in case of flexural tension or flexural compression.

Why we provide development length.

Development length creates a safe bond between bar surface and concrete. It also ensure during ultimate load conditions the reinforcement bar should not sleep through the complete it transfers stress or loads from beam to column smoothly.

B) In which condition doubly reinforced beam can be used?

Doubly reinforced: reinforced beam with steel in compression zone and tension zone are known as doubly reinforced beam.

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condition when doubly reinforced beam used.

Three important conditions where doubly reinforced sections are to be used.

1. when the dimensions of the beam are restricted for architectural or structural purposes.

2- sections that are subjected to the reversal of bending moment (piles, braces in water towers etc.

3- The portion of the beam over middle support in continious T- beams has to be designed as doubly reinforced section.

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c) Differentiate b/w T-beams analysis and rectangular beam analysis.

T-Beam analysis:

The interacting flange and web produce the cross section having the typical T-shape. thus the T-beam gets its ~~m~~ name.

The large compressive in the flange of the T, beam, the moment strength is usually limited by the yielding of the tensile steel.

Therefore it is safe to assume that the tensile steel will yield before the concrete reaches its ultimate strain

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Rectangular beam analysis.

A rectangular beam is one which is generally used as compression in top fibre and tension in bottom fibre of the beam. where as t- beam having beam and slab compositive section. A. t - beam is more economical than rectangular beam.

It is most commonly use in offices, buildings, commerial flats.

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D) Effect of strength reduction factor on flexural strength

In the design of the flexural strength the strength reduction factor decrease from tension control section to compression controled section to increase safety with decreasing ductility this show to determine the reduction factor for flexural strength of reinforcemet concrete.

also strength reduction factor shows the strength in terms of percentage while designing a section to resist the movement caused by Load.

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E) Designing method:

we have two methods which are wordely used. which are given below

i) ASD Method (Allowable stress design method)

ii) USD Method (ultimate strength design Method)

i) Allowable stress design method.

In allowable stress design method the designer must size the anchorage such that the service load does not exceed the allowable load for any anchor. The designer must be read the applicable table and adjust the allowable load for all applicable design perameters for the anchor, such as spacing, edge distance in-service temperature or allowable-stress increase for short term loads.

2) Ultimate stress design Method (USD)

- Its primarily based on strength concept of concrete.
- Its consider to design ~~control~~ critical combination of load.
- Its designing to elastic behaviour of materials.
- Materials strength to be used for member design.
- Stability of structure more than WSD and ASD.
- Low cost design Method.

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Question No 3

A concrete floor system consists parallel T- beams spaced 10' on centers and spacing 32' b/w supports. The 6" thick slab is cast monolithicly with T- beam webs having width b/w 14" and total depth measured from the top of the slab of h = 28". The effective depth will be taken 3" less than the total depth. In addition to its own weight each beam must carry a superimpased D.L of 50 psf and service L.L of 225 psf. Material strengths are fy = 60,000 Psi and fc' = 4000 psi. Determine the required tensile steel area and select the reinforcement needed for a typical member. Draw sketch of your final diagram.

Given data

span of a beam = 32'

c/c distance between beams = 10'

Height of flange = hf = 6"

Total depth of beam = 28"

web width = 14"

Dead load = 50 psf

live load = 225

fy = 60000 Psi

fc' = 4000 psi

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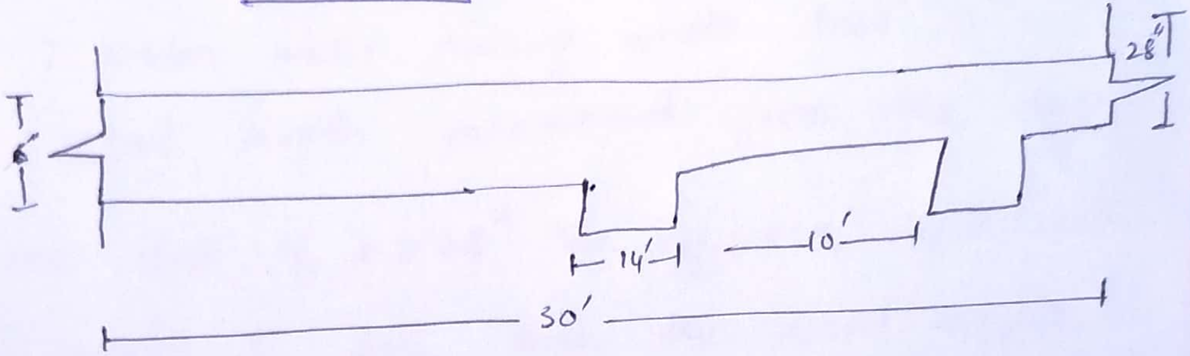
Solution:

Effective depth $(d) = h - 3$

$= 28 - 3$

$d = 25$

$d = 25$



Step 1:

The factor moment

By the formula we have

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

The self weight of the beam

$wt = b \times t \times \gamma c$

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

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

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

Now factored load

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

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$= 909.99\ lb/ft$

$= 0.90999\ kip/ft$

$$\frac{wL^2}{8} = \frac{0.90999 \times (32)^2}{8} \times 12$$

$M = 1396.23$ kip inch

Step 2 Now calculate the effective breath for T beams.

By the using of 3 formulas we chose least value.

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

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

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

$= 96'' \rightarrow$ at least value so we choose

STep 3: T- Beam analysis

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

we know that by the formula of steel

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

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$= \frac{1397.76}{0.90 \times 60 \times (25 - 6/2)} = 1.17 in^2$

Trial 2 :

$a = \frac{Ast \times fy}{0.85 \times f_c' \times b}$

$= \frac{1.17 \times 60}{0.85 \times 4 \times 96}$

$\boxed{0.2'' < 6''} \Rightarrow$

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

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

Now Trial 3 = As we know that from the formula

we get

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

$\boxed{a = 0.18''}$

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

$= 1.03 in^2$

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Step 4# Now check the order ↑ ρ_{max} and ρ_{min}

Max reinforcement ratio

$$\rho_{max} = 0.85\,\beta \times \frac{fc}{fy} \times \left(\frac{\epsilon u}{\epsilon u + \epsilon y}\right)$$

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

$$\boxed{\rho_{max} = 0.018}$$

minimum reinforce ratio

$$\rho_{min} = 200/fy$$

$$\frac{200}{60,000} \Rightarrow \boxed{0.003}$$

$$\rho = \frac{Ast}{bd} = \frac{1.03}{14 \times 25} = 0.002$$

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

$$0.003 < 0.002 < 0.018$$

if ρ is leess than ρ_{min}, then we have to find Ast on ρ_{min}.

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

$$\boxed{Ast = 1.05\ in^2}$$

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Step 5# No. of bars required

let try #8 main bar having the

area of one #8 bar = 0.785 in²

dia = 8/8 = 1"

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

so take the 2 #8 bars.

Step # 6 the minimum depth so we have by formula

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

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

The bars comes in the single layer and will be good.

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Step 7 # Design of moment

$Md = \phi \times fy \times AST \times (d - a/2)$

But first find 'ast' and 'a'

Ast = area of one bar × No of bars

so

= 0.785 × 2 = $1.57 in^2$

Now

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

$Md = 0.90 \times 60 \times 1.57 \, (25 - 0.2/2)$

Md = 2111.03 Kip-inch

so 2111.03 > 1396.23 → (a)

Now the (a) value is minimum and smaller so the design is ok!