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NAME	SYED ANAS
ID	7648
SEM	10th
Subject	PRL I
Submitted to	ENGR. FAWAD KHAN

Agha's

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Q1 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.

Span = 18ft

f'_c = 4000 psi = 4ksi

f_y = 60000 psi = 60ksi

Assume effective cover = d' = 2.5inch

Let

d = h - 3

d = 20 - 3

d = 17 inch

Sol

Step 1

First check the capacity of section as simply reinforcement beam

Reinforcement ratio:

As we know that

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

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

$\rho_{max} = 0.0181$ → Reinforcement ratio

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Step 2

Find area of steel

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

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

$= 0.0181 \times 10 \times 17$

$Ast = 3.077$ inch

Step 3 Design moment

$M_{u_2} = \phi \times Ast \times f_y \times (d - \frac{a}{2})$

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

There

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

$M_{u_2} = 2373.567$ kip-inch

Moment due to given load

Beam self weight $= \frac{10}{2} \times \frac{20}{12} \times 150 = 208.33$ Lb/ft

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

$= 5461.99$ Lb/ft

$= 5.46$ kip/ft

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

$= \frac{5.46 \times 18^2}{8} \times 12$ $\boxed{M_u = 2653.56}$

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As

$M_{u_2} < M_u$

2373.57   2653.56

Now Doubly reinforcement required

Step 4

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

$M_{u_1} = 2653.56 - 2373.57$

$M_{u_1} = 279.99$

$M_{u_1} = 280$ kip/inch

Step 5

Steel area in compression zone

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

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

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

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

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

Step 6

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

$= 3.077 + 0.36$

$A_s = 3.44 \; in^2$

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Step 7

For Tesile Zone

Using #8 bar $\quad dia = 8/8 = 1''$

Area = $0.785\ in^2$

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

$= \frac{3.44}{0.785} = 4.38$

No of bars = $4.38 \cong 5$ bar

so

5 #8 bars

For compression zone:

use #6 bars $\quad dia = \frac{6}{8} = 0.75''$

Area = $0.44\ in^2$

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

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

So 1 #6 bar in compression zone

Step 8

Beam Minimum width

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

$= 12.75 > 10''$

in multiple layer.

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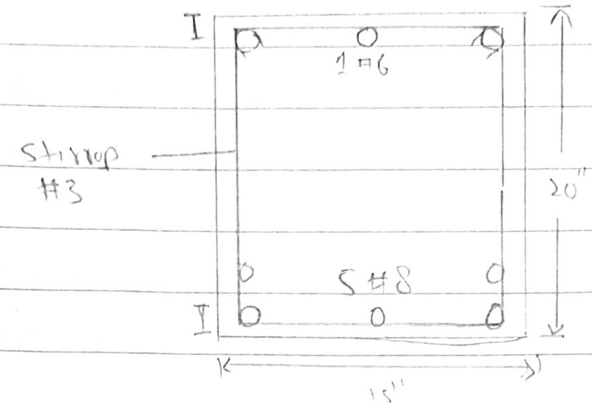

Effective depth $d = 20 - 1.5 - 3/8 - 8/8 - \frac{1}{2}(8/8)$

$d = 16.62''$

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

$d' = 2.25''$

Step 9 — Design moment is given

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

$a = \frac{(A_{st} - A'_{st}) \times f_y}{0.85 - f'_c \times b}$

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

$M_d = 2890.46$

$M_d = 2890.46 > 2653.56$

Design is ok.

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Q2//

a) Bond stress:

The stress which is acting on the outer interface of steel to the soourronding concrete is called bond stress

=> The stress help in keeping bond b/w reinforcement and concrete together. Bond stress resist any force that tries to pull out the rod from the concrete.

=> When we try to pull out the reinforcement bar from hardest concrete. Then this bond stress resist the bar to come out.

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

Development length:

The length of the bar required for transfering the stress into the concrete.

=> In other words development length is the quantity of the reber length that is actually required to be enclosed into the concrete to make the desired bond strength b/w two materials and further more 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 is responsible for transferring the stress development in any section of the adjoing section

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Q2(b) Doubly Reinforced beam:

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

Condition why 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 tan 12" and the external load on beam is very much which cannot resist a beam of singly reinforcement in that condition we used Doubly reinforcement beam.

Q2(c)

T-Beam	Rectangular beam
=> T-beam having beam and slab composite section	=> A rectangular Beam is one which is generally used as compression in Top fiber and Tension in bottom fiber of that Beam
=> A T-Beam is more economical than Rectangular Beam	=> Rectanglar Beam is less economical than 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 beam are more often used in office or commerical building. These can be cast in-situ using standard reinforcement.
=> In case of T-Beam slab are connected with one another and act as as one member	=> In case of rectangular beam slab has been placed on the beam so there is no connection b/w slab & beam.

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Q2 (d)

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

Q2 (e)

Designing method:
Two method are worldly 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 member 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 ~~load~~ 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:

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

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Q3

Given data

c/c distance = 10 ft

Total span = L = 32 ft

Slab thickness = h_f = 6 inch

width = b_w = 14 inch

depth = h = 28 inch

D.L = 50 psf = 50 lb/ft^2

L.L = 225 psf = 225 lb/ft^2

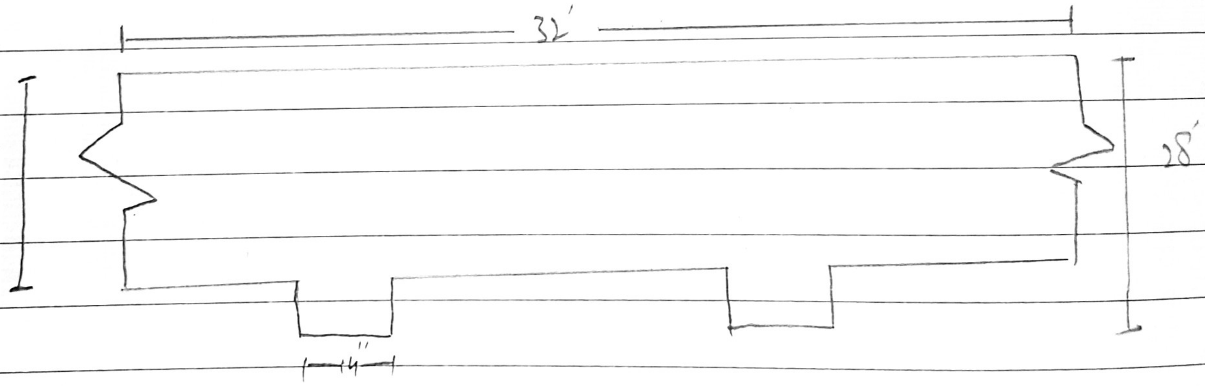
f'_c = 4000 psi = 4 ksi

f_y = 60000 psi = 60 ksi

(a) Effective depth = h - 3

= 28 - 3

25 inch



Step 1 To find factored load

To find Beam self weight per feet

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

$w_t = \frac{14}{12} \times \frac{28}{12} \times 150 \text{ lb/ft}^2$

$w_t = 408.33$ lb/ft

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As we know that Total factored load.

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

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

$W_u = 909.996$ lb/ft

$W_u = 0.91$ kip/ft

Step 2

Ultimate factored ~~load~~ moment

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

$M_u = 1397.76$ kip-inch

Step 3 Effective width (be)

* 1) $16 \times h_f + b_w$

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

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

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

Then the $be = 96$ inch

Step 4 To check which Type of analysis is required.

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

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

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

$A_{st} = 1.177 \text{ in}^2$

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Trial: 02

$$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b_e} = \frac{1.177 \times 60}{0.85 \times 4 \times 96}$$

$a = 0.216'' < h_f = 6''$

So design is rectangular beam

$$A_{st} = \frac{1397.76}{0.9 \times 60 \times (25 - \frac{0.216}{2})}$$

$A_{st} = 1.04 in^2$

Trial 3

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

$$A_{st} = \frac{1397.76}{0.9 \times 60 \times (25 - \frac{0.191}{2})}$$

$A_{st} = 1.04 in^2$

Step 5

To find ρ_{max} and ρ_{min}

As we know that

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

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

$\rho_{max} = 0.0181$

$$\rho_{min} = \frac{200}{f_y} = \frac{200}{60,000} = 0.0033$$

As we know that

$$\rho = \frac{A_{st}}{b_e \times d} = \frac{1.04}{14 \times 25}$$

$\rho = 0.00297$

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So $\rho_{min} < \rho < \rho_{max}$ → not o/k
b/c $\rho_{min} < \rho$ not satisfied so

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

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

$= 0.0033 \times 14 \times 25$

$Ast = 1.155 \, in^2$

Step6

No of Bar and Bar section
Let #8 bar use

No of bar $= \frac{Ast}{Ab} = \frac{1.155}{0.785}$ Area of #8 is 0.785

No of bar $= 1.47 \cong 2$
we take 2 #8 bar As main bar.

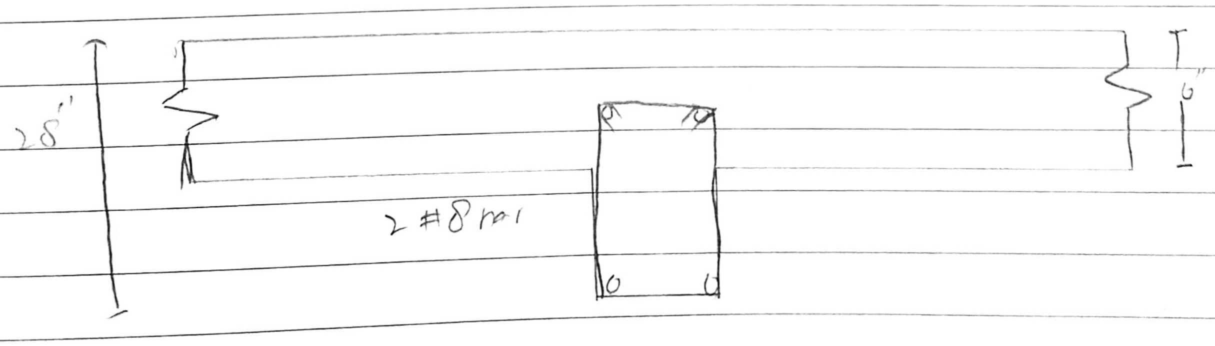
Step7 Minimum width.

b min = 2×C.C + 2×stirup + 2 × Main bar + 1 × Spacing

$b\,min = (2 \times 1.5) + (2 \times \frac{3}{8}) + 2(8/8) + (1 \times 8/8)$

$b\,min = 6.75'' < 14''$

So the main bar are good in One layer.



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Step 8

$A_{st} = 0.785 \times 2$
$= 1.57 in^2$
$a = \frac{A_{st} \times f_y}{0.85 \times f'_c \times b_e}$
$a = 0.289 in$

Design moment
As we know that
$M_d = \phi \times f_y \times A_{st} \times (d - \frac{a}{2})$

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

$M_d = 2160.24$
$M_d > M_u$
Design is ok