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Programme :- "BEC"

page # 01

Q#02

part # "A"

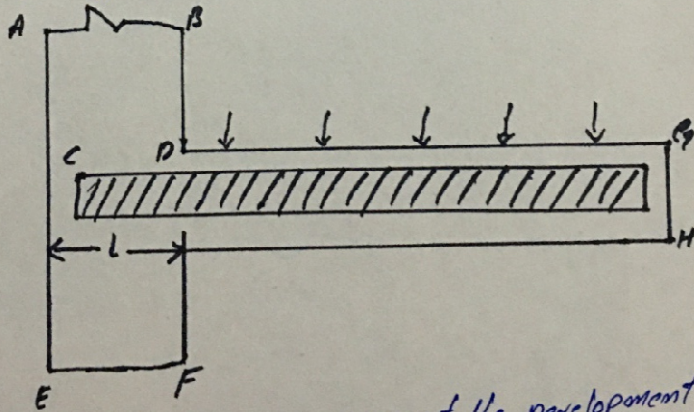
=> Bond stress:

Def: Bond stress is the stress produced because of the bond betw concrete surface and the reinforcement steel. It varies depending upon the type of the concrete and reinforcement used.

=> It is like a grip. if surface is rough and less Grip and if the surface is smooth and rounded.

=> Development length:

=> Development length contain minimum length of the bar required on either side of a point of maximum steel stress in order to transfer the load bar to the surrounding concrete through bond without slip to prevent bar from pulling out under tension.

Fig:

=> In the diagram (L) represent the development length.

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part B⇒ Doubly Reinforced Beam:

Doubly reinforcement beam

is used due to the following reason.

#01: when the dimension of the beam (length, depth) are limited for architectural or structure purposes.

#02: when the section such as bridge in water, towers etc such as subjected to reversal bending moment.

#03: Due to high demand of load that causes movement and due to restriction in dimension, section is designed as doubly reinforced.

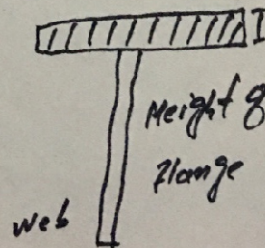
#04: in condition T-beam the portion of the beam over middle support has to be designed as doubly reinforced section.

part #cT-Beam Analysis:

T-beam consist of T-shaped structure the top of the T-shaped cross-section serves as a flange or compression member is resisting compression stresses. the lower section web serve to resist the shear stresses. It is economical than rectangular beam and is cast monolithically with the slab.

= 9747

→ α = depth of compression block
 → h_f = slab thickness / flange-height.



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⇒ Rectangular Beam Analysis:

⇒ A rectangular beam is one which is generally used as compression in top fiber and tension in bottom fiber.

⇒ Rectangular beam is more used to office/commercial buildings. these can be cast in-situ design standard reinforcement or precast.

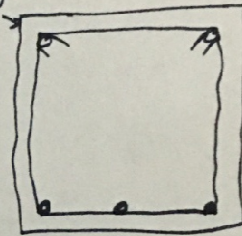
⇒ In rectangular beams the stress block diagram show the top fiber are subjected to maximum compression linearly reduced till the neutral axis.

⇒ Its analysis is required when.

$$a \leq h_f$$

a = depth of compression block
 h_f = height of flange

supporting bars

part # D⇒ strength Reduction factors:

strength to yield strength.

denoted by:

 ϕ
⇒ Effect on strength:

strength reduction factors, shows the strength in terms of percentage while designing of a section to resist the moment caused by load.

⇒ Basically it represent the uncertainty in determining the members behavior to the type of stress as to which it is subjected.

For example: determining the design process of a beam usually we take 0.75 for shear loads. its show that 75% of its strength is considered here and the rest of 25% is for future accidental process.

longitudinal bars.

part # E

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=> Designing Methods:

Two methods are used for the designing of concrete and different structure members.

1- ASD (Allowable stress design method)

2) USD (Ultimate strength design method)

1) Allowable stress design method:

ASD method is also known as working stress design method. It is based on the principle that stress developed in the structural members should not exceed a certain limit / fraction of elastic limit.

=> In this method all loads are taken as service loads and no factor is applied to increase these service loads.

2) ultimate strength design method:

Design method is also known as load factor method or ultimate load factor.

=> For structural subjected to large external loads the ultimate strength determined by the plastic (non linear analysis)

=> ultimate strength design method is for designing different structural members because of the following.

#01: As the ultimate strength of the material is considered we will get much slender section for column and beams compared to other method.

#02: ultimate design method result is more economical design for a building with fewer special needs for construction areas of reinforcement.

#03: Also better determines design for higher safety factor areas where a building is more prone to eminent pressure or must behavior loads that stress a specific portion of a buildings

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Q # 01

Given data:

width " b " = 10"

Height " h " = 20"

Live load = 2.47 kips/ft

Dead load \cdot D.L = 1.05 kips/ft

span = 18'

$f'_c = 4000 \text{ psi} = 41 \text{ ksi}$

$f_y = 60,000 \text{ psi} = 61 \text{ ksi}$

Sol:

Step # 01

Effective depth " d " = $h - s = 20 - 3 = 17$ "

Effective cover = $a' = 2.5$ "

Reinforcement ratio:

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

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

$$\rho_{max} = 0.0180$$

Step # 02: Finding area of steel:

$$\rho_{max} = \frac{A_{steel}}{b \times d} \quad A_{steel} = \rho_{max} \times (b \times d)$$

$$\Rightarrow 0.0180 \times (10 \times 17)$$

$$\Rightarrow 3.06 \text{ in}^2$$

Step # 03: By formula of design moment:

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

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

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$$m_u2 = 0.90 \times 9.06 \times 60 \times (17 - 5.462)$$

$$\Rightarrow 2362.92 \text{ kip-inch}$$

moment due to given loads:

$$\text{beam self weight} = \frac{10}{12} \times \frac{20}{12} \times 150$$

$$\Rightarrow 208.33 \text{ lb/ft}$$

$$\text{Total factored load} = 1.2(1050 + 208.33) + 1.6(2470)$$

$$\Rightarrow 5461.99 \text{ lb/ft}$$

$$\Rightarrow 5.46 \text{ kips/ft}$$

ultimate factored moment: $wl^2/8$

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

$$m_u = 2653.56$$

Now A_s , m_u2 & m_u

$$\Rightarrow 2362.92 < 2653.56$$

Doubly reinforcement required.Step #04:

$$m_{u1} = 2653.56 - 2362.92$$

$$m_{u1} = 290.64 \text{ kip-inch}$$

Step #05:

Steel area in compression zone will be

$$m_{u1} = \phi \times A_{st} \times f_y \times (d - d')$$

$$A_{st} = \frac{m_{u1}}{\phi \times f_y \times (d - d')} \Rightarrow \frac{290.64}{0.90 \times 60 \times (17 - 2.5)}$$

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

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step #6:

$$A_s = A_{st} + A'_{st} = 3.06 + 0.37 = 3.43 \text{ in}^2$$

$$A_s = 3.43 \text{ in}^2$$

step #7:

we used bar #8

$$\text{dia} = 8/8 = 1''$$

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

$$\text{No of bars} = \frac{A_{st}}{\text{Area of one bar}} = 3.43 / 0.785$$

$$\Rightarrow 4.36 \Rightarrow 5 \text{ bar}$$

So 5 #8 bars:
its for tensile zone.Compression steel:

use #6 bars

$$\text{dia (6/8)} = 0.75''$$

$$\text{Area} = 0.44 \text{ in}^2$$

$$\text{No of bars} = \frac{A'_{st}}{\text{Area of one bar}} = 0.37 / 0.44 = 0.84$$

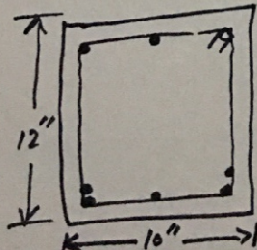
$$\text{No of bars} = 0.84 \approx 1 \text{ bar}$$

So 1 #6 bars in compression zone.

step #8: Beam minimum width:

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

$$\Rightarrow 12.75 > 16'' \rightarrow \text{in multiple layer}$$



Effective depth

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$$(d) = 20 - 1.5 - 3/8 - 8/8 - 1/2 (8/8)$$

$$d = 16.62''$$

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

$$d' = 2.25''$$

Step #09:

Design moment is

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

$$a = \frac{(A_{st} - A_{st}') f_y}{0.85 \times f_c \times b} = \frac{5 \times 0.785 - 1 \times 0.44 \times 60}{0.85 \times 4 \times 10}$$

$$a = 6.15''$$

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

$$M_d = 2890.46$$

$$M_d = 2890.46 \text{ } 72653.56$$

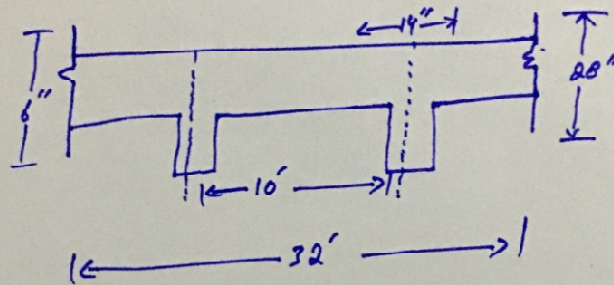
The design is 'ok'

Q#03

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Given data:

clear cover = 10", span = 32', slab thickness = 6"
 web width = 14", total depth = 28"
 Effective depth = 28 - 3 = 25"
 $D.L = 50 \text{ lb/ft}^2$, $S.S = 225 \text{ lb/ft}^2$
 $f_y = 60,000 \text{ psi}$, $f_c = 4000 \text{ psi}$

Sol:Step #01

$$m_u = \frac{w_u \times l^2}{8}$$

Beam self wt per foot

$$w_u = b \times t \times \gamma_c = 14/12 \times 28/12 \times 150 = 408.93 \text{ lb/ft}$$

Total factored load

$$\Rightarrow 1.2(50 + 408.93) + 1.6(225)$$

$$\Rightarrow 909.99 \text{ lb/ft} = 0.909 \text{ kip/ft}$$

Moment

$$\Rightarrow \frac{w_u l^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12 = 1396.23 \text{ kip-ft}$$

Effective breadth:

$$(1) (d + t) + b_w = 16(6) + 14 = 110"$$

$$(2) \text{ c/c distance} = 10(12) = 120"$$

$$(3) \text{ span}/4 = 32/4 \times 12 = 96" \therefore b_e = 96"$$

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Step #01:

Rectangular or T-beam

Trial #01

let $a = 4f = 6''$

$$A_{st} = \frac{m_u}{\phi f_y (d - a/2)} \Rightarrow \frac{1396.23}{0.70 \times 60 (25 - 6/2)}$$

$$A_{st} = 1.17 \text{ in}^2$$

Trial #02:

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

$$\Rightarrow 0.2'' < 6''$$

So rectangular beam are designed.

$$A_{st} = \frac{1396.23}{0.70 \times 60 (25 - 0.2/2)} \Rightarrow 1.03 \text{ in}^2$$

Trial #03

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

$$A_{steel} = \frac{1396.23}{0.70 \times 60 (25 - \frac{0.18}{2})} \Rightarrow 1.03 \text{ in}^2$$

Step #4:check ρ_{max} and ρ_{min}

$$\rho_{max} = 0.85 \times 0.85 \times 4/60 \left(\frac{0.003}{0.003 + 0.005} \right) \Rightarrow \rho_{max} = 0.018$$

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

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

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

$$\rightarrow 0.003 < 0.002 < 0.018$$

\rightarrow As ρ is less than ρ_{min}

$$\text{So, } \rho = \frac{A_{st}}{b \times d} = A_{st} = \rho_{min} \times b \times d$$

$$A_{steel} = 0.003 \times 14 \times 25 \Rightarrow 1.05 \text{ m}^2$$

Step # 5:

No. of and selection of bars let use #8 bars then

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

$$\text{No of Bars} = \frac{1.05}{0.785} = 1.32 \approx 2$$

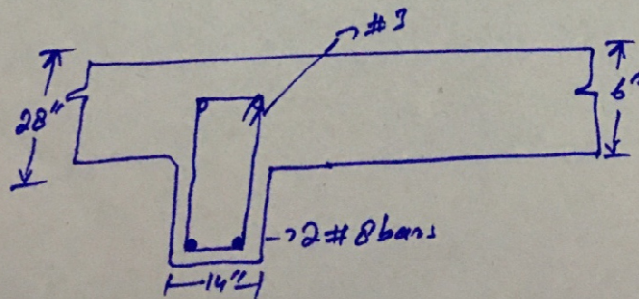
we use 2 #8 bars :-

Step # 6:

minimum width

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

$$\Rightarrow 6.75" < 14" \rightarrow \text{it is good in single layer cr case.}$$



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Step # 7:

Design moment

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

Area of steel = Area of 1 bar \times no of bars

$$= 0.785 \times 2 = \boxed{1.57 \text{ m}^2}$$

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

$$M_d = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2) \Rightarrow \boxed{2111.02 \text{ kip-inches}}$$

$$A_s \Rightarrow \boxed{2111.02 / 71396.23}$$

Result:

The design is ok.