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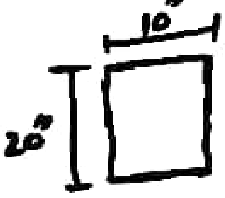
QNo 1:-
Numerical:-



Given:-

Height (h) = 20"
Width (b) = 20"
live load (L.L) = 2.47 kips/ft
span = 18'
f_c' = 4000 psi = 4 ksi
f_y = 60,000 psi = 60 ksi
Dead load (DL) = 1.05 kips/ft

Sol:- As

Step #01:- we assume (d').

→ Effective cover (d') = 2.5"

→ Effective depth (d) = h − 3 ∴ we can take also 4. so we take 3.

= 20 − 3

= 17"

Now reinforcement ratio:-

we know that

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

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

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

Step # 2:-

finding area of steel

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

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

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

$$\boxed{Ast = 3.06 in^2}$$

Step # 3:-

we know that

$$Mu_2 = \phi \times Ast \times fy \times \left(d - \frac{a}{2}\right)$$

first we find a

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

$$= \frac{3.06 \times 60}{0.85 \times 4 \times 10} = 5.4''$$

Now

$$Mu_2 = 0.90 \times 3.06 \times 60 \times \left(17 - \frac{5.4}{2}\right)$$

$$\boxed{Mu_2 = 2362.93 \text{ kip-inch}}$$.

Due to given load:-

Beam own weight

We know that

$Mu = \frac{wL^2}{8}$

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

$= 208.33 lb/ft$

Now total factored load

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

$= 5461.99 \; lb/ft$

$= 5.46 \; kips/ft$

Now $\frac{wL^2}{8}$

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

$Mu = 2653.56$

so $Mu_2 < Mu$

$2362.92 < 2653.56$

Doubly reinforcement required

Step # 04:-

$Mu_1 = 2653.56 - 2362.92$

$= 290.64$ kip-inch

Step # 5:-

Steel area in compression zone will be,

$Mu_1 = \phi \times A'_{st} \times f_y \times (d - d')$

$$A'_{st} = \frac{Mu_1}{\phi \times f_y \times (d-d')}$$

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

Step # 6:-

Total steel area

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

$= 3.06 + 0.37 = 3.43\ in^2$

Step # 07:- selection of bars for tensile zone

we use # 8 bars (dia 8/8 = 1")

Area = 0.785 in^2

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

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

5 # 8 bars.

⇒ **Compression zone:-**

try # 6 bars.

dia (6/8) = 0.75″ area 0.44 in^2.

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

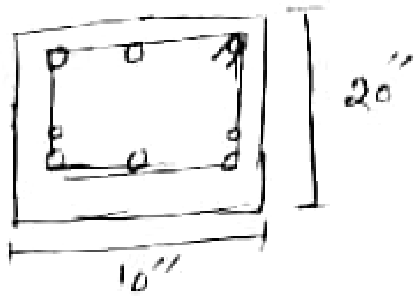
$0.84 \simeq 1$ bars

So 1 # 6 bars.

Step # 8:- Beam minimum width

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

$= 12.75 > 10''$



⇒ Effective depth (d)

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

$d = 16.62''$

Effective cover (d′)

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

$= 2.25''$

Step # 09:-

Design moment

$Md = \phi \times [As t' \times fy \times (d-d')) + (As t - As' t) \times fy \times (d - \frac{a}{2})$

$a = \frac{(As t - As t') \times fy}{0.85 \times f'c \times b}$

$= \frac{(5 \times 0.785 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 16} = 6.15''$

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

$Md = 2890.46$

$Md = 2890.46 > 2653.56$

Design is correct.

QNO 2:-
(A)

Bond stress:-

⇒ The pulling out of steel bar from concrete is resisted by slipping action of concrete is known as bond and the resulting stress is called bond stress.

⇒ Resistance offered to slipping of bars is due to three reasons.

⇒ Chemical adhesion between two materials.

⇒ Friction due to natural roughness of bars.

⇒ Due to closely spaced rib-shaped deformations made on the bar surface.

Development length:-

⇒ The amount of reinforcement (bar) length needed to be embedded or projected into the column to establish the desired bond strength between the concrete and steel.

B) In which conditions doubly reinforcement beam can be used:-

⇒ The ultimate moment of resistance required is greater than the ultimate moment of resistance of singly reinforced balanced section.

⇒ When depth of the beam is constraints.

Part (c):-
Different between T and rectangular beam analysis:-

T- beam:-

⇒ T-beam are more often used for more heavy duty / large spans such as bridges. These are almost always precast using prestressed reinforcement

⇒ The design procedure of T beam depends on the location of moment as the case of its flexural strength.

⇒ T- beam is more economical.

⇒ In case of T- beam slab and beam are connected with one another and acts as a one member.

Rectangular beam:-

⇒ Rectangular beam are more often used in commercial building. These can be cast insitu using standard reinforment

⇒ A rectangular beam is one which is generally used as compression in top fibre and tension in bottom fibes of that beam.

⇒ Rectangular beam is less-economical.

⇒ In case of rectangular beam, slab has been placed on the beam so there is no connection between slab and beam

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Part D:-

Effect of strength reduction factors on flexural strength

In the design of flexural strength, the strength reduction factor decreases from tension - controlled sections to compression-controlled sections to increase safety with decreasing ductility. This show that to determined the reduction factor for flexural strength of reinforced concrete beam according to ACI code. In the reliability-based design, the reliable prediction of the flexural strength of reinforced concrete members is assured by the use of reduction factors corresponding to different target reliability index.

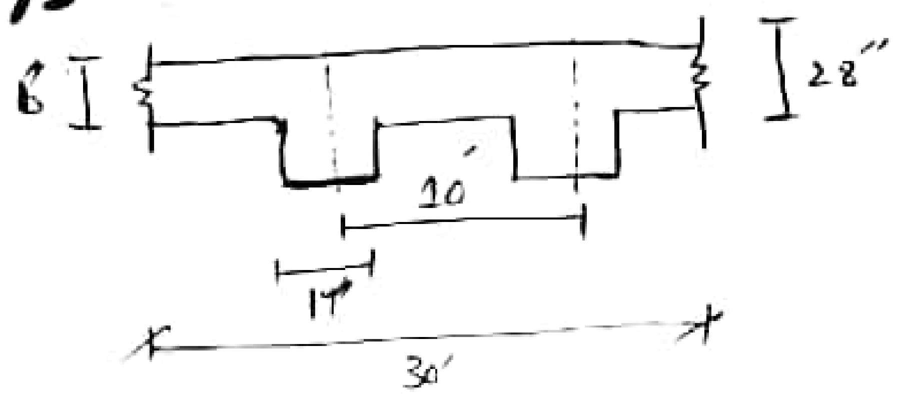
QNo 2

Part E:-

QNo3:-
Given:-

span = 32'
c/c distance = 10'
slab thickness = 6"
Web width = 14"
Total depth (h) = 28"
Effective depth = 28" - 3" = 25"
D.L = 50 lb/ft²
S.S = 225 lb/ft²
fy = 60,000 psi
f'c = 4000 psi

Sol:- As



Step #01:-

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

Beam self weight per feet

$$w_t = b \times t \times \gamma_c$$

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

Step #2

Total factored load:-

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

$= 909.99$ lb/ft

$= 0.909$ kip/ft

Moment:-

$$\frac{WL^2}{8} = \frac{0.909 \times (32)^2}{8} \times 12$$

$= 1396.23$ kip-inch.

Effective breadth:-

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

⇒ c/c distance $= 10(12) = 120''$

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

Step #3:-

(Rectangular or T- beam)

Trial #1:-

let $a = h_f = 6''$

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

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

Trial #2:-

~~let~~ $a = \frac{A_{st} f_y}{0.85 f'_c b} = \frac{1.17 \times 60}{0.85 \times 4 \times 96}$

$= 0.2'' < 6''$

so rectangular beam design.

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

$$= 1.03 in^2$$

Trial #3

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

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

Step #4:-

Check ρ_{max} and ρ_{min}

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

$$\rho_{max} = 0.018$$

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

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

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

$$0.003 < 0.002 < 0.018$$

As

ρ is less than ρ_{min}

So,

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

Ast = 0.003 × 14 × 25 = 1.05 in²

Step # 5:- No and selection of bars

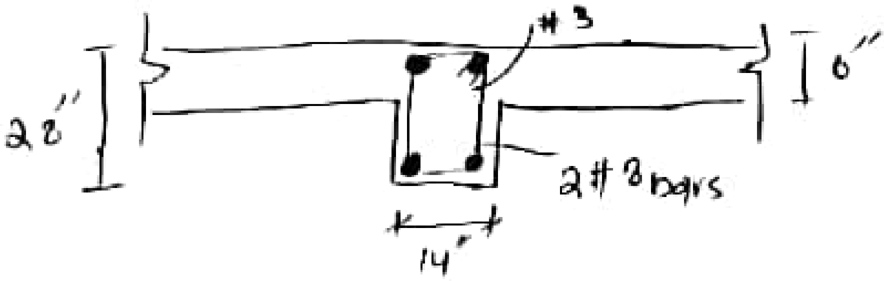
Try # 8 bar,
dia (8/8) = 1". Area = 0.785 in².

No of bars = $\frac{1.05}{0.785}$ = 1.03 ≅ 2

We use 2 # 8 bars.

Step # 6:- minimum width

bmin = 2(1.5) + 2(3/8) + 2(8/8) + 1(8/8)
= 6.75" < 14"



Step # 7:- Design moment

Md = φ × fy × Ast × (d − a/2)

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

= 0.785 × 2 = 1.57 in²

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

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Md= 0.90x 60x 1.57 x (25-0.2/2)

= 2111.02 kipinch

As, 2111.02 > 1396.23
Design is ok