FINAL PAPER

SUBJECT : PR(I) - I

SECTION : B

MODULE : 6th

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QUESTION 01

SOLUTION :

STEP 01: Minimum Thickness

$t_{min} = \frac{L}{28} \times 12$

$= \frac{15}{28} \times 12$

$= 6.428$

$Factored = 0.4 + \frac{fy}{100}$

$= 0.4 + \frac{40}{100}$

$actual\ t_{min} = 6.428 \times 0.8$

$= 5.1424 \approx 5.5''$

STEP 02 Effective depth.

$d = t - clear\ cover - \frac{1}{2}(d\ main bar)$

$= 5.5 - 0.75 - \frac{1}{2}(4/8)$

$d = 4.5''$

STEP 03 : Self wt of slab.

$= t/12 \times \gamma_{concrete}$

$= \frac{5.5}{12} \times 150 = 68.75$

STEP 04 Total Factored Load

$$W_U = 1.2(D.L) + L.L$$

$$= 1.2(68.75 + 20) + 160$$

$$= 266.5 \text{ Psf} \pm 0.266 \text{ Ksf}$$

STEP 05: Ultimate Moment:

$$M_U = \frac{W_U \times L^2}{8} = \frac{0.266 \times 15^2}{8} \times 12 = 89.735 K''$$

STEP 06 Area of steel for main bar by Trail Method.

Trail 01# Let $a = 0.2 \times t$

$$= 0.2 \times 5.5 = 1.1''$$

$$A_s = \frac{M_U}{\phi \times f_y \times (d - a/2)} = \frac{89.735}{0.90 \times 40(4.5 - \frac{1.1}{2})} = 0.631$$

Trail 02:

$$a = \frac{A_s \times f_y}{0.85 \times f'_c \times b} = \frac{0.631 \times 40}{0.85 \times 4 \times 12} = 0.618$$

$$A_s = \frac{89.735}{0.90 \times 40 \times (4.5 - \frac{0.618}{2})} = 0.594$$

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Trail 03:

$$a = \frac{0.594 \times 40}{0.85 \times 4 \times 12} = 0.582$$

$$A_s = \frac{89.735}{0.90 \times 40 \times \left(4.5 - \frac{0.582}{2}\right)} = 0.599$$

Trail 04:

$$a = \frac{0.599 \times 40}{0.85 \times 4 \times 12} = 0.587$$

$$A_s = \frac{89.735}{0.90 \times 40 \times \left(4.5 - \frac{0.587}{2}\right)} = 0.592$$

Trail 05:

$$a = \frac{0.592 \times 40}{0.85 \times 4 \times 12} = 0.580$$

$$A_s = \frac{89.735}{0.90 \times 40 \times \left(4.5 - \frac{0.580}{2}\right)} = 0.592$$

STEP 07 Area of Steel for distribution Reinforcement.

$$A_{smin} = 0.002 \times b \times t$$

$$= 0.002 \times 12 \times 5.5 = 0.132 \text{ in}^2/\text{ft}.$$

STEP 08 Spacing for main bars.

$$S = \frac{A_b}{A_s} \times 12 = \frac{0.2 \times 12}{0.592} = 4.05 \approx 4'' \text{ c/c}.$$

STEP 09: Spacing for Distribution bar. (#4 bar)

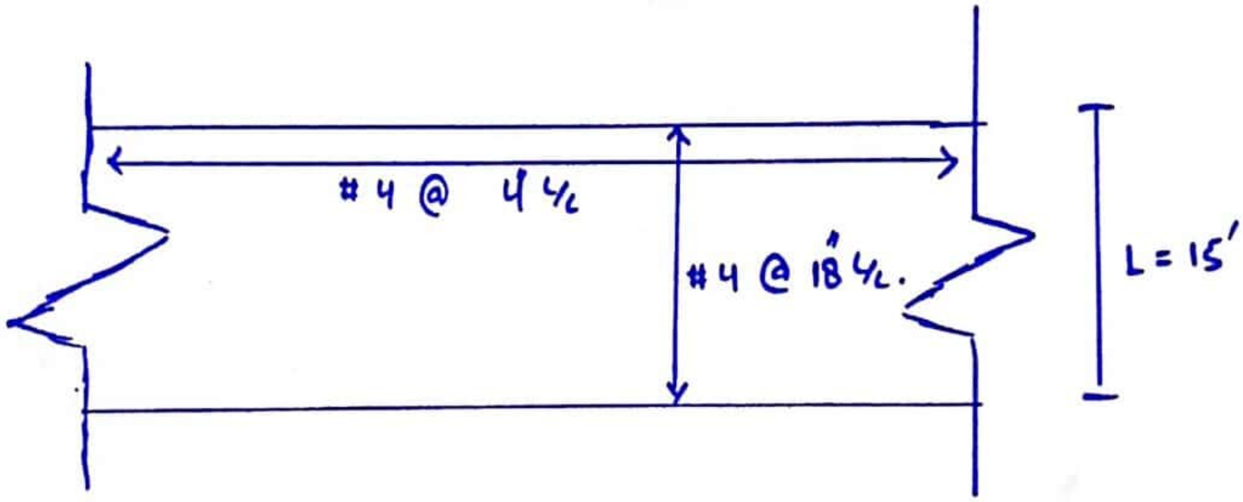
$$S = \frac{A_b}{A_s} \times 12 = \frac{0.2}{0.132} \times 12 = 18.18 \approx 18'' \text{ c/c}.$$

STEP 10 Final Summary.

$f'_c = 4$ ksi , $f_y = 40$ ksi , $t = 5.5''$

Main steel # 4 at 4" c/c.

Distribution steel # 4 at 18" c/c.



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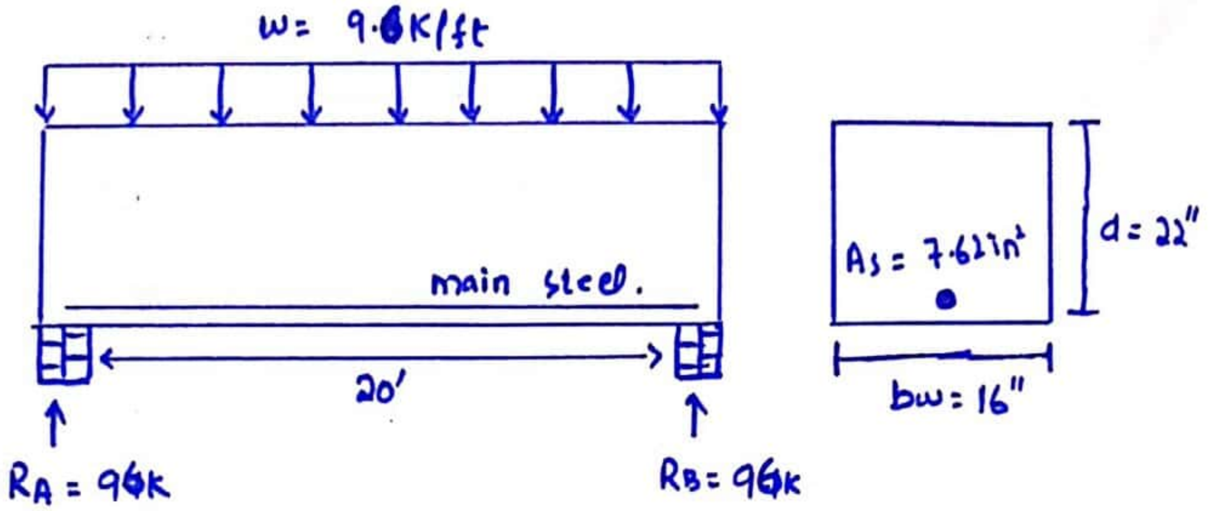
QUESTION: 02

SOLUTION

Find self weight

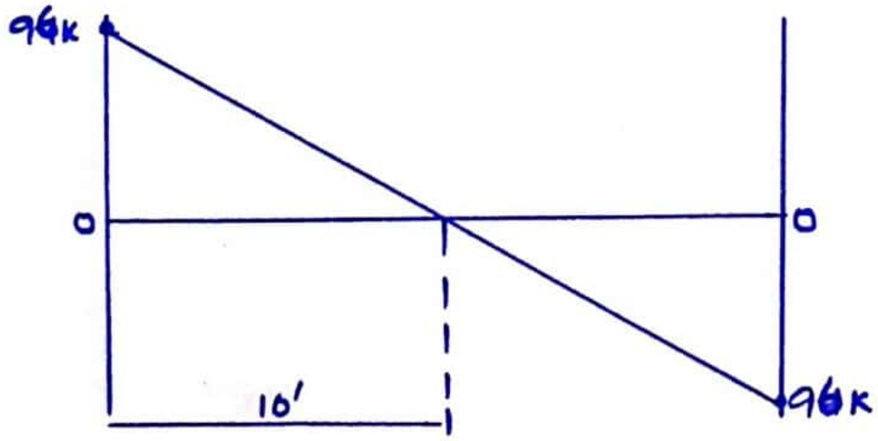
$b \times \gamma_c \Rightarrow 16/12 \times 150 = 0.2\ k/ft$



STEP 01 Find the Value Of R_1 and R_2

Total load = $9.6 \times 20 = 192/2 = 96K.$

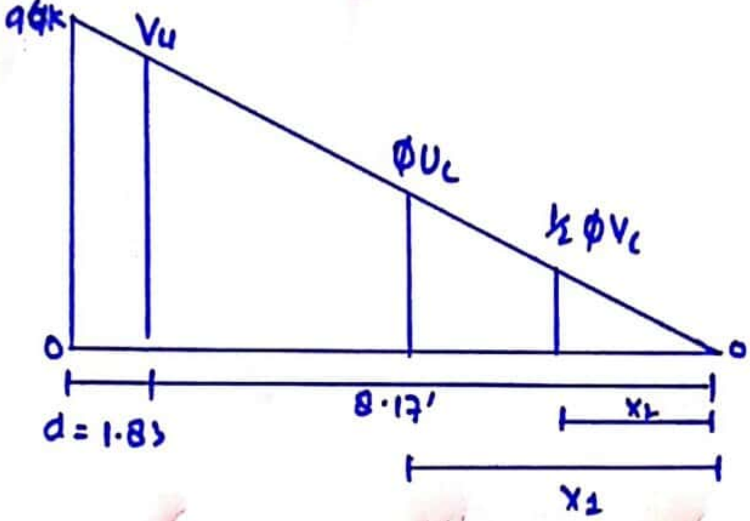
Step 02 Draw its shear Force Diagram.



STEP 03 Find the Value of critical shear "Vu" and its ~~section~~ location.

As we know that critical section is located at distance "d" from face of support = d = 22" = 1.83'

Value of critical sheal at distance 'd' by similarity of Triangles.



STEP 04 Find the Value of ϕV_c and $\frac{1}{2}\phi V_c$ and also its distance from zero shear to right side.

$$\phi V_c = \phi \times 2 \times \sqrt{f'_c} \times b_w \times d = \frac{0.75 \times 2 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 33.40K$$

Location of ϕV_c by similarity of Δ's

$$\frac{96}{10} = \frac{33.40}{X_1}$$

$$X_1 = ~~3.55'~~\ 4.84'$$

Now

$$\frac{1}{2}\phi V_c = \frac{33.40}{2} = 16.70K$$

Location of $\frac{1}{2}\phi V_c \Rightarrow \frac{96}{10} = \frac{16.70}{X_2}$

$$X_2 = 1.73'$$

STEP 05: **Value Of ϕV_s**

$$V_u = \phi V_s + \phi V_c$$

$$\phi V_s = V_u - \phi V_c$$

$$= 76.80 - 33.40 = 43.40K$$

STEP 06: **Check on Section Adequency**

$$\phi \times 8 \times \sqrt{f'_c} \times b_w \times d = \frac{0.75 \times 8 \times \sqrt{4000} \times 16 \times 22}{1000}$$

$$= 133.57K$$

As

$$\phi V_s < \phi \times 8 \times \sqrt{f'_c} \times b_w \times d$$

It means section is adequate.

STEP 07 **Check minimum spacing for stirrup**

$$\phi \times 4 \times \sqrt{f'_c} \times b_w \times d = \frac{0.75 \times 4 \times \sqrt{4000} \times 16 \times 22}{1000} = 66.79 \text{ kip}$$

As $\phi 4 \sqrt{f'_c}\, b_w d > \phi V_s = 43.40K$.

So, max spacing will be added/selected from following 4 conditions.

using # 3 Stirrup

1- $S_{max} = 24''$

2- $\frac{d}{2} = \frac{22}{2} = 11''$

3- $S_{max} = \frac{A_v \times f_y}{0.75 \times \sqrt{f'_c} \times b_w}$

$= \frac{0.22 \times 60000}{0.75 \times \sqrt{4000} \times 16}$

$= 17.40''$

4- $S_{max} = \frac{A_v \times f_y}{50 \times b_w}$

$= \frac{0.22 \times 60000}{50 \times 16}$

$= 16.50''$

From above conditions, least value of spacing for #3, 2 legged stirrup will be ~~added~~ selected.

So $S_{max} = 11''$ c/c

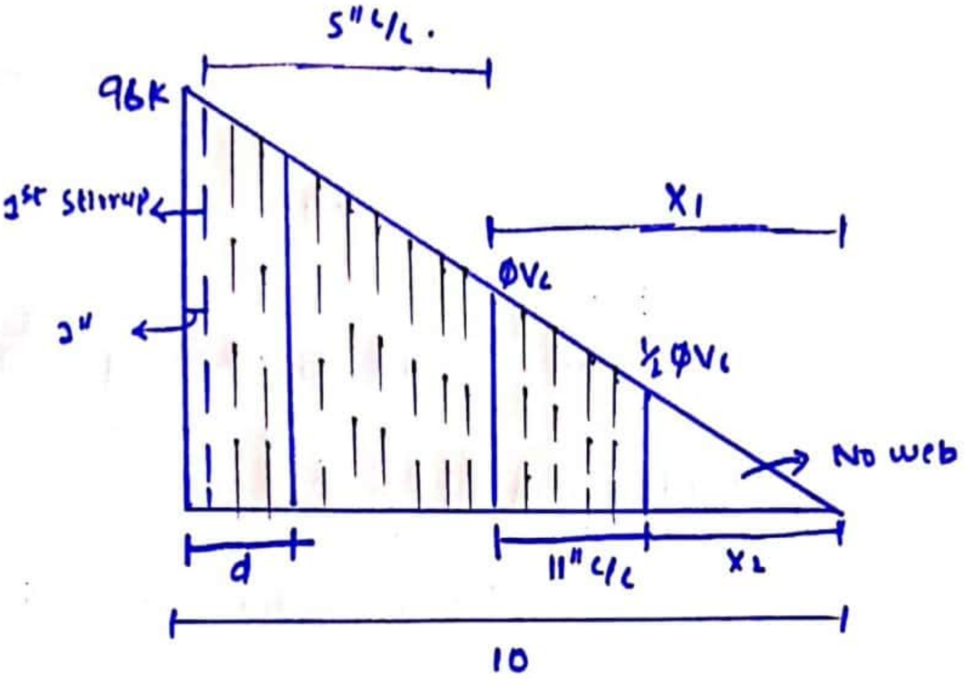
STEP 08 Spacing of stirrup from/at critical section

$$S = \frac{\phi \times A_v \times f_y \times d}{V_u - \phi V_c}$$

$$= \frac{0.75 \times 0.22 \times 60 \times 22}{76.80 - 33.44}$$

$S = 5''$ c/c.

Step 09 Final Sketch



As we know that first stirrup from face of support

$= 5/2 \approx 2"$

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QUESTION 03

SOLUTION :

STEP 01 Find Gross Area Of Concrete:

$A_g = b \times b$ (since it is square tied column)

$A_g = 12 \times 12 = 144\, m^2$ (Actual)

Step 02: Find the Area of steel.

$A_s = 5\%$ of A_g.

$= 0.05 \times 144$

$A_s = 7.2\, in^2$.

STEP 03 Ultimate load carrying capacity.

$P_u = \phi \times 0.80 \times [0.85 \times f'c \times (A_g - A_s) + A_s \times f_y]$

$= 0.65 \times 0.80 \times [0.85 \times 4 \times (144 - 7.2) + 7.2 \times 60]$

$P_u = 466.50k$

STEP 04: Sketch and Design of Ties (c/c to Distance)

From the below values we choose the least value of all this.

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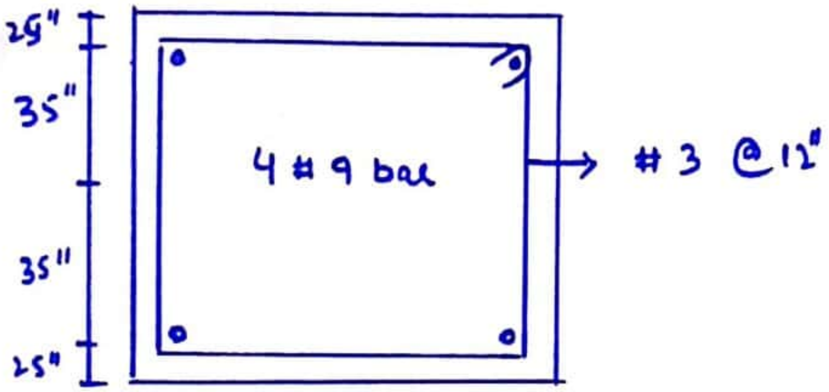
1 - 16 x dia of long bar = 16 x 9/8 = 18"

2 - 48 x dia of Tie bar = 48 x 3/8 = 18"

3 - least column dimension = 12"

So c/c distance b/w ties = 12"



Since it is a tied square column so there is no spiral stirrup used, the stirrup used is of rectangular shape due to the specification of the structure thus we will use the stirrups instead.

QUESTION 04.

SOLUTION :

STEP 01

Let $h = 24''$

Step 02: Total Weight.

= wt of soil + wt of R.C

$= 3 \times 120 + 2 \times 150 = 660 = 0.660$ ksf

Step 03 Effective Bearing Capacity.

$q_e = q_a - W = 2.5 - 0.660 = 1.84$ ksf

Step 04 Required Area for foundation.

$$A_{req} = \frac{\text{Service load}}{q_e} = \frac{100 + 120}{1.84} = 119.56$$

STEP 05 Since foundation is square.

$A_{req} \Rightarrow B \times B = 119.56$

$B = 10.934$

STEP 06 Upward Bearing Capacity.

$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{1.2(100) + 1.6(120)}{(10.934)^2}$$

$q_{up} = 2.609$ k/ft².

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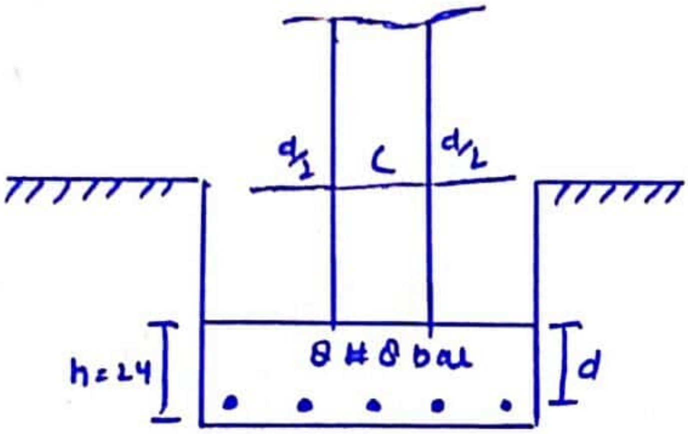
STEP 07 : Punching shear.

$b_o = 4 \times (c + d)$



$d = h - \text{clear cover} - \text{dia of bar} - \frac{1}{2} \times d_b$

$= 24 - 3 - 1 - \frac{1}{2} \times 1 = 19.5$

$b_o = 4 \times (16 + 19.5) = 142''$

STEP 08

$V_{u_2} = q_{up} \times \left[B^2 - (c+d)^2 \right]$

$= 2.609 \times \left[(10.934)^2 - \left(\frac{16 + 19.5}{12} \right)^2 \right]$

$= 289.078$

STEP 09

$\phi V_{c/p} = \phi \times 4 \times \sqrt{f'_c} \times b_o \times d$

$= \frac{0.75 \times 4 \times \sqrt{3000} \times 142 \times 19.5}{1000}$

$= 454.993$ okay.

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STEP 10: Beam Shear

$$V_{u1} = q_{up} \times B \times \left(\frac{B}{2} - \frac{c}{2} - d \right)$$

$$= 2.609 \times 10.934 \times \left(\frac{10.934}{2} - \frac{16/12}{2} - \frac{19.5}{12} \right)$$

$$= 90.58$$

STEP 11 Self shear capacity.

$$\phi V_c = \phi \times 2 \times \sqrt{f'_c} \times B \times d$$

$$= \frac{0.75 \times 2 \times \sqrt{3000} \times (10.934 \times 12) \times 19.5}{1000}$$

$$= 105.10 > V_{u1} \Rightarrow OK$$

STEP 12 Ultimate Moment.

$$M_u = \frac{q_{up} \times B}{8} \times \left(10.934 - \frac{16}{12} \right)^2$$

$$= 328.67\,k' = ~~3944~~k\ 3944.09\,k''$$

STEP 13 Area of steel for main bars by trail method.

Trail 01 Let $a = 0.2 \times h = 0.2 \times 24 = 4.8''$

$$A_s = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{3944.09}{0.90 \times 60 \times ([illegible] - \frac{4.3}{2})} = 8.56\,in^2$$

Traid 02:

$$a = \frac{4.2 \times 60}{0.85 \times 3 \times 11 \times 12} = 1.53''$$

$$\boxed{A_s = 7.197\ in^2}$$

Traid 03:

$$a = 1.28$$

$$\boxed{A_s = 7.1}$$

STEP 14: Check the main reinforcement

$$A_{smin} = 0.0018 \times B \times h = 0.0018 \times (10.934 \times 12) \times 24$$

$$= 5.70\ in^2$$

$$A_{s\,min} = \frac{200}{f_y} \times B \times d$$

$$= 8.58\ in^2$$

$$A_{smin} = \frac{3 \times \sqrt{f'_c}}{f_y} \times B \times d$$

$$= 7.05\ in^2$$

From the above values greater value will be selected.

Step 15: Using # 8 bar.

No of bars = $\frac{A_s}{A_b} = \frac{8.58}{0.785}$

$= 10.92 \approx 11$ bars in each direction.