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Subject: PRCD-I

Semester: 6th

Section : B

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Question no: 01

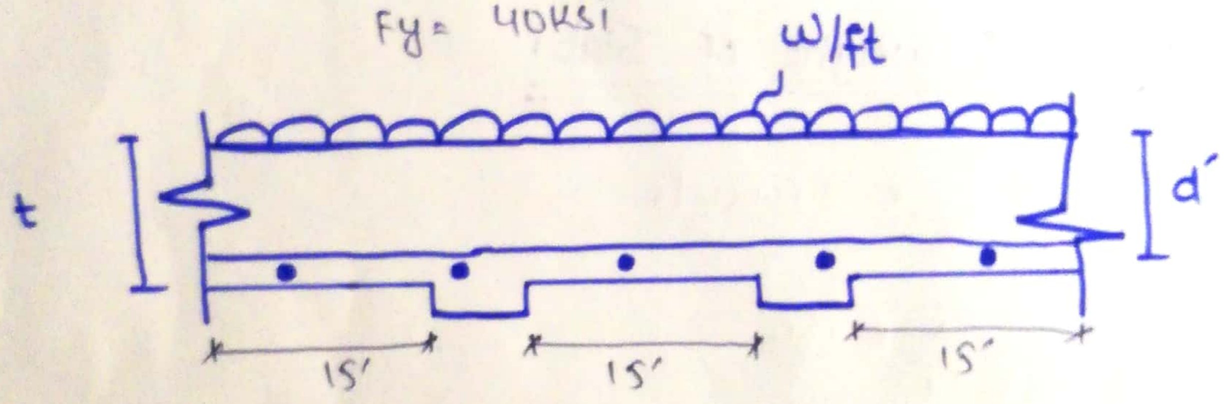
Given Data: clear Span = 15 ft

Factored live load = 160 PSF

Service floor finish load = 20 PSF

$f_c' = 4000$ Psi or 4 ksi

$f_y = 40$ ksi



Solution:

Step: 01 Minimum thickness:

$$\text{Factor} = \left(0.4 + \frac{f_y}{100}\right) \Rightarrow = \left(0.4 + \frac{40}{100}\right)$$

$$\boxed{\text{Factor} = 0.8}$$

$$t_{min} = \frac{l}{28} * 12$$

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

$$\boxed{t_{min} = 6.428''}$$

Actual t_{min} = Factor * t_{min}

$$t_{min} = 0.8 * 6.428$$

$$\boxed{t_{min} = 5.5''}$$

Step:02 Effective depth:

$d = t - \text{clear cover} - \frac{1}{2}(d_{\text{mainbar}})$

$d = 5.5 - 0.75 - (4/8)0.5$

$d = 4.5''$

* we are using #4 bar for main reinforcement

Step:03 Self weight of Slab:

$= \frac{t}{12} * \gamma_{\text{concrete}}$

$= \frac{5.5}{12} * 150$

$= 68.75$ PSF

Step:04 Total Factored Load:

$w_u = (1.2 * D.L) + (1.6 * L.L)$

* we are neglecting 1.6 because we already have factored live load.

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

$w_u = 266.5$ PSF or $w_u = 0.2665$ KSF

Step:05 Ultimate Moment:

$M_u = \frac{w_u * l^2}{8} = \frac{0.2665 * (15)^2}{8} * 12$

$M_u = 89.94$ Kip$''$

Step: 06 Area of Steel of main bar by Trial and repeat method:

Trial: 1

let $a = 0.2 * t \Rightarrow a = 0.2 * 5.5$

$a = 1.1''$

$$AS = \frac{mu}{\phi * fy * (d - \frac{a}{2})} \Rightarrow = \frac{89.94}{0.90 * 40 * (4.5 - \frac{1.1}{2})}$$

$AS = 0.632 \ in^2/ft$

Trial: 2

$$a = \frac{AS * fy}{0.85 * f'c * b}$$

$$a = \frac{0.632 * 40}{0.85 * 4 * 12}$$

$a = 0.62''$

$AS = 0.596 \ in^2/ft$

Trial: 3

$a = 0.58''$

$AS = 0.59 \ in^2/ft$

Trial: 4

$a = 0.58''$

$AS = 0.59 \ in^2/ft$

Step: 07 Area of Steel for distribution Reinfo:

$AS_{min} = 0.002 * b * t$

$AS_{min} = 0.002 * 12 * 5.5$

$AS_{min} = 0.132 \ in^2/ft$

Step: 08 Spacing of main bars:

$$S = \frac{A_b}{A_s} * 12$$

* Using #4 bar
* Area of one bar = $0.2 in^2$

$$S = \frac{0.2}{0.59} * 12$$

$$\boxed{S = 4.07 \approx 4'' \; c/c}$$

Step: 09 Spacing for distribution bars:

$$S = \frac{A_b}{A_s} * 12$$

* lets using #4 bar
* Area of one bar = $0.2 in^2$

$$S = \frac{0.2}{0.132} * 12$$

$$\boxed{S = 18.18'' \approx 18''} \; c/c$$

Step: 10 Final Summary:

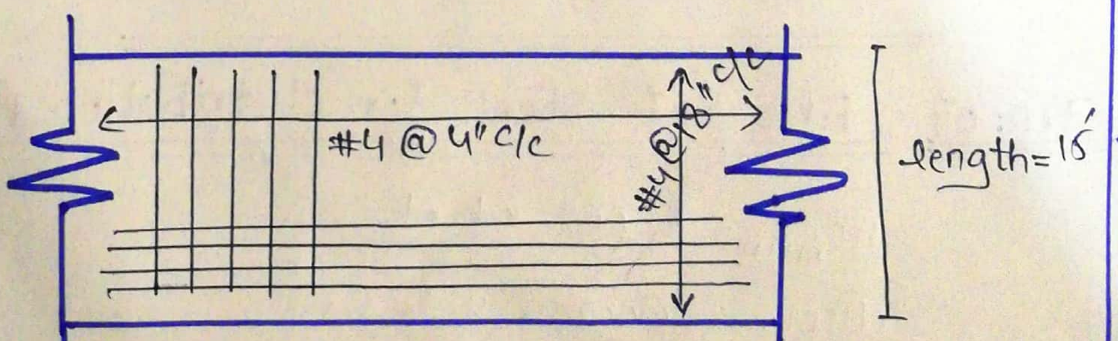
$f_c' = 4ksi$

$f_y = 40ksi$

$t = 5.5''$

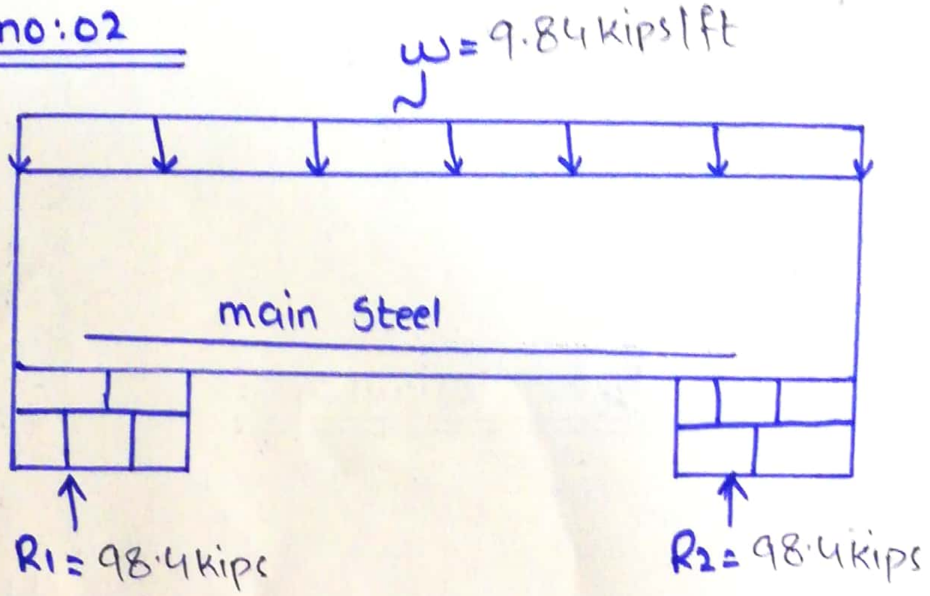
Main Steel #4 at 4" c/c

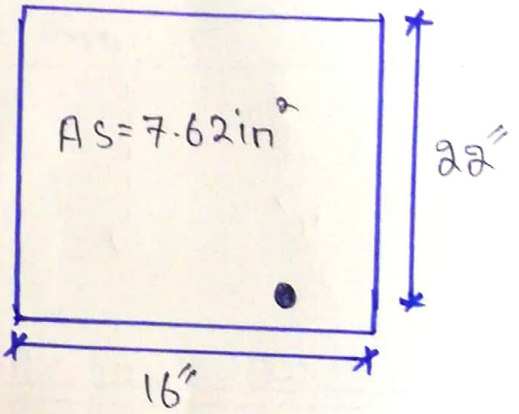
Distribution Steel #4 at 18" c/c



* (Plain view of slab)

Question no:02





first we have to find Beam Self weight:

By formula:

$$w = b * t * \gamma_c \Rightarrow w = \frac{16}{12} * \frac{22}{12} * 150$$

$$\boxed{w = 366.67\ lb/ft} \text{ or } \boxed{w = 0.3666\ K/ft}$$

So the factored load will be

$$= 1.2(0.3666) = 0.44\ kips/ft$$

so total applied factored load will be

$$= 9.4 + 0.44$$

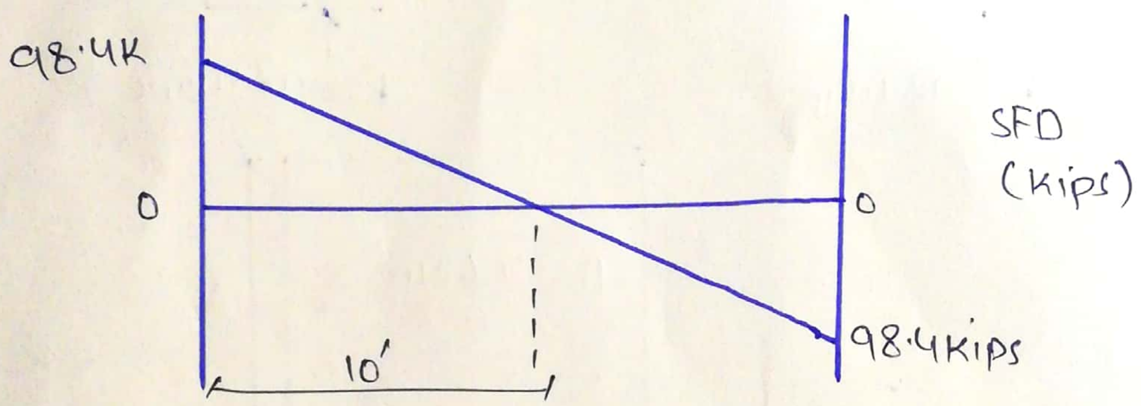
$$\boxed{= 9.84\ kips/ft}$$

Step:01 R1 and R2 value:

$$R_1 = R_2 = \frac{9.84 * 20}{2}$$

$$\boxed{R_1 = R_2 = 98.4 \text{ Kips}}$$

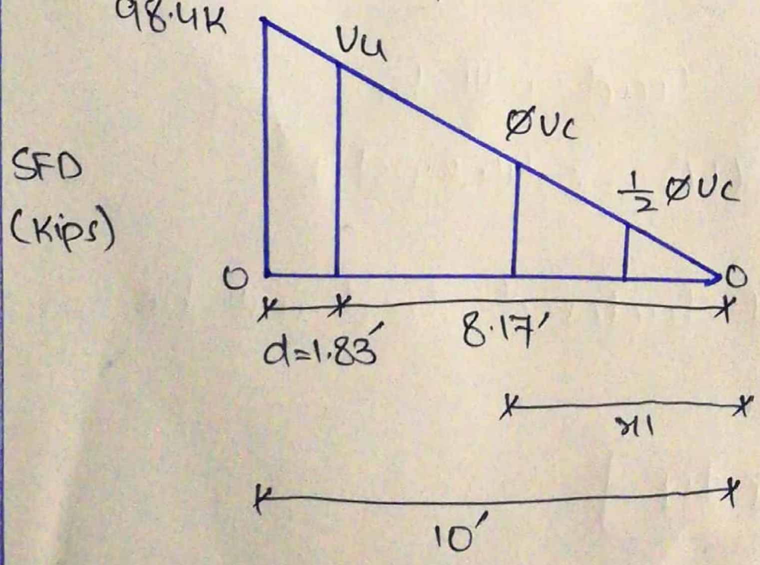
Step:02 Shear Force diagram:



Step:03 Critical Shear value and its location:

⇒ location from support face = d = 22" = 1.83'

⇒ value of critical shear at "d" by similarity of triangles



From Similar Δ's:

$$\frac{98.4}{10} = \frac{Vu}{8.17}$$

$$\boxed{Vu = 80.39 \text{ Kips}}$$

Step:04 **value of ϕV_c and $\frac{1}{2}\phi V_c$ and its distances from zero shear to right side:**

$\Rightarrow \phi V_c = \phi * 2 * \sqrt{f'_c} * b_w * d$

$= \frac{0.75 * 2 * \sqrt{4000} * 16 * 22}{1000}$

$\boxed{\phi V_c = 33.40K}$

$\Rightarrow$ location of ϕV_c by Similarity of Δ's:

$\frac{98.4}{10} = \frac{33.40}{x_1}$

$\boxed{x_1 = 3.39'}$

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

$\Rightarrow$ location of $\frac{1}{2}\phi V_c = \frac{98.4}{10} = \frac{16.70}{x_2}$

$\boxed{x_2 = 1.697'}$

Step:05 **value of ϕV_s**

$\phi V_s = V_u - \phi V_c$

$\phi V_s = 80.39 - 33.40$

$\boxed{\phi V_s = 46.99K}$

Step:06 Section Adequacy:

$\phi * 8 * \sqrt{f'c} * bw * d$

$$\frac{0.75 * 8 * \sqrt{4000} * 16 * 22}{1000} = 133.57\,K$$

⇒ As $\phi Vs < (\phi * 8 * \sqrt{f'c} * bw * d)$, it means section is adequate.

Step: 07 Check max. Spacing for stirrup:

⇒ $\phi * 4 * \sqrt{f'c} * bw * d$

⇒ $\dfrac{0.75 * 4 * \sqrt{4000} * 16 * 22}{1000}$

⇒ 66.79 kips

* As $\phi 4 \cdot \sqrt{f'c} \cdot bw \cdot d > \phi Vs = 48.99$

⇒ So max. spacing will be selected from following four conditions:

① $S_{max} = 24''$	② $\frac{d}{2} = \frac{22}{2} = 11''$
③ $S_{max} = \dfrac{0.22 * 60{,}000}{0.75 * \sqrt{4000} * 16}$ $S_{max} = 17.40''$	④ $S_{max} = \dfrac{AV * fy}{50 * bw}$ $= \dfrac{0.22 * 60{,}000}{50 * 16}$ $= 16.50''$

* least value of Spacing for #3, 2 legged Stirrup will be $S_{max} = 11''$ c/c

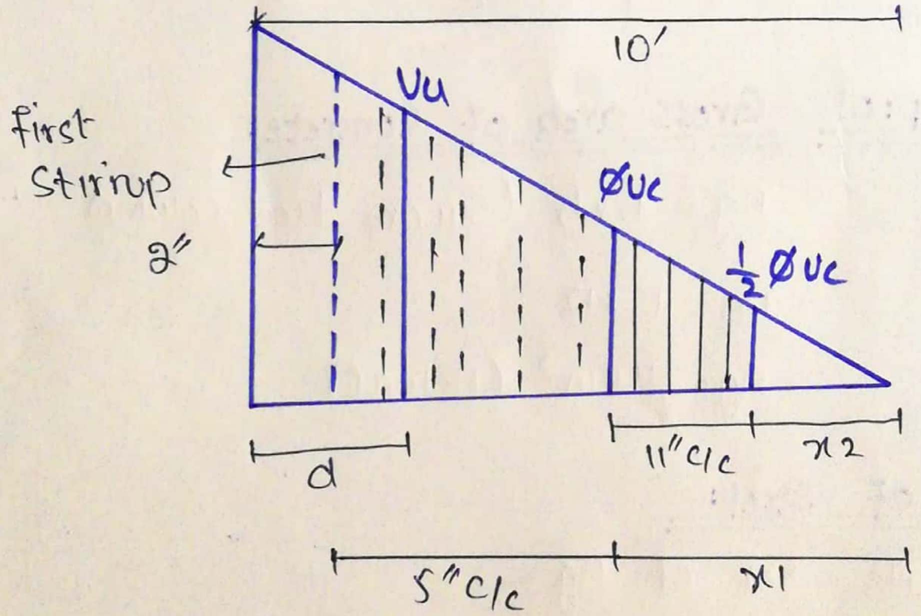
Step: 08 Spacing of Stirrup at Critical section:

$$S = \frac{\phi * (Av \text{ of } \#3, 2 \text{ legged}) * fy * d}{Vu - \phi Vc}$$

$$S = \frac{0.75 * 0.22 * 60 * 22}{80.39 - 33.40}$$

$$S = 4.64 \approx 5'' \text{ c/c}$$

Step: 09 Final Sketch:



⇒ first stirrup from Support face $= \frac{S}{2} = \frac{5}{2} \approx 2''$

Question no: 03

Given Data:
* anial ultimate load carrying capacity = ?
* Breadth = 12"
* Depth = 12"
* Bar number = 9
* Spacing @ 12"
* f'_c = 4000Psi
* f_y = 60Ksi

Solution: Step: 01 Gross area of Concrete:

Ag = b*b (Square tied column)

Ag = 12*12

Ag = 144in² (Actual)

Step: 02 Area of Steel:

As = 5% of Ag

= 0.05 * 144

As = 7.2in²

Step: 03 Ultimate load Carrying capacity:

$P_u = \phi * 0.80 * [0.85 * f'_c * (Ag - As) + As * f_y]$

$P_u = 0.65 * 0.80 * [0.85 * 4 * (144 - 7.2) + 7.2 * 60]$

$P_u = 466.50K$

Step:04 Ties sketch and its design (c/c distance):

⇒ From the below values we choose the least value of all this:

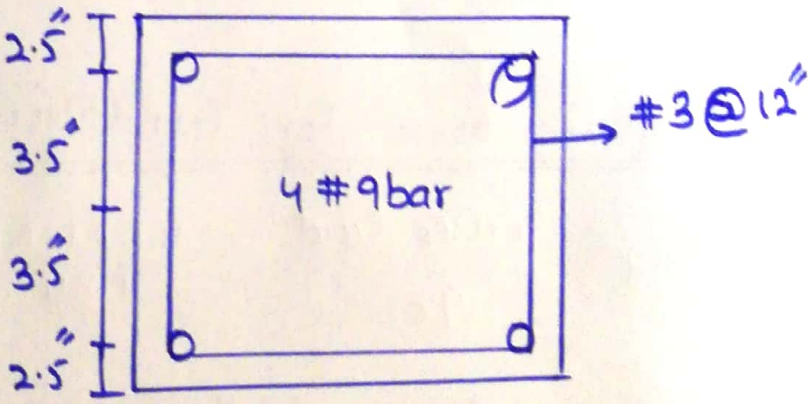
① 16 * dia of longitudinal bar

$16 * \frac{9}{8} = 18''$

② 48 * dia of tie bar = $48 * 3/8 = 18''$

③ least column dimension = $12''$

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



* As we know it is a tied square column so there will be only square ties used and there is no concept of use of spirals in circular shape around column, which is rectangular or square in shape.

$S = (3.5 - \frac{9}{8}) \Rightarrow$ **$S = 2.375'' < 6''$**

* Hence no additional ties are required.

Question no: 04

Step:01 Let $h = 24''$

Step:02 Total weight = wt of Soil + wt of R.C

$= (3*120) + (2*150)$

$= 660$ Psf

$= 0.660$ ksf

Step:03 Effective Bearing Capacity:

By formula: $q_e = q_a - w$ (Total weight)

$q_e = 2.50 - 0.660$

$q_e = 1.84$ ksf

Step:04 Required area for Foundation:

$$A_{req} = \frac{\text{Service load}}{q_e} = \frac{100+120}{1.84} = 119.57\ ft^2$$

Step:05 As we know about Square foundation:

$A_{req} = b \times b = \sqrt{119.57}$

$A_{req} = 119.57$ $\Rightarrow B*B = \sqrt{119.57}$

$B = 10.93'$ or $B = 11'$

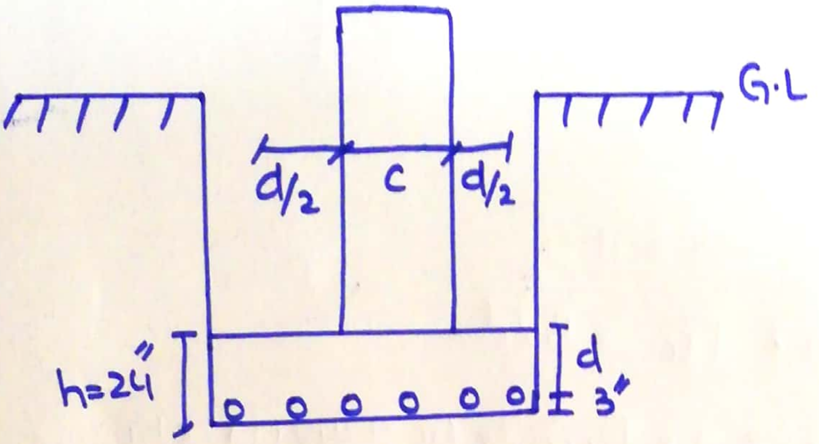
Step:06 Upward bearing capacity of soil:

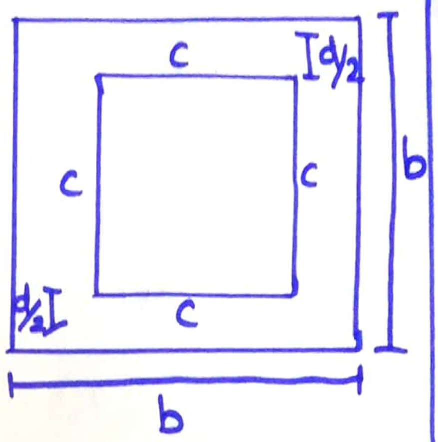
$$q_{up} = \frac{\text{Factored load}}{(B)^2} = \frac{(1.2*100)+(1.6*120)}{(11)^2}$$

$q_{up} = 2.58\ k/ft^2$

Step: 07 Punching Shear:

Using Formula: $b_o = 4 * (c + d)$





Effective depth (d):

$d = h - cc - \text{dia of bar} - \frac{1}{2} db$

$\Rightarrow d = 24 - 3 - 1 - \frac{1}{2}(1) = 19.5''$

* Take #8 bar
* dia $= \frac{8}{8} = 1''$
* Area $= 0.785 \, in^2$

Punching Shear:

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

Step: 08 Value of V_{u2}:

$V_{u2} = q_{up} * [B^2 - (c+d)^2]$

$'' = 2.52 * [(11)^2 - (16 + 19.5)^2]$

$V_{u2} = 289.60 \text{ kips}$

Step: 09 (Value of ϕV_{cp}):

$\phi * 4 * \sqrt{f'c} * b_e * d$

$\frac{0.75 * 4 * \sqrt{3000} * 142 * 19.5}{1000} \Rightarrow 454.99 \text{ k}$

Step:10 Beam Shear check:

$$V_{u1} = q_{up} * B * [B/2 - C/2 - d]$$

$$V_{u1} = 2.58 * 11 * \left[11/2 - \frac{16/12}{2} - \frac{19.5}{2}\right]$$

$$\boxed{V_{u1} = 91.05 \text{ Kips}}$$

Step:11 Self Shear Capacity:

$$\phi V_c = \phi * 2 * \sqrt{f_c'} * B * d$$

$$= \frac{0.75 * 2 * \sqrt{3000} * (11*12) + 19.5}{1000}$$

$$\boxed{\phi V_c = 211.47 > V_{u1}} \rightarrow \text{OK!}$$

Step:12 Ultimate moment:

$$M_u = \frac{q_{up} * B}{8} * (B-c)^2$$

$$= \frac{2.58*11}{8} * (11 - 16/12)^2$$

$$= 331.49 \text{ K.ft}$$

$$\boxed{= 3977.88 \text{ Kip.inch}}$$

Step:13 Area of steel (main bars):

Trial:01 let $a = 0.2 * h$

$$= 0.2 * 24 \boxed{= 4.8''}$$

$$A_{st} = \frac{M_u}{\phi * f_y * (d - a/2)} = \frac{3977.88}{0.90 * 60 * (19.5 - 4.8/2)}$$

$$\boxed{A_{st} = 4.31 \text{ in}^2}$$

Trial : 02 $a = 0.76''$

$A_{st} = 3.85 \, in^2$

Trial : 03 $a = 0.68''$

$A_{st} = 3.85 \, in^2$

Step: 14 Mini Reinfo check:

(a) $A_{st\,min} = 0.0018 * B * h$

$= 0.0018 * (11*12) * 24$

$= 3.168 \, in^2$

(b) $A_{s\,min} = \frac{200}{60{,}000} * (11*12) * 19.5$

$= 8.58 \, in^2$

(c) $A_{s\,min} = \frac{3 * \sqrt{3000}}{60{,}000} * (11*12) * (19.5)$

⇒ From above 3 conditions selection of greater value

$A_{s\,min} = 8.58$

Step: 15 No of bars:

Using #8 bar:

Area = $0.785 \, in^2$

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

no of bars $= 10.9 \approx 11$ bars in each direction