Name Owais Humayoun

ID 7869

Submitted to Sir Engr Fawad Khan

Subject P.R.C Design I"

Semester 6th

Section:. 'B'

Qno2. A rectangular beam that must carry a service live load of 2.47 kips/ft. and a calculated dead load of 1.05 kips/ft. (without sel-weight) on an 18 ft. simple span is limited to 10 inches width and 20 inches total depth for architectural reasons. If $f_y = 60000$ psi and $f_c = 4000$ psi, what steel area must be provided. Draw sketch of your final design.

Solution:

Given:
$f_y = 60000$ psi, $w = 10''$, $h = 20''$
$f'_c = 4000$ psi, D.L = 1.05 K/ft
L.L = 2.47 K/ft
$d = h - 3 = 20 - 3 = 17''$, $d' = 2.5''$

Step 01:

$$\rho_{max} = 0.85 \times \beta \times f'_c \times \left(\frac{\varepsilon_0}{\varepsilon_u + \varepsilon_y}\right)$$

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

ρ_{max} 0.0181

Step 02: Area of Steel

$$\rho_{max} = \frac{A_{ST}}{b \times d}$$

(2)

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

$= 0.0181 \times 10 \times 17$

AST = $3.077 m^2$

Step 03: Design factored moment:

$M_{u2} = \phi \times AST \times f_y \times \left(d - \frac{a}{2}\right)$

$a = \frac{AST \times f_y}{0.85 f'_c b}$

$= \frac{3.08 \times 60}{0.85 \times 4 \times 10} = 5.4''$

$M_{u2} = 0.90 \times 3.08 \times 60 \times \left(17 - \frac{5.4}{2}\right)$

$M_{u2} = 2378.38 K''$

Now,

Moments of the given load.

Beam self weight $= b \times t \times \gamma_c$

$= \frac{10}{12} \times \frac{20}{12} \times 150$

$= 208.33 lb/ft$

Now:

total factored load $= 1.2 DL + 1.6 LL$

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

$= 5461.996\ lb/ft$

$= 5.46\ K/ft = 5461.996$

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

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

$= 2653.56K''$

thus $2378.38 < 2653.56K''$

it should be dably designed beam.

Step 04:

$$Mu1 = Mu - Mu2$$

$= 2653.56 - 2378.38$

$Mu1 = 275.18K''$

Step 05:

$$Mu1 = \phi \times As' \times fy \times (d - d')$$

$$As' = \frac{Mu1}{\phi \times fy \times (d - d')}$$

$$= \frac{275.18K''}{0.90 \times 60(17 - 2.5)}$$

$= 0.35 in^2$

Step 6:

$$A_s = A_{st} + A_s'$$
$$= 3.08 + 0.35$$
$$= 3.43 \text{ in}^2$$

this lies in the tension zone of steel.

Step 7:

selection of bars for tensile steel; Lets take #6 having an area of

$$A = \frac{\pi D^2}{4} = \frac{3.14}{4}(6/8)^2 = 0.44 \text{ in}^2$$

$$\text{No of bars} = \frac{3.43 \text{ in}^2}{0.44 \text{ in}^2} = 7.795$$

$\simeq 8$

for compression steel; lets take #6 having an area of 0.442 in^2

$$\text{No of bars} = \frac{A_s}{A_b} = \frac{0.35}{0.442} = 0.79$$
$$= 1 \text{ bar.}$$

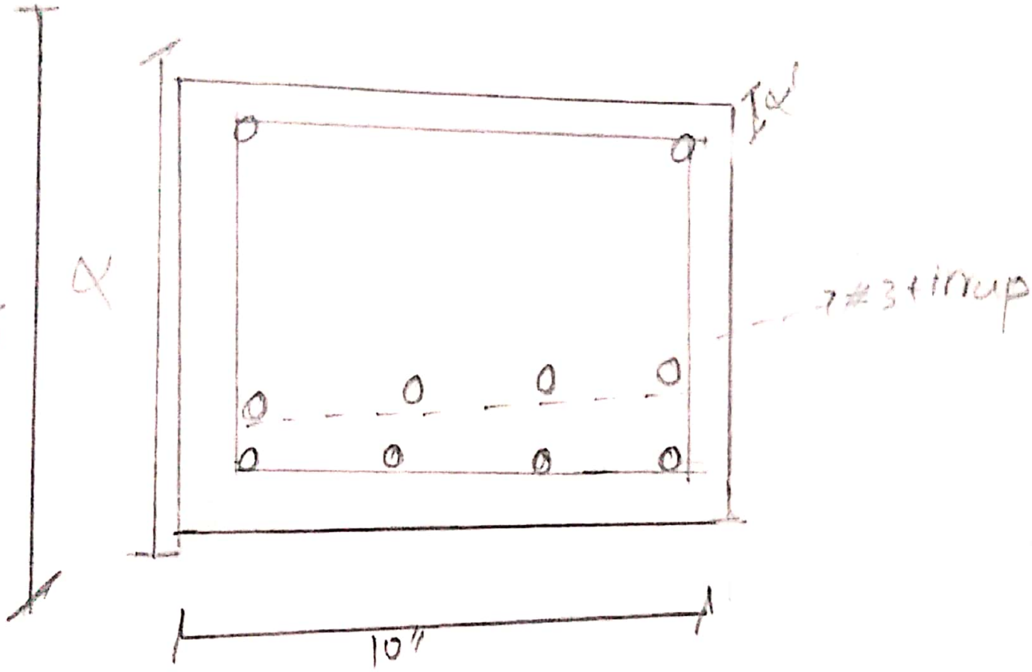
Step #08:

Beam Minimum width

$$b_{min} = (2 \times 1.5) + 2(3/8) + \left(8 \times \frac{6}{8}\right) + \left(7 \times \frac{8}{8}\right)$$

$$= 16.75'' > 10''$$

It should be in multiple layers



$$d = 20 - 1.5 - 3/8 - \frac{6}{8} - 6/8 - 1/2\,(6/8)$$

$$d = 17$$

$$d' = 1.5 + 3/8 + 1/2\,(6/8) = 2.25''$$

Step #9:

Design moment:

$$M_d = \phi \times \left\{ A_s' \times F_y \times (d - d') + (A_s - A_s') \times F_y \times \left(d - \frac{a}{2}\right) \right\}$$

(6)

$$a = \frac{(As - As') \times Fy}{0.85 Fc \times b} \Rightarrow \frac{(8 \times 0.442 - 1 \times 0.44) \times 60}{0.85 \times 4 \times 10}$$

$$a = 6.15''$$

$$Md = 0.90 \times \left[1 \times 0.44^2 \times 60 \times (17 - 2.25) + (17 - \frac{6.15}{2}) \right]$$

$$Md = 2666.466 K'' > 2653.56''$$

Q No 2(a) (7)

Bond Stress:- It can be defined as, the pulling out of steel bar from concrete is resisted by gripping action of concrete is known as bond stress.

Development length:- the necessary length b/w the point of maximum stress in a bar and the end of bar. #11 as smaller bars the development length must not be less than the obtained from the

(b)

- the) Following are the reason's due to such conditions dubly reinforcement must be used.
- where depth is restricted.
- when load applied is more and depth is restricted than we ~~appl~~ apply doubly reinforced beam.

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(8)

(c)

Both beams have "T" shape but their analysis and design is quiet different from one another. In case of T beams, slab and beams are connected with one another and act as one member. In case of rectangular beams, slab has been placed on the beam so there is no connection b/w slab and beam.

(d)

the effects of strength reduction factor on flexural strength is briefly explained by ACI (440.2R-08) 2008, two distinct modes of failure govern the behaviour of the members externally strengthed with FRPs and thus affect the calculation of equations. the first mode is initiated by the crushing concrete (ε_{cu} = 0.003).

It also state that the effects on flexural strength due to strength reduction also relies on the member parameter.

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(c) there are two types of design methods

1) ultimate Strength ~~Des~~ Design method. (USDm)
2) Allowable Stress Design method (ASDm)

USDm → Due to this method we can find thickness of beam and depth of the beam

ASDM → In this method we only count service load. In this method actual loads are considered means (live load + dead load)

- ASDm is more preferable because it consideris actual load.

(10)

QNo3 A concrete floor system consists of parallel T beams spaced 10ft on centers and spanning 32ft b/w supports. the 6 inch thick slab is cast monolithically with T-beam webs having width bw = 14" and total depth measured from the top of the slab of h = 28. the effective depth will be taken 3" less than the total depth. In addition to its own weight, each beam must carry a superimposed D.L of 50psf and S.L = 225psf. materials strength are fy = 60,000 psi and f'c = 4000psi. Determine the required tensile steel area and select the reinforcement needed for a typical member. Draw sketch of your final design.

Given data:

C/C distance = 10'

span = 32'

$h_f = 6''$

$b_w = 14''$

$h = 28''$

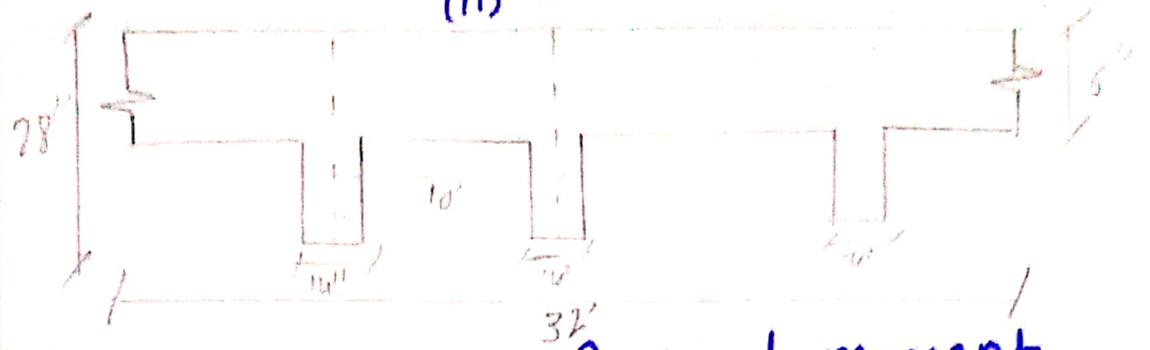
d = effective depth $= h - 3 = 28 - 3 = 25''$

$D.L = 50\ lb/ft^2$

$L.L = 225\ lb/ft^2$

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

$f'_c = 4000\ psi = 4\ ksi$



Step 01:: Ultimate factored moment

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

i- Self weight of the beam

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

$$= \frac{14}{12} \times \frac{28}{12} \times 150$$

$$= 408.33\ lb/ft$$

γ_c :-
For PCC = 140 lb/ft
For RCC = 150 lb/ft

ii - total factored load

$$= 1.2\,D.L + 1.6\,L.L$$

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

$$= 909.99\ lb/ft$$

$$= 0.909\ k/ft$$

$$M_u = \frac{0.909 \times (32^2)}{8} = 116.352 \times 12 = 1396.224\ k/ft$$

Step 02: Determine the effective width "be"

1 - $16 \times h_f + b_w = 16 \times 6 + 14 = 110''$

2 - c/c distance $= 10 \times 12 = 120''$

3 - Span/4 $= \frac{32 \times 12}{4} = 96''$

Select the least value of be i.e 96

Step 03: Check whether Rectangular or T-beam analysis is required.

Trial # 1: Let $a = h_f = 6''$

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.244}{0.90 \times 60 \times (25 - 6/2)}$$

$A_{ST} = 1.175 \, in^2$

Trial # 2:

$$a = \frac{A_{ST} \times f_y}{0.85 f_c' \times b_e} = \frac{1.175 \times 60}{0.85 \times 4 \times 96}$$

$= 0.22'' < 6''$

thus Rectangular beam analysis is required

$$A_{ST} = \frac{M_u}{\phi \times f_y \times (d - a/2)} = \frac{1396.244}{0.90 \times 60 (25 - \frac{0.2}{2})}$$

$= 1.04 \, in^2$

Trial #3:

$$a = \frac{1.04 \times 60}{0.85 \times 4 \times 96} = 0.19''$$

$$AST = \frac{1396.244}{0.90 \times 60 \times (25 - 0.19/2)} = 1.04 in^2$$

→ Same Area

Step 04: Check ρ_{max} and ρ_{min}

$$\rho_{max} = 0.85 \times \beta \times \frac{f'c}{fy} \times \left(\frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t}\right)$$

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

$$\rho_{max} = 0.018$$

$$\rho_{min} = \frac{200}{fy} = \frac{200}{60000} = 0.003$$

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

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

$$0.003 < 0.002 < 0.018$$

As ρ is less than ρ_{min} thus $\rho = \frac{ASi}{b \times d}$; $AST = \rho_{min} \times b \times d$

$= 0.003 \times 14 \times 25$

$= 1.05 in^2$

Step 05: No and selection of bar

Let use #8 bars, then

dia = (8/8) = 1" , Area = 0.785 in^2

$$\text{No of bars} = \frac{1.05}{0.785} = 1.3 \approx 2$$

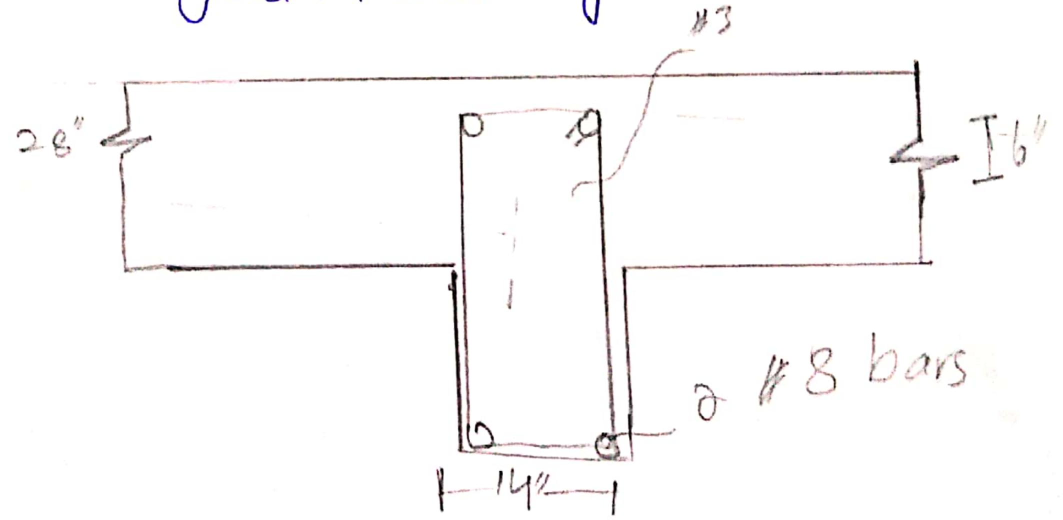
So we use 2 #8 bars

Step #6: Minimum width

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

$= 6.75'' < 14''$

So good in one layer.



Step #7: Design moment.

$Md = \phi \times fy \times Ast \times (d - a/2)$

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

$= 0.785 \times 2 = 1.57\ in^2$

(15)

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

$$M_d = 0.90 \times 60 \times 1.57 \times (25 - 0.2/2)$$

$$= 2111.02 \text{ kip-inch}$$

As, $2111.02 > 1396.23$