MID - TERM EXAM

Name : Sarmad Mahmood

ID : 7828

Subject : PRC Design - I

Teacher : Engr. Fawad khan

Date : 21 - 04 - 2020

Q#1a

Given data:-

$f_y = 60{,}000\ psi$, $w = 10''$

$f'_c = 4000\ psi$, $h = 20''$

$d = h - 3$, $D.L = 1.05\ k/ft$

$= 20 - 3$, $L.L = 2.47\ k/ft$

$= 17$, $d' = 2.5''$

→ **Step 01** :-

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

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

$$\rightarrow \rho_{max} = 0.018$$

→ **Step 02** :-

Area of steel.

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

$$= 0.0181 \times 10 \times 17$$

$$\rightarrow A_{ST} = 3.07\ in^2$$

→ Step 03 :- Design factor moment.

$$M_{u2} = \phi \times A_{ST} \times f_y \times (d - a/2)$$

$$a = \frac{A_{ST} \times f_y}{0.85 f'_c \cdot b} = \frac{3.08 \times 60}{0.85 \times 4 \times 10}$$

$$a = 5.4''$$

$$M_{u2} = 0.90 \times 3.08 \times 60 \times (17 - 5.4/2$$

$$\rightarrow M_{u2} = 23783 \text{ k}''.$$

→ Now

Moment of given load:

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

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

$$= 208.33 \text{ lb/ft.}$$

Total factored load $= 1.2 D.L + 1.6 L.L$

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

$$= 5.5 \text{ k/ft.}$$

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

$$M_u = \frac{5.5\,(18)^2 \times 12}{8}$$

$$= 2653.6\ k''$$

Thus $2378.3 < 2653.6$

→ It should be doubly designed beam.

→ **Step 04 :-**

$$M_{u1} = M_u - M_{u2}$$

$$= 2653.6 - 2378.3$$

$$\rightarrow M_{u1} = 275.2\ k''$$

→ **Step 05 :-**

$$M_{u1} = \phi \times A_s' \times f_y \times (d - d')$$

$$A_s' = \frac{M_{u1}}{\phi \times f_y \times (d - d')} = \frac{275.2}{0.90 \times 60\,(17 - 2.5)}$$

$$\rightarrow A_s = 0.35\ in^2$$

Step 06:- $A_s = A_{s_1} + A_s'$
$= 3.08 + 0.35$
$= 3.43 \text{ in}^2$

→ This lies in tension zone of steel

→ Step 07:-

Bars Selection

→ For tensile steel lets take #8 having an area of 0.785 in^2

$$\text{No. of bars} = \frac{A_s}{A_b} = \frac{3.43}{0.785} = 4.36 \approx 5 \text{ bars}$$

→ For compression steel lets take #6 having an area of 0.442 in^2

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

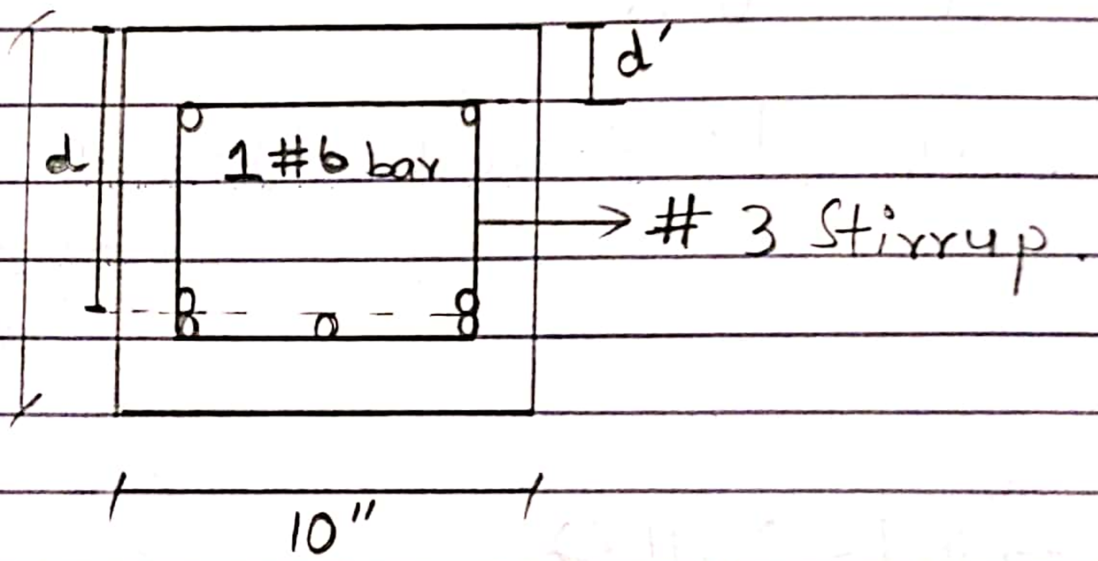
→ **Step 08 :-**

Beam minimum width.

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

$$= 12.75'' > 10''$$

→ It should be in multiple layers.



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

$$\rightarrow d = 16.62''$$

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

→ Step 09 :-

Design moment.

$$M_d = \phi \times [A_s' \times f_y \times (d - d') + (A_s - A_s') \times f_y (d - \frac{a}{2})$$

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

$$a = 6.15''$$

$$= 0.90 \times [0.44 \times 60 \times ((16.62) - 2.25) + (5 \times 0.785 \times 1 \times 0.44) \times 60 \times (16.25 - \frac{6.15}{2})$$

→ $M_d = 2891.52$

$M_d = 2891.52 > 2653.56\,k$

→ Design is ok

Q# 2a

→ Answer

• **Bond stress :-** Stress acting on the outer interface of steel to the surrounding concrete is called bond stress. It helps in keeping bond b/w reinforced steel and concrete together. It resist any force that tries to pull out the rods from concrete.

• **Development length :** The length of the bar required on either side of the section to develop the required stress in steel at the section through bond. The development length of the bar required to develop the design stress in reinforcements at the critical section.

→ 2b Answer : The conditions are given below :-

→ This type of beam is provided when the depth of beam is restricted. If a beam with limited depth is reinforced on the tension side it might not have sufficent resistance to oppose the bending moment.
→ DRB is provided to increase the moment of resistance of a beam having limited dimensions.
→ Minimum compression reinforcement is provided to hold the shear reinforcement in position and force increases the ductility of beam.
→ For safety reasons we provide doubly reinforced beam to counter wind force and seismic forces.

→2c Answer :-

T- beam	Rectangular beam
• In T-beam, slab and beams are connected with each other and acts as one member	• In R-beam, slab is placed on the beam so that there is no connection b/w slab and beam
• Flexural capacity of T-beam varies based on the sign of moment.	• Flexural capacity depends on location of reinforcement to the yield.
• Design procedure depends on the location of moment	• Simple design with no complexion.

→2d Answer :- In the design of flexural strength, the strength reduction factor decreases from tension controlled section to compression controlled section to increase safety with decreasing ductility. The tension controlled sections are desirable for their ductile behaviour for giving sufficent warning to failure. Depending on the structure compression controlled section have less ductility thus they act simultaneously to hold the structure together.

→ Qe Answer :- Following are the designs methods of PRC :-

1) **Ultimate load design** :

Defined as the method which limit the structural usefulness of material of the structure upto ultimate load.

2) **Limit state method** :

Defined as the method which limits the structural usefulness of the material of the structure upto certain load at which

(11)

acceptable limit of service ability and safety are applied so that the failure of the structure does not happen.

3) Elastic Method of Design:-

Defined as the method which limits the structural usefulness of the material of the structure upto a certain load at which the minimum stress is extreme fiber reaches the characteric strength of the material in bonding.

→ Q #03
Answer :

→ Given data: c/c distance = 10'

span = 32

h_f = 6"

b_w = 14"

h = 28"

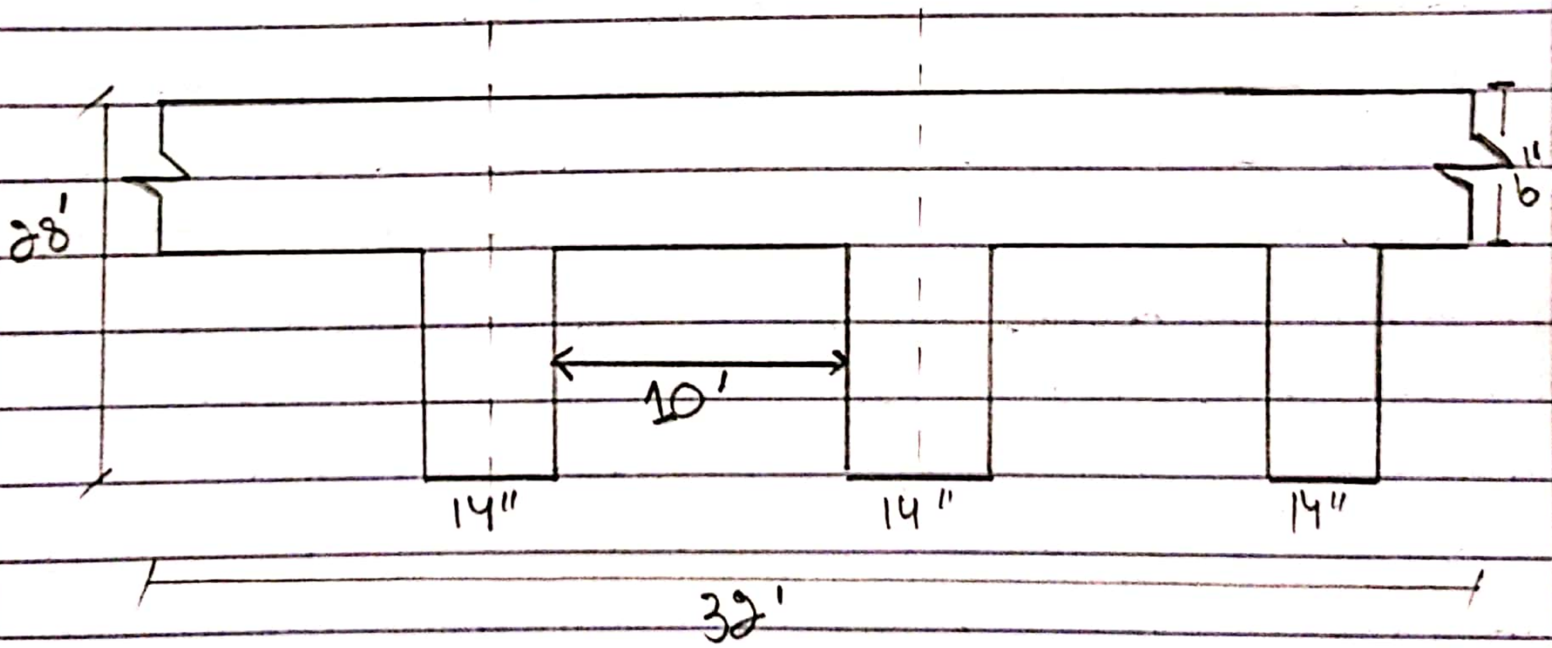
d = effective depth = h - 3 = 28 - 3 = 25"

D·L = 50 lb/ft²

L·L = 225 lb/ft²

f_y = 60,000 psi = 60 ksi

f'_c = 4,000 psi = 4 ksi



→ **Step 01 :-** Ultimate factored moment.

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

i) Self weight of the beam

$W_t = b \times t \times \gamma_c$ ∴ γ_c

$= 14/12 \times 28/12 \times 150$ For PCC = 140 lb/ft³

$= 408.33$ lb/ft. For RCC = 150 lb/ft.

ii) Total factored load.

$= 1.2\ DL + 1.6\ L.L$

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

$= 909.99$ lb/ft

$= 0.909$ k/ft

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

$= 1396.224$ lb/ft.

→ **Step 02 :-** Determine effective width.

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

2) C/C distance $= 10 \times 12 = 120''$

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

Select the least value i-e $96''$

→ **Step 03 :-** Check wether rectangular or T-beam analysis is required.

Trial #1

let $a = h_f = 6''$

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

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

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

$$A_{ST} = \frac{M_u}{\phi \times f_y (d - a/2)} = \frac{1396.244}{0.90 \times 60 (25 - \frac{0.22}{2})}$$

$A_{ST} = 1.04 \ in^2$

Trial #3

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

Trial #3

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

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

→ Same area.

→ **Step 04 :-**

Check ρ_{max} and ρ_{min}

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

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

$\rho_{max} = 0.018.$

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

- $\rho = \frac{A_{ST}}{b \times d} = \frac{1.03}{14 \times 25} = 0.0029$

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

$0.003 < 0.002 < 0.018$

As ρ is less than ρ_{min} Thus;

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

$= 0.003 \times 14 \times 25$

$\rightarrow = 1.05 \text{ in}^2$

→ **Step 05 :-**

Selection and no. of bars

lets use # 10 bar having area 1.27 in^2

No. of bars $= \frac{A_{ST}}{A_b} = \frac{1.05}{1.27}$

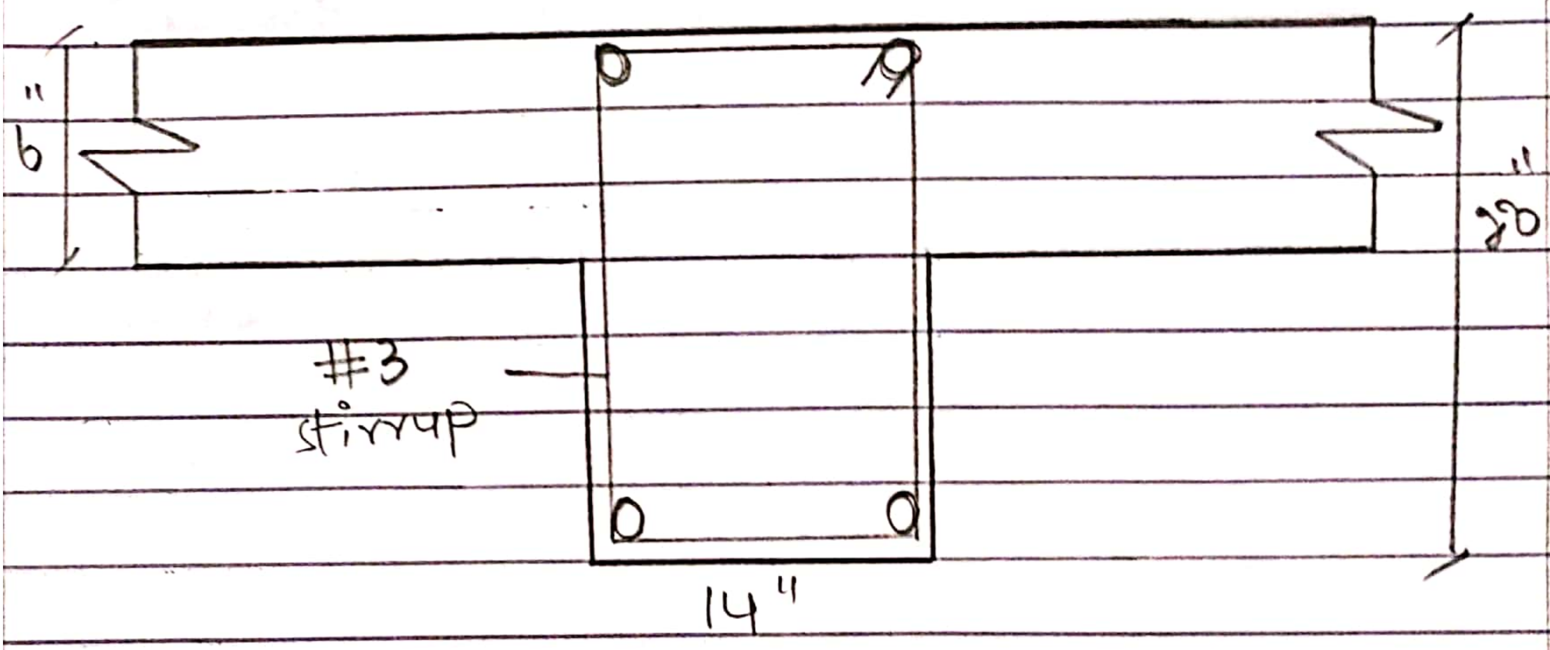
$\rightarrow \approx 2$ bars

→ **Step 06 :-** Check on minimum width.

$b_{min} = (2 \times 1.5) + (2 \times 3/8) + 2(10/8) + 1(10/8)$

$= 7.5'' < 14''$

It is good in one layer.



→ **Step 07 :-**

Design moment.

- $M_d = \phi \times f_y \times A_{ST} \times (d - a/2)$
- $A_{ST} = 1.27 \times 2 = 2.54 \ in^2$
- $a = \dfrac{A_{ST} \times f_y}{0.85 f'_c \times b_e} = \dfrac{2.54 \times 60}{0.85 \times 4 \times 96} = 0.467$

→ $M_d = 0.90 \times 60 \times 2.54 \, (25 - 0.467/2) = 3396.97$

→ $3396.97 > 1396.244$

→ Design is OK!