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Subject Reinforcement Concrete Design.

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Q No 1

Ans:

Given data:

Span length of beam = 30 ft

=> Dead load = D.L = 1000 lb/ft = 1.0 Kip/ft

=> Live load = L.L = 1100 lb/ft = 1.1 Kip/ft

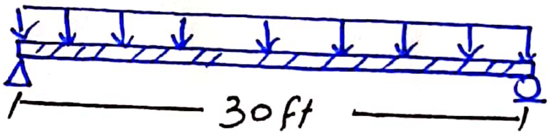
=> f_y = 60,000 psi

=> f_c' = 4000 psi

Required data:

Design Beam, Draw sketch and also check design Capacity.

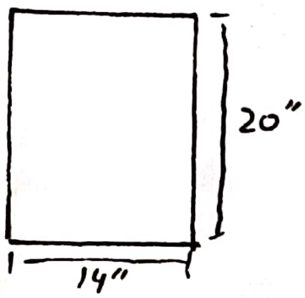
Solution:



Step No 1 Sizes:

Here $h_{min} = \frac{l}{16} = 20 \times \frac{12}{16}$

$= 15''$



However we use 20" deep Beam.

Width of Beam crossection (b_w) = 14" (assumption).

Step No 2 Load.

=> Self weight of beam $= \gamma_c \, b_w \, h$

$= 0.15 \times \left(14 \times \frac{20}{12 \times 12}\right)$

$= 0.292$ Kips/ft

$\Rightarrow W_u = 1.2\,W_D + 1.6\,W_L$

$= 1.2\times(1.0)(0.292) + 1.6\,(1.1)$

$= 3.3104$ Kips/ft

Step No 3 Analysis.

$$M_u = \frac{W_u \ell^2}{8} = 3.3104 \times \frac{30^2 \times 12}{8}$$

$= 4469.04$ in-Kips.

Step No 4 Design.

Design for flexural.

$\phi M_n \geq M_u$

For $\phi M_n = M_u$

Now; Calculate "A_s" by trial and Success Method

1st trial

$$\Rightarrow A_s = \frac{M_u}{\phi f_y (d - a/2)}$$ assume $a = 4''$

$$\Rightarrow A_s = \frac{4469.04}{0.9\times 60\left(17.5 - \frac{4}{2}\right)}$$

$= 5.33\ in^2$

$$\Rightarrow a = \frac{A_s f_y}{0.85 f'_c b} = \frac{5.33\times 60}{0.85\times 4\times 14} = 6.71''$$

2nd trial

$$A_s = \frac{4469.04}{0.9 \times 60\left(17.5 - \frac{6.71}{2}\right)}$$

$$= 5.85 \text{ in}^2$$

$$a = \frac{5.85 \times 60}{0.85 \times 4 \times 14}$$

$$a = 7.37 \text{ in}$$

3rd trial

$$A_s = \frac{4469.04}{0.9 \times 60\left(17.5 - \frac{7.37}{2}\right)}$$

$$\Rightarrow A = 5.96 \text{ in}^2$$

$$a = \frac{5.99 \times 60}{0.85 \times 4 \times 14}$$

$$\Rightarrow a = 7.55 \text{ inc}$$

So we take $A_s = 5.96 \text{ in}^2$

Step No 5

Check for Minimum or Maximum Reinforcement allowed ~~for~~ by ACI

$$\rho_{min} = \frac{3\sqrt{f_c'}}{f_y} \geq \frac{200}{f_y}$$

$$= \frac{3 \times \sqrt{4000}}{60,000} = 0.0032$$

$$\frac{200}{60000} = 0.0033$$

Therefore, $\rho_{min} = 0.0033$

$\Rightarrow A_{s\,min} = \rho_{min}\, b_w d$

$= 0.033 \times 14 \times 17.5 =$

$\Rightarrow A_{s\,min} = 0.81 \text{ in}^2$

Now

$$\rho_{max} = 0.85\beta_1 (f_c'/f_y) \left\{ \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} \right\}$$

Here $\varepsilon_t = 0.9$ for flexural design

$\beta_1 = 0.85$ (for $f_c' \leq 40$ ksi)

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

$\rho_{max} = 0.018$

$A_{s\,max} = 0.018 \times 14 \times 17.5 = 4.98 \text{ in}^2$

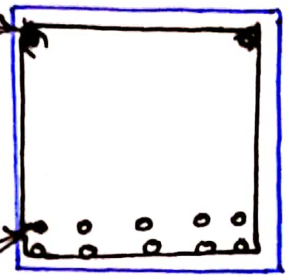
$A_{s\,min} (0.81 \text{ in}) < A_s (4.96) < 4.98 \; A_{s\,max}$

Bar placement: 10 #6 bar will provide 4.40 in^2 of Steel area is slightly greater than required.

Step No 6

Drafting.

(2) #6



(5+5) #6

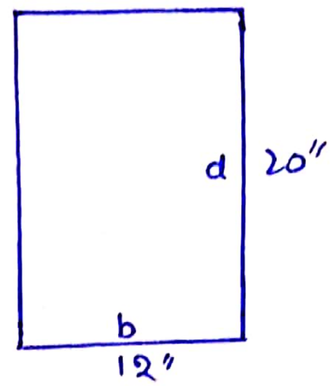
Q No 2

Given data:

=> $f_c' = 3$ Ksi

=> $f_y = 40$ Ksi

=> Flexural demand = 3500 in-Kip.



Sol:-

Step No 1:

Calculation of $\phi M_{n\,max}$ (singly)

=> $\rho_{max\,(singly)} = 0.0203$

=> $A_{s(max)\,singly} = \rho_{max\,singly} \times bd$

$= 0.0203 \times 12 \times 20$

$= 4.87\ in^2$

$\phi M_n = 2948.88$ in-Kip

Step No: 2

Moment to be carried by Compression Steel

$M_{u(extra)} = M_u - \phi M_{n\,max\,(singly)}$

$= 4500 - 2948.88$

$= 1551.12$ in-Kip

Step No 3:

Find ε_s' and f_s'.

From table: $d = 20'' > 12.3''$ and for $d' = 2.5''$,

d'/d is $0.125 < 0.20$ for grade 40 steel. So Compression Steel will be.

$$\Rightarrow \varepsilon_s' = (0.003 - 0.008\, d'/d)$$

$$\Rightarrow \varepsilon_s' = 0.003 - 0.008 \times \frac{2.5}{20} = 0.002 > \varepsilon_y = \frac{40}{29000} = 0.00137$$

As ε_s is greater than ε_y, So the Compression Steel will yield.

Step No 4:

Calculation of A_s' and A_{st}.

$$\Rightarrow A_s' = \frac{M_{u\,(extra)}}{\phi f_s'(d-d')} = \frac{1551.12}{0.9 \times 40\,(20-2.5)}$$

$$= 2.46\ in^2$$

Total amount of tension reinforcement (A_{st}) is,

$$A_{st} = A_{s\,max\,(singly)} + A_s' = 4.87 + 2.46$$

$$\boxed{A_{st} = 7.33\ in^2}$$

Using #8 bar, with Bar Area. $A_b = 0.79\ in^2$

No. of Bar to be provided on tension side $= \frac{A_{st}}{A_b} = \frac{7.33}{0.79}$

$= 9.28$

No. of Bar to be provided on Compression side $= \frac{A_s'}{A_b}$

$= \frac{2.46}{0.79} = 3.1$

provide 10 #8 ($7.9\ in^2$ in 3 layer) on tension side and 4 #8 ($3.16\ in^2$ in 1 layer) on Compression side.

Step 5: Ensure that $d'/d < 0.2$ (for grade 40) So that Selection of bars does not creat Compressive stresses lower than yield.

With tensile reinforcement of 10 #8 bars in 3 layer and Compression reinforcement of 4 #8 bars in Single layer, $d = 19.625''$ and $d' = 2.375$

Now $d'/d = \frac{2.375}{19.625} = 0.12 < 0.2 \rightarrow$ OK

Step 6 Ductility Reinforcement: $A_{st} \leq A_{st\,max}$

A_s, which is the total steel Area actually provided as tension reinforcement must be less than

A_s max.

=> $A_{st\,max} = A_{s\,max\,singly} + A_s' f_s'/f_y$

=> $A_{s\,max\,(Singly)}$ is a fixed number for the Case under the Consideration and A_s' is steel area actually placed on Compression side.

=> $A_{s\,max\,(Singly)} = 4.87 in^2$; $A_s = 4 \times 0.79 = 3.16 in^2$

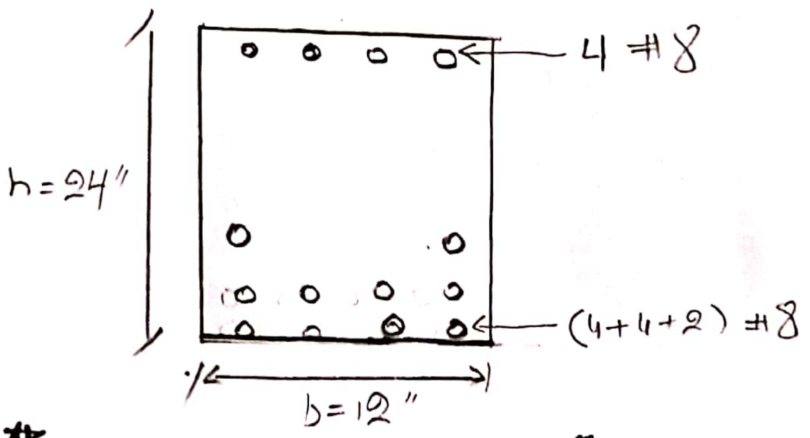
=> $A_{s(max)} = 4.87 + 3.16 = 8.036 \; in^2$

=> $A_{st} = 7.9 \; in^2$

Therefore $A_{st} = 7.9 \; in^2 < A_{st\,max}$ —> OK.

Step No # 7 Drafting:

=> provide 10 # 8 (7.9 in² in 3 layer) on tension Side and 4 # 8 (3.16 in 1 layer) on Compression Side



Q(3) Behavior of Rc Beam under Gravity load:

* Beam Test:.

in order to clearly understand The behavior of Rc members Subjected to flexure load only. The responces of Such members at Three different loading stages is discused.

1 un-cracked concrete- Elastic stage:

* At loads much lover Then The ulitmute. concrete remains un-cracked in compression as well as tension and The behavior of Stel and Concrete both is elastic

(2) cracked concrete (tension zone)- Elastic Stage:

* with increase in load comrete cracks in tension but remains un-cracked in compression concrete in compression and steel in tension both behave in elastic manner.

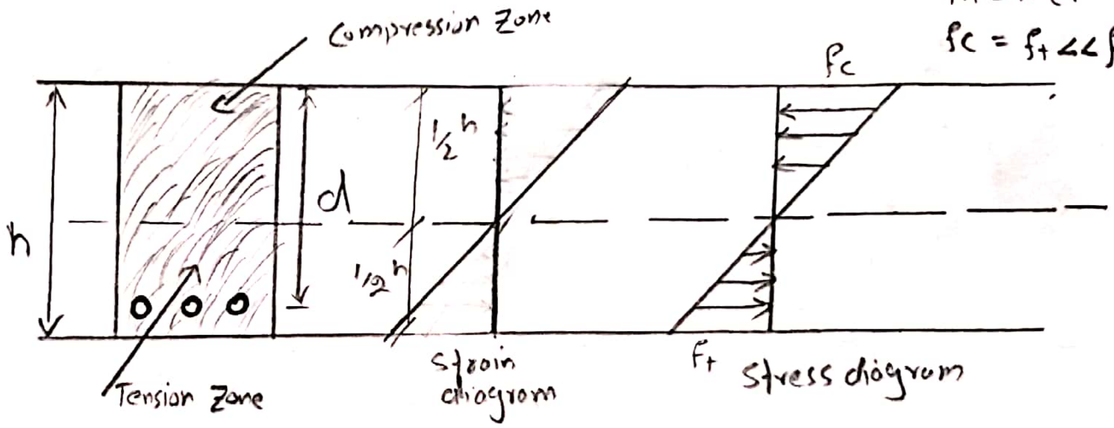
(3) cracked concrete (tension zone- Elastic (ultimate strength) Stage:.

* concrete is creaked in tension.

Concrete in compression and Steel in tension both enters into inelastic range. At collapse. Steel Yeicldls and concrete in compression crushes.

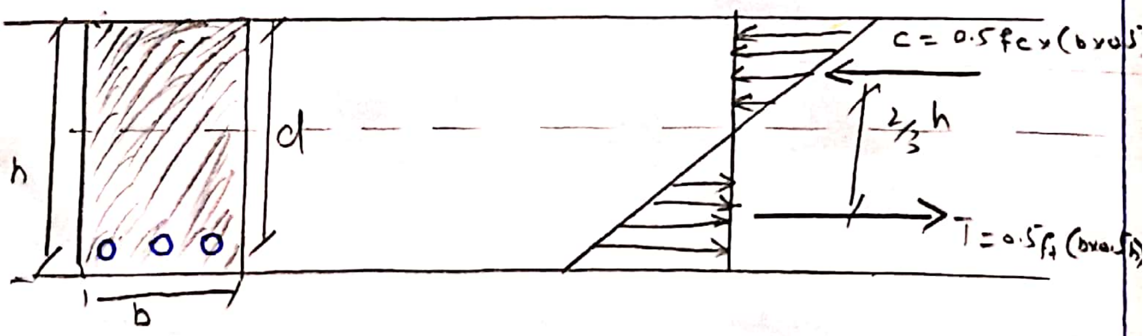
Stage 1 : Behavour:

$f_t = f_r$
$M = M_{cr}$
$f_c = f_t << f_c'$



This The stage where concrete is at the verge of failure in tension.

Calculation of Forces:



$C = T \; ; \quad f_c = f_t$

$M = 0.5 f_c \times (b \times 0.5h) \times \frac{2}{3}h$

$= \frac{1}{6} f_c \times b \times h^2$

$f_c = f_t = \frac{6M}{bh^2}$

OR

$f_c = f_t = \frac{Mc}{I_g}$

where $c = 0.5h$

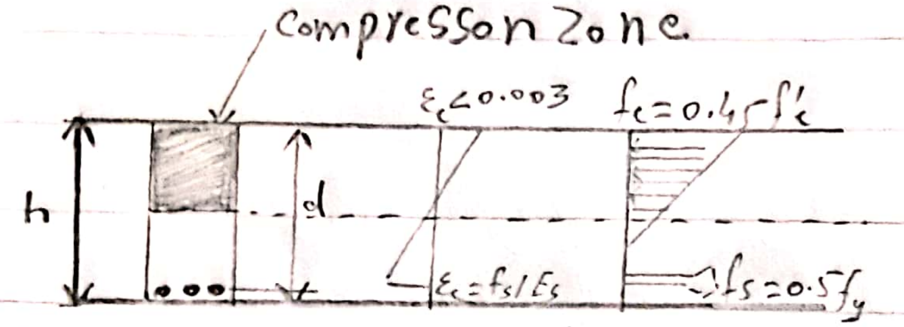
$I_g = \frac{bh^3}{12}$

$f_c = f_t = \frac{6M}{bh^2}$

At $f_t = f_r$, where Modulus of rupture, $f_r = 7.5\sqrt{f_c'}$

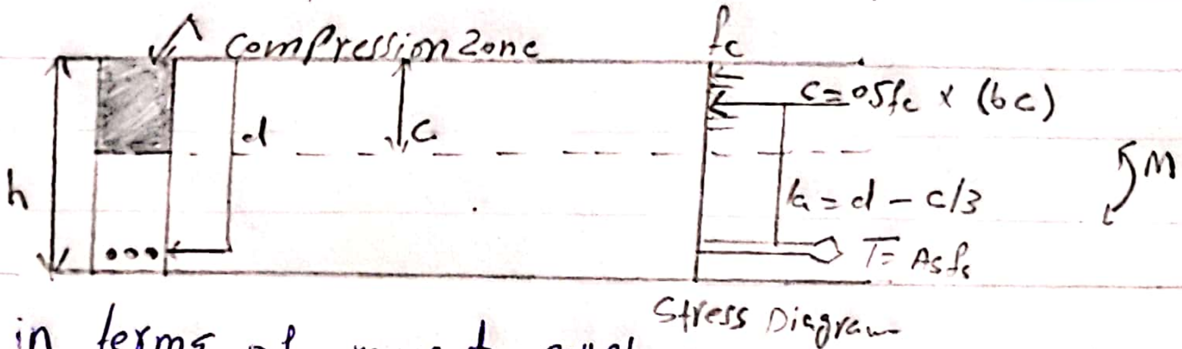
Cracking moment capacity, $M_{cr} = f_r \times I_g / 0.5h = \frac{f_r \times b \times h^2}{6}$

Stage#2: Behavior:



$f_t > f_r$
$M > M_{cr}$
$f_c = 0.45 f_c'$
$f_s = 0.4 f_y$.

Stage#2: calculation of forces:



in terms of moment couple ($\Sigma M = 0$)

$M = T/2 = A_s f_s \ (d - c/3)$

$A_s = M/f \ (d - c/3)$

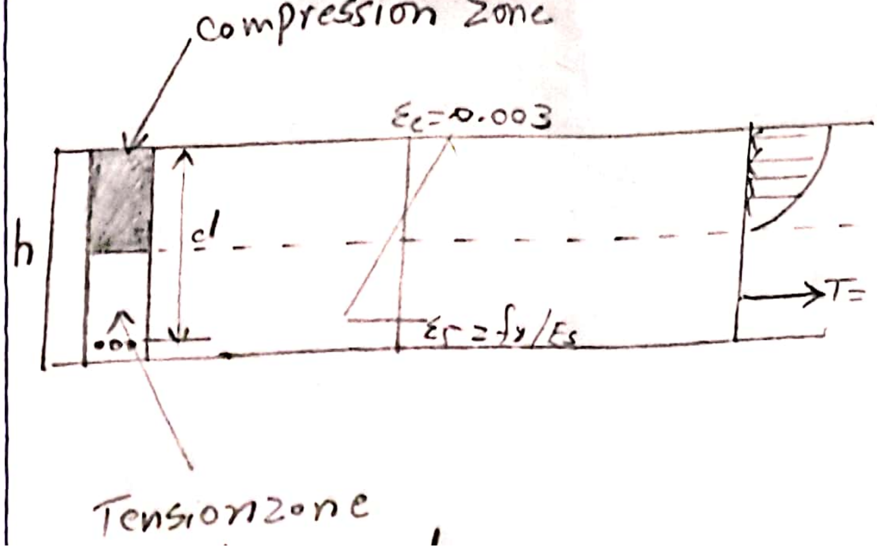
$C = T$ ($\Sigma F_x = 0$)

$C(1/2) f_c b c = A f$

$C = 2 A_s f_s \ f_c b$ {where f_s

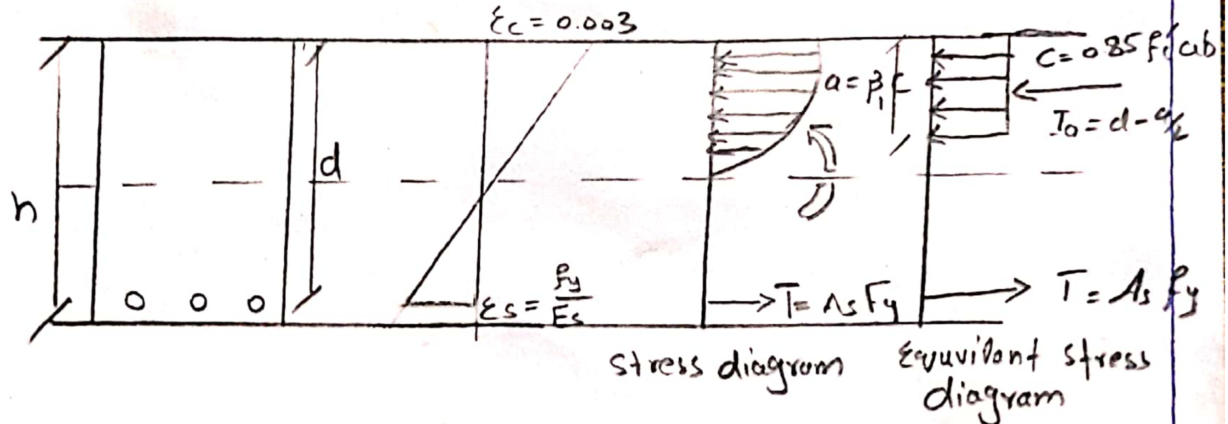
$C = 2 A_3 \ S/b$

Stage#(3) Behavior:



$f_t > f_r$
$M > > M_{cr}$
$f_s = f_y$
f_c are when $\varepsilon_s > 1$

Stage 3: Calculation of Forces:



In term of moment couple $(\Sigma M = 0)$

$$M = TJ_a = A_s f_y (d - a/2)$$

$$A_s = \frac{M}{f_y (d - a/2)}$$

$C = T \; (\Sigma F_x = 0)$

$$0.85 f_c' ab = A_s f_y$$

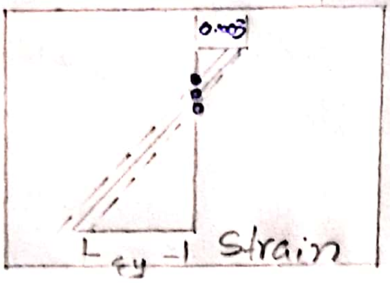
$$a = \frac{A_s f_y}{0.85 f_c' b}$$

Basic Assumption: (ACI 22.2):

* A plane section before bending remain plane after bending.
* Stresses and strain are approximately proportional upto moderate loads (concrete stress $\leq 0.5 f_c$)
When the load is increased, the variation in the concrete stress is no longer linear.
* Tensile strength of concrete is neglected in the design of reinforced concrete beam.
* The bond between the steel and concrete is perfect and no slip occur.
* Strain in concrete and reinforcement shall be assumed proportional the distance from neutral axis.

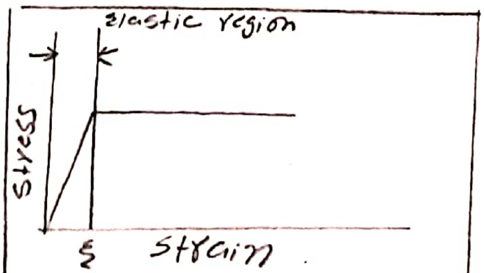
Basic Assumption (ACI 22.2)

* The maximum usable concrete compressive strain at The epterme fiber is assumed to be 0.003.



Bastic Assumptions:

The steel is assumed to be uniformly strained to The strain That exists at The level of The centroid of The steel. Also The strain in The steel ε_s is Less Than The Yeild strain of The steel. The stress in The steel is $E_s \varepsilon_s$. if $\varepsilon_s \geq \varepsilon_y$ The stress in steel will be equal to f_y.



idealized stress-strain curve