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Subject:	Reinforce Concret structure
Programme	B-tech (civil)
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Q1:- Required Data :-

Design Beam, Draw Sketch & also check design Capicity-

Solution:

Step (1) :-

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

$= 15''$

However we use : 20" deep beam

width of beam Crossection $(b_0) = 14''$

Step (2) :-

Load:

$\Rightarrow$ Self weight of beam

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

$= 0.292$ Kips/ft

$\Rightarrow W_a = 1.2 \; W_D + 1.6 \; W_L = 1.2(10)(0.292) + 1.6(1.1) = 3.3104$ Kips/ft

Step (3):- Analysis:

$$Mu = wa \frac{l^2}{8} = 3.3104 \times \frac{30^2 \times 12}{8}$$

$$= 4489.04 \text{ in-kips.}$$

Step (4):- Design:-

$$\phi Mn = Mu$$

For $\phi Mn = Mu$

Now calculate As by trail.

1st trail

$$\Rightarrow As = \frac{Mu}{\phi fy(d - \frac{a}{2})}$$

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

$$= 5.33 \text{ in}^2$$

$$\Rightarrow a \quad \frac{As fy}{0.85 f'c b} = \frac{5.33 \times 60}{0.85 \times 4 \times 14}$$

$$= 6.71''$$

2nd Trail :-

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

$$= 5.85 \ in^2$$

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

$$a = 7.36 \ in$$

Check for minimum or maximum Reinforcement :-

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

$$= 3 \times \sqrt{\frac{4000}{60{,}000}} \geq \frac{200}{f_y}$$

$$= 0.0032$$

$$\frac{200}{60{,}000} = 0.0033$$

Therefore $\rho_{min} = 0.0033$

=> $A_s = \rho_{min}\, b_w d$

$$= 0.0033 \times 14 \times 17.5 = 0.81\ in^2$$

Now ρ_{max} $0.85 \; \beta_1 (f_c'/f_y)$

$$\left\{ \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_t} \right.$$

$\varepsilon_t = 0.9$ for flexured design

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

$$\rho_{max} \; 0.85 \times 0.85 \left(\frac{4}{60}\right) \times \left\{ \frac{0.003}{0.003 + 0.05} \right\}$$

$$\rho_{max} = 0.018$$

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

$A_{s\,min}$ $(0.81 \text{in}) < A_s$

$(4.96) < 4.89$ $A_{s\,max}$

Q2:

Solution:-

Step (1):- Calculate of ϕM_{nmax} (Singly)

ρ_{max} (Singly) $= 0.0203$

A_{smax} (Singly) $= \rho_{max}$ (Singly) $bd = 4.87\ in^2$

ϕM_{nmax} (Singly) $= 2948.88$ in-kip

Step (2):- Moment to be Carried by Compression Steel.

$M_u = M_u - \phi M_{nmax}$ (Singly)

$= 3500 - 2948.88 = 551.12$ in-kip

Step (3):- Find E_s' and f_s':-

From Table 2, $d = 20" > 12.3"$ and for $d' = 2.5"$,

$\frac{d'}{d}$ is $0.125 < 0.20$ for grade 40 steel.

So Compression Still will Yield-

Stress in Compression steel $f_s' = f_y$

Alternatively,

$$\varepsilon_s' = (0.003 - 0.008\, d'/d) \quad \text{.......} \quad (i)$$

$$\varepsilon_s' = (0.003 - 0.008 \times 2.5/20) = 0.002 > \varepsilon_y = 40/29000$$
$$= 0.00137$$

As ε_s' is greater Than ε_y', So

The Compression Still will yield.

Solution:-

Step (4) Calculation of A_s' and A_{st}

$$A_s' = M_{u(extra)} \{\phi f_y' (d - d')\} = 1551.12 / \{0.90 \times 40 \times (20 - 2.5)\}$$
$$= 2.46 \text{ in}^2$$

* Total amount of Tension reinforcement (A_{st}) is

$$A_{st} = A_{s\,max}\,(\text{singly}) + A_s' = 4.87 + 2.46 = 7.33 \text{ in}^2$$

* Using # 8 bar, with bar area $A_b = 0.79 \text{ in}^2$

No. of bars to be provided on Tension side =

$$A_{st}/A_b = 7.33/0.79 = 9.28$$

No. of bars to be provided on Compression side =

$$A_s'/A_b = 2.46/0.79 = 3.11$$

Provide 10#8 (7.9 in^2 in 3 layers) on Tension side

& 4#8 (3.16 in^2 in 1 layer) on Compression side.

Solution :-

Step 05 :- Ensure That $d'/d < 0.2$ (for grade 40)

So That Selection of bars does not Create Compressive Stresses lower Than Yield.

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

$$d'/d = 2.375 / 19.625 = 0.12 < 0.2, \text{ OK}$$

Solution:-

Step 06 :- Ductility requirements $A_{st} \leq A_{st\,max}$

* A_{st} Which is The total Steel area actually provided as tension reinforcement must be less Than $A_{st\,max}$.

* $A_{st\,max} = A_{s\,max}\,(\text{singly}) + \dfrac{A_s' f_s'}{f_y}$

* A_{stmax} (singly) is a fixed number for the case under consideration & A_s' is steel area actually placed on compression side.

* A_{smax} (singly) $= 4.87\ in^2$; $A_s' = 4 \times 0.79 = 3.16\ in^2$

* $A_{stmax} = 4.87 + 3.16 = 8.036\ in^2$

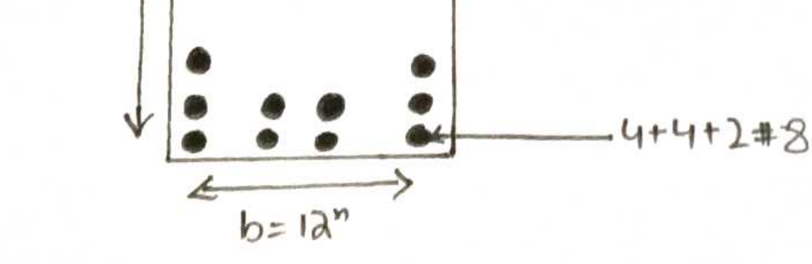
* $A_{st} = 7.9\ in^2$

—— Therefore $A_{st} = 7.9\ in^2 < A_{stmax}$ OK.

Solution:-

Step (07) Drafting:-

* Provide 10#8 ($7.9\ in^2$ in 3 layers) on tension side & 4#8 ($3.16\ in^2$ in 1 layer) on compression side.



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⇒ Mechanics of RC Beam Under Gravity Load:

→ **Uncracked Concrete:-**

At load much lower then ultimat, concrete remains uncracked in compresion as well as tension and behavior of steel and conrete both in elastic.

→ **Cracked Conrete (tension Zone):-**

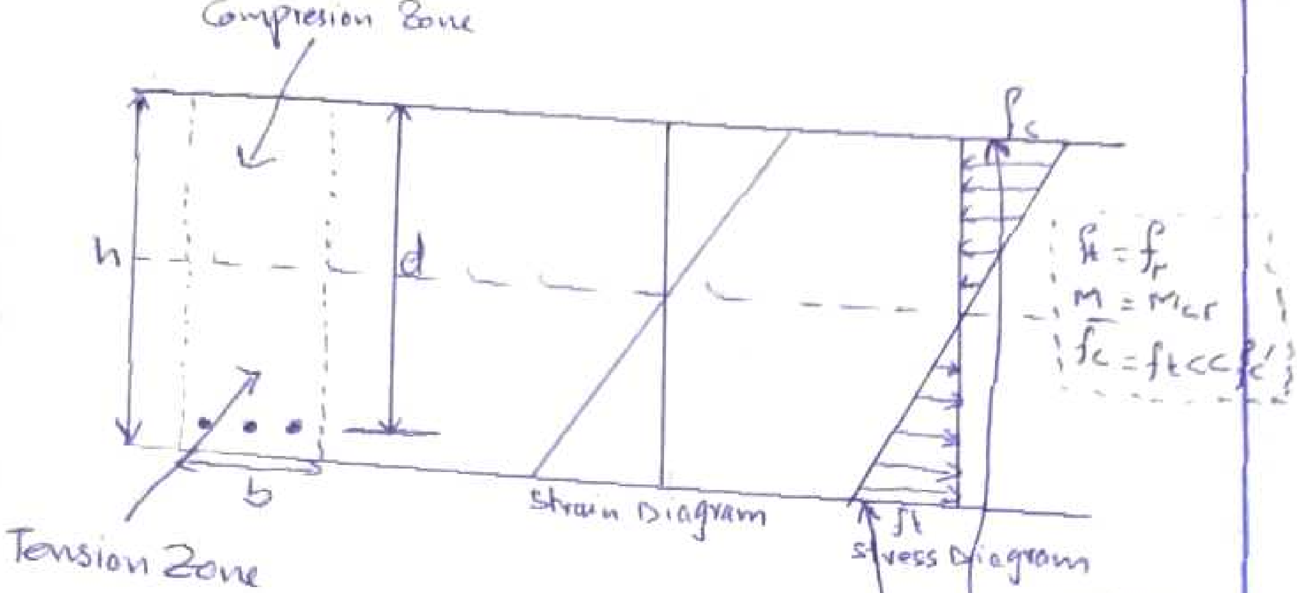
with increase in load Conrete crack in tension but remain uncracked in Compression Concrete in compression and steel in tension both behave in elastic manner.

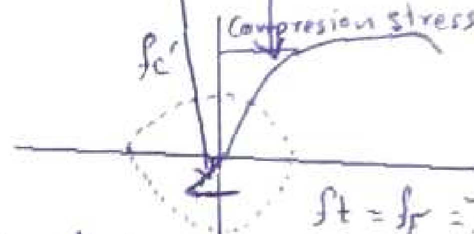
→ Cracked Concrete (tension Zone) - Inelastic (ultimate strength) stage:-

conrete is cracked in tension. Concrete in compression and steel in tension both enters into inelastic range. At collaps, steel yeild and conrete in compresion crushes.

→ stage-1:

⇒ **Behavaior:-**



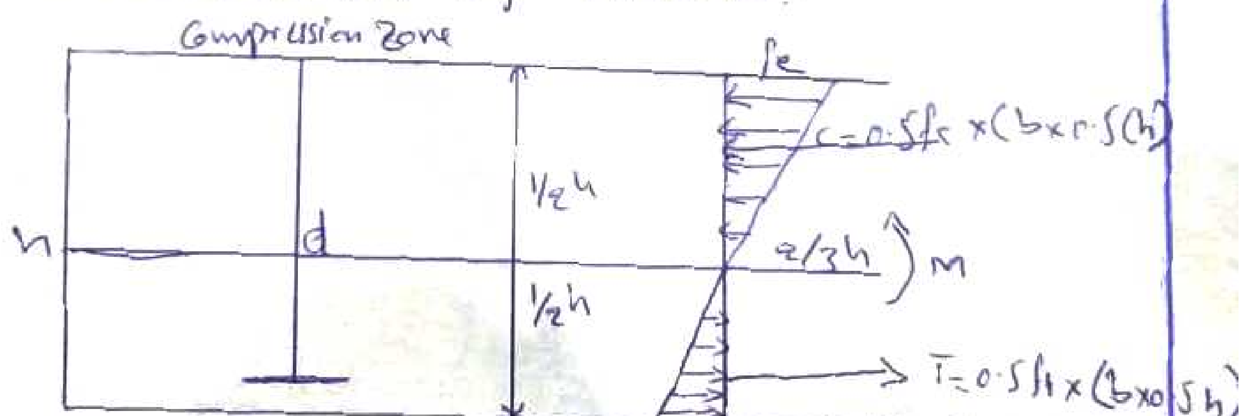


$f_t = f_r = 7.5\sqrt{f_c'}$
(ACI 19.2.3.1)
concrete stress strain diagram

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

=> stage: 1

=> Calculation of Forces:



$C = T : f_c = f_t$

$M = 0.5 f_c \times (b \times 0.5h) \times (2/3\, h)$

$= 1/6\, f_c \times b \times h^2$

$f_c = f_t = 6M/(bh^2)$

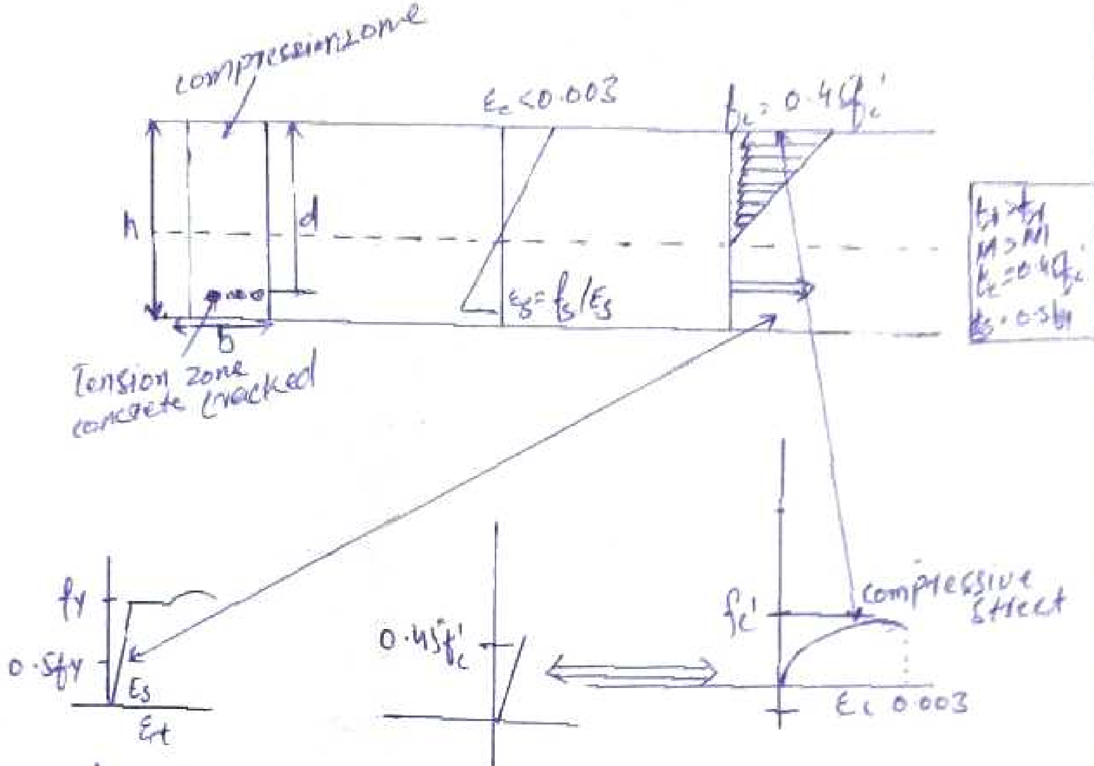
$F_c = f_t = Mc/I_g$
where $c = 0.5$
$I_g = bh^3/12$
$f_c = f_t = 6M/(bh^2)$

At $f_t = f_r$, where modulus of rapture, $f_r = 7.5\sqrt{f_c'}$

cracking moment capacity $M_{cr} = f_r \times I_g/(0.5h) = (f_r \times b \times h^3)$

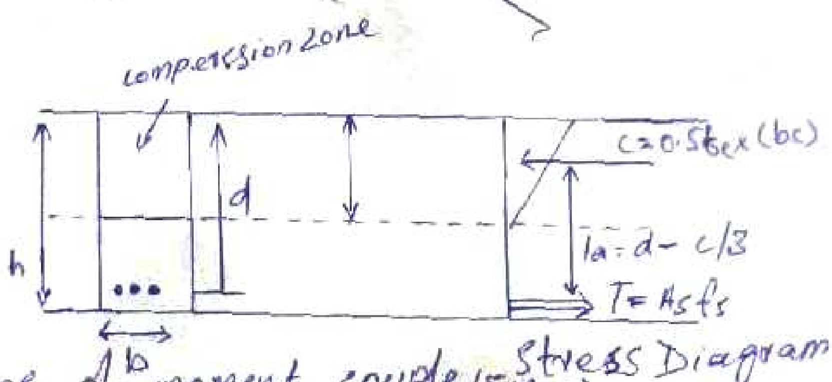
Stage # 02

=> Behavior:



=> Stage # 02

=> Calaulation of Force



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

$M = Tla = A_s f_s (d - c/3)$

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

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

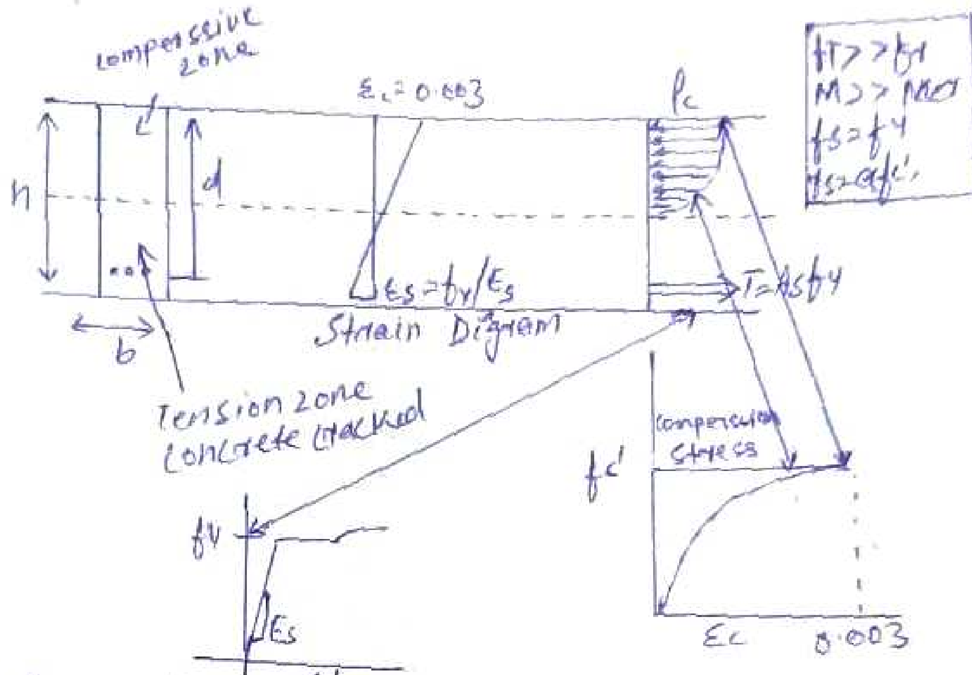
$(1/2) f_c bc = A_s f_s$

$C = 2 A_s f_s / f_c b$

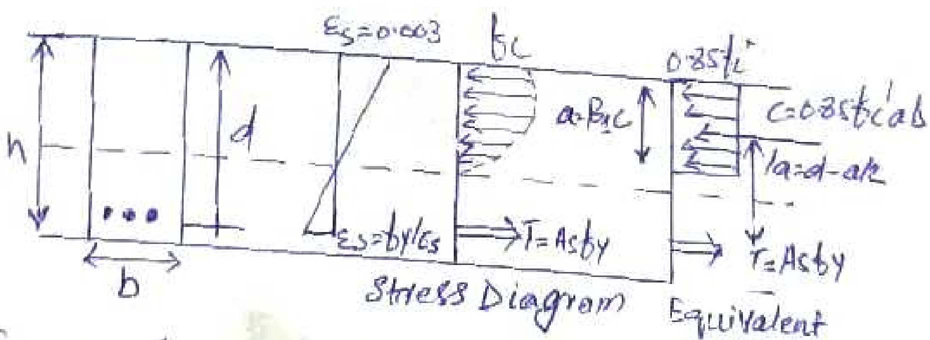
$C = 2 A_s n / b$

Stage # 03

⟹ Behavior:-



⟹ Calculation of Forces:



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

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

$A = M / f_y (d - a/2)$

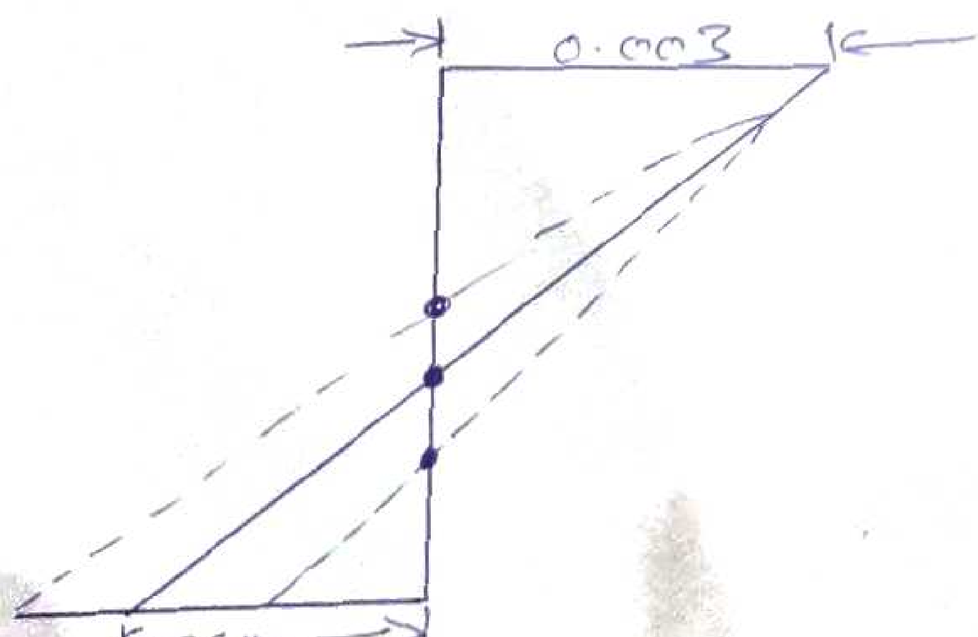
$C = T$ ($\Sigma F_x = 0$)

$0.85 f_c' ab = A_s f_y$

$a = A_s f_y / 0.85 f_c' b$

=> **Basic Assumptions (ACI 22.2**

- A plan section befor bending remains plan after bending.
- stress and strain are approximelly proportional upto moderate loads (concrete stress $\leq 0.5 f_c'$). When the loads in increased the variation in the concrete stress is no leanear.
- The bond between the steel and concrete is perfect and no slip occurs.
- The maximum usable concrete compression strain at the extreme fiber is assumed to be 0.003.



strain

- The steel is assumed to be uniformly straind to the strain that exists at the level of the centroid of the steel. Also if the strain in the steel ε_s is less then the yeild strain of the steel ε_y, 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.