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Subject Reinforce Concrete structure

Programme B-tech (civil)

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(1) REQUIRED Data:

Design Beam, Draw Sketch and also check design capacity.

SOLUTION:

Step# (1)

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

$= 15''$

However we use 20'' deep Beam width of Beam Crosection (bw)

$= 14''$

Step # (2) Load:

→ self waight of beam

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

$= 0.292$ kips/ft

⇒ $w_u = 1.2\ w_D + 1.6\ w_L$

→ $1.2(1.0)(0.292) + 1.6(1.1)$

$= 3.3104$ kips/ft

Step #(3) Analysis:

$m_u = w_u \frac{l_2}{8} = 3.3104 \times \frac{30^2 \times 12}{8}$

$= 4469.04$ in-kips.

Step (4) = (Design)

$\phi\, m_n = m_u$

For $\phi\, m_n = m_u$.

Now, calculate 'As' by trial

1st trail

$$A_s = \frac{M_u}{\phi f_y (d - \frac{a}{2})}$$

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

$$= 5.33\, in^2$$

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

$$= 6.71''$$

2nd trial:

$$A_s = \frac{4469.\text{-}4}{0.9 \times 60 (17.5 - \frac{6.71}{2})}$$

$$= 5.85\, in^2$$

$$a = \frac{5.85 \times 60}{0.85 \times 4 \times 14} \Rightarrow a = 7.36\, in$$

Check for minimum or maximum Reiforcement.

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

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

$$= 0.0032$$

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

Therefore $\rho_{min} = 0.0033$

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

$$= 0.0033 \times 14 \times 17.5$$

$$= 0.81 \text{ in}^2$$

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

$$\cdot \left\{ \frac{\varepsilon_u}{\varepsilon_u + \varepsilon_T} \right.$$

Q14

$\epsilon_x = 0.9$ for flexured design.

$B_1 = 0.85$ (for $f_c' \leq 40ksi$)

$\rho_{max} \cdot 0.85 \times 0.85 \left(\frac{4}{60}\right) \times \left\{\frac{0.0032}{0.003+0 \ldots 005}\right\}$

$\rho_{max} = 0.018$

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

As min $(0.81 in) <$ As

$(4.96) < 4.89$. As max.

Q3 Explain the mechanics of RC beams under the gravity load.

Ans The following mechanics of RC beams under the gravity load.

MEChanics of RC BEAMS UNDER gravity load :

→ 1 UN-cracked concrete – Elastic Stage

→ At loads much lower than the ultimate concrete remains un-cracked in compression as well as tension and the behavior of Steel and Concrete both is elastic.

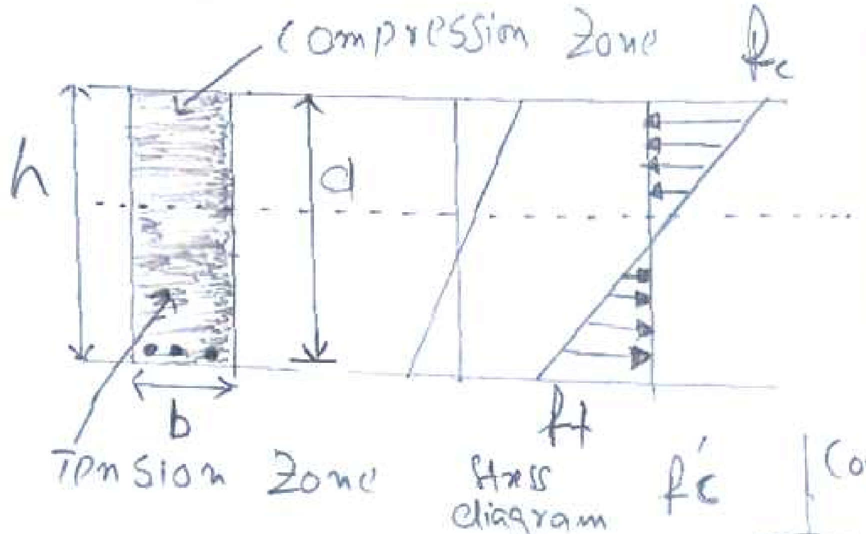
→ 2 Cracked concrete (tension zone) – Elastic Stage

→ With increase in load. concrete it cracks in tension but remains un-cracked in compression. Concrete in compression and steel in tension both behave in elastic manner.

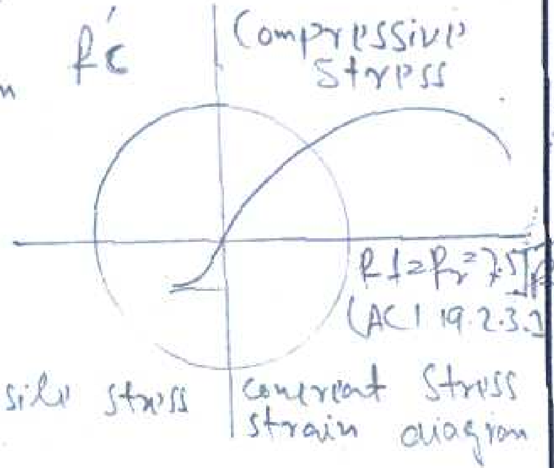
→ 3 Cracked concrete (tension zone) – Inelastic (ultimate strength) Stage.

→ Concrete is cracked in tension. Concrete in compression and steel in tension both enter into inelastic range. At collapse, steel yield and concrete in compression crushes.

Stage-1: Behavior

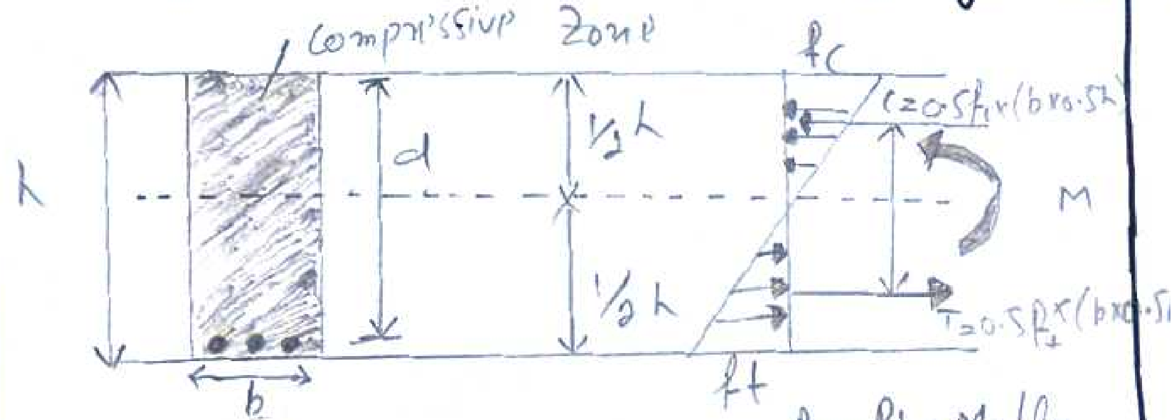


$f_t = f_r$
$M = M_{cr}$
$f_c = f_t < f'_c$



* This is a stage when concreat is at the verge of failure in Tension.

Stag-1: Calculation of forces:-



$C = T$; $f_c = f_t$

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

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

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

At $f_t = f_r$, where modulus of ...

OR

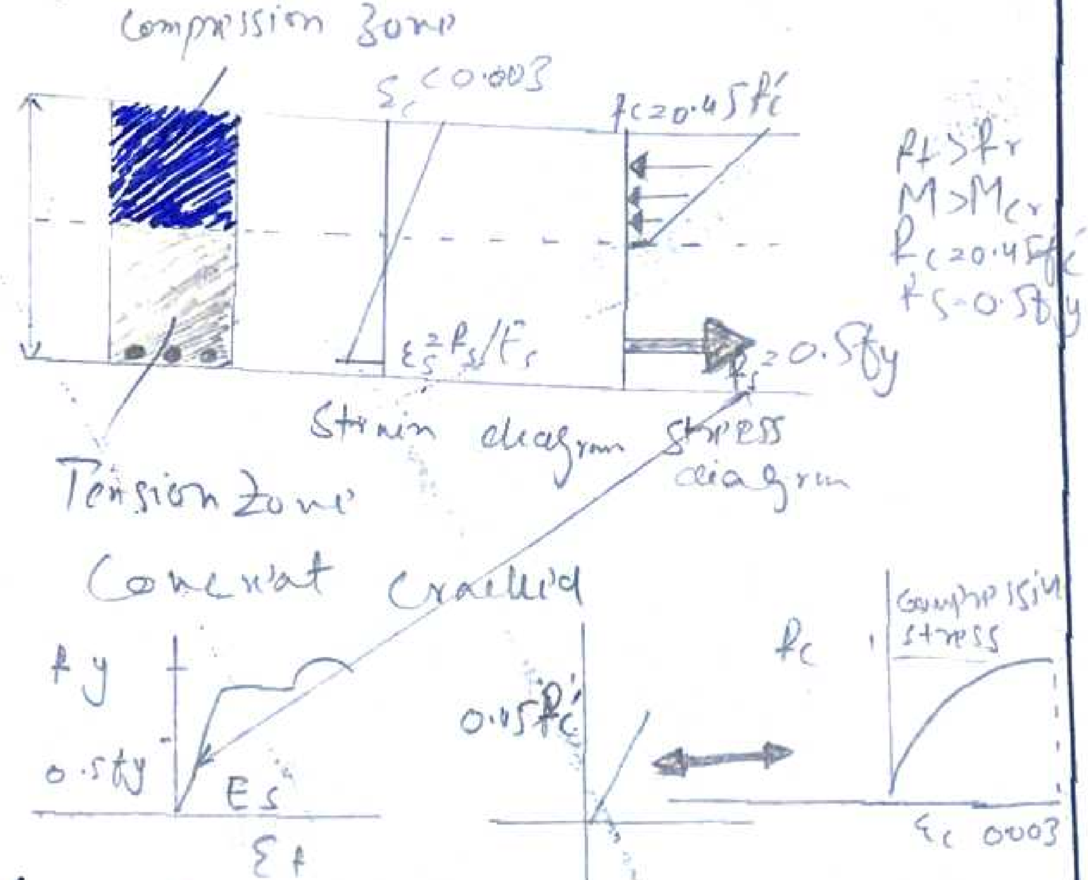
$f_c = f_t = Mc/I_g$

where $c = 0.5h$

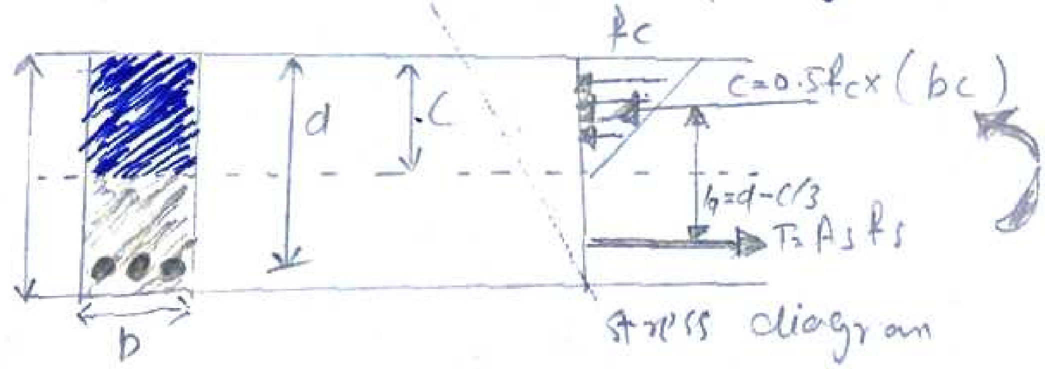
$I_g = bh^3/12$

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

Stage-2: Behavior



Stage-2: Calculation of Forces



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

$M = T l_a = A_s f_s (d - C/3)$

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

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

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

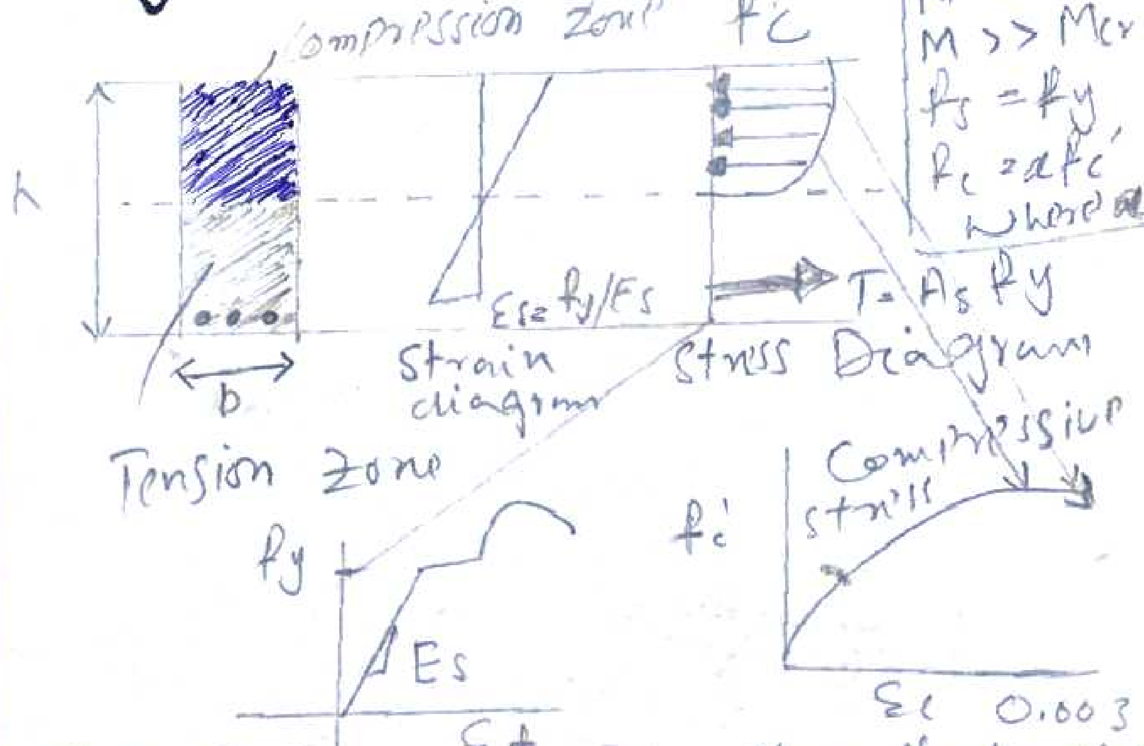
$C = 2 A_s f_s / f_c b$

$C = 2 A_s n / b$

where $f_s = n f_c$ & $n = E_s / E_c$ }

Stage 3: Behavior

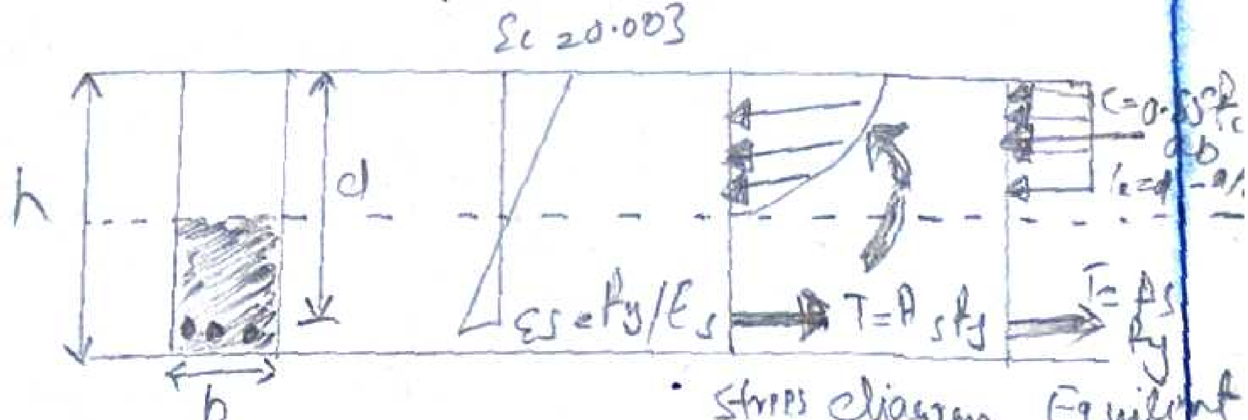
$f_t >> f_r$
$M >> M_{cr}$
$f_s = f_y$
$f_c = \alpha f_c'$ whereas



Stress Strain diagram for reinforcing Stee in Tension

Stress-Strain diagram for concrete in Compression

Stage 3: Calclation of forces



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

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

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

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

$0.85 f_c' ab = A_s f_y$

$a = A_s f_y / 0.85 f_c' b$

Basic Assumption (ACI 22.2)

→ A plane section before bending plane after bending.

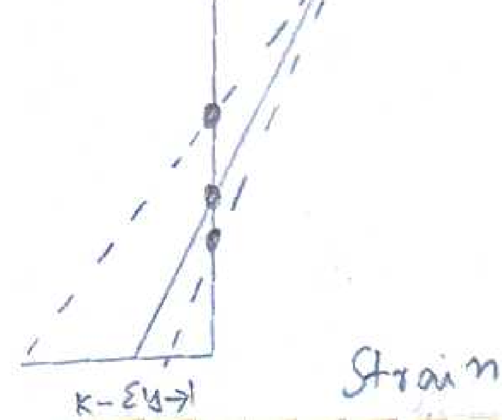
→ Stresses and strain are approximately proportional up to moderate loads (concrete ~~steel~~ stress $\leq 0.5f'_c$) when the load is increased the variation in the concrete stress is no loger linear.

→ Tensile strength of concrete is nelected in the design of reinforced concrete beams.

→ The bond between the steel and concrete is perfect and no slip occurs.

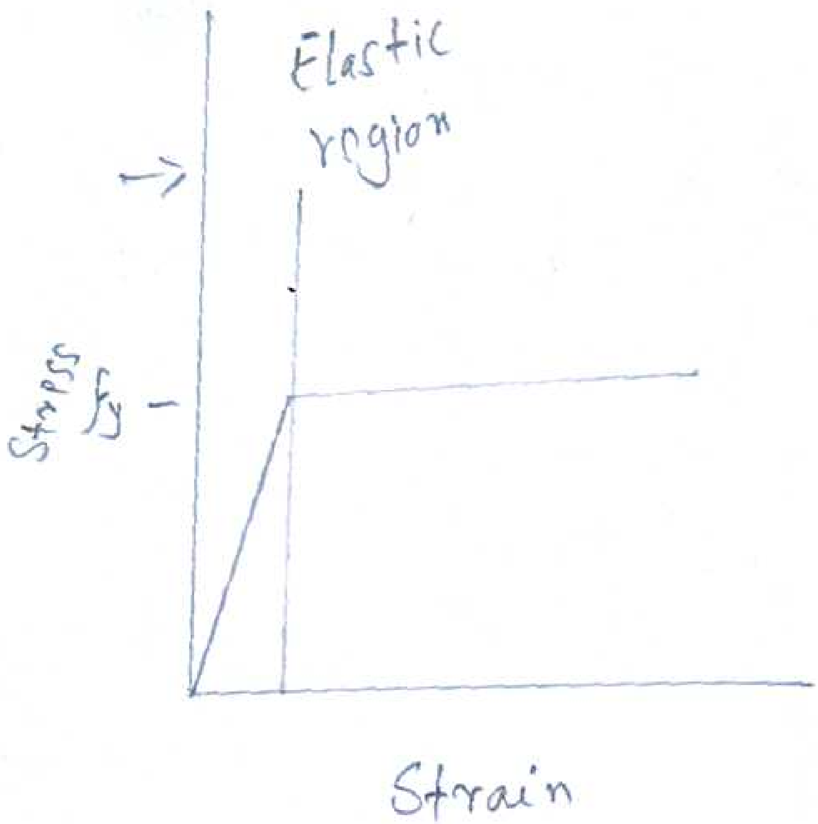
→ strain in concrete and reinforcement shall be assumed proportional to the distance from neutral axis.

→ The maximum usable concrete compressive strain at the extreme fiber is assumed to be 0.003.



→ Basic Assumptions: (ACI 22.2)

→ The steel is assumed to be uniformly strained 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 than the yield 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 stress in Steel will be equal to f_y



Idealized Stress-Strain Curve

Q2 **Solution:**

Step ① Calculate of $\phi M_{n max}$ (Singly)

ρ_{max} (Singly) = 0.0203

$A_{s max}$ (Singly) = ρ_{max} (Singly) bd = 4.87 in^2

$\phi M_{x max}$ (Singly) = 2948.88 in-kip

Step ②: moment to be carried by compression steel

$M_u = M_u - \phi$ (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,

$$\varepsilon_s' = (0.003 - 0.008\, d'/d) \text{ ---- } (1)$$

$$\varepsilon_s' = (0.003 - 0.008 \times 2.5/20) =$$

$$0.002 > \varepsilon_y = 40/2900$$

$$= 0.00137$$

As ε_s' is greater than ε_y. So

The compression still win yield

Solution:-

Step (4) calculation of A_s' and A_{ST}

$$A_s' = \frac{M_{u\,(extra)}}{\{\phi f'(d-d')\}} = 1551.12/\{0.90 \times 40 \times (20-2.5)\}$$

$$= 2.46\ in^2$$

* Total amount of tension reinforcement (A_{ST}) is $A_{ST} = A_{s max}$ (singly) $+ A_s' = 4.87 + 2.46 = 7.33 in^2$
* Using # 8 bar, with bar area $A_b = 0.79 in$

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

· Solution :

Step (5):

Ensure that $d_1 / d < 0.2$ (for grade 40) so thant 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

$d = 19.625$ & $d' = 2.375$

$d'/d = 2.375/19.625 = 0.12 < 0.2$ OK

Solution

Step ⑥

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 $A_{st,max}$

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

* $A_{st\,max}$ (singly) is a fixed number for the case under consideration & A_s' is steel area actually ... compression side.

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

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

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

Therefor $A_{st} = 7.9\ in^2 < A_{stmax}$ ok.

Solution

Step (7) Drafting.

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