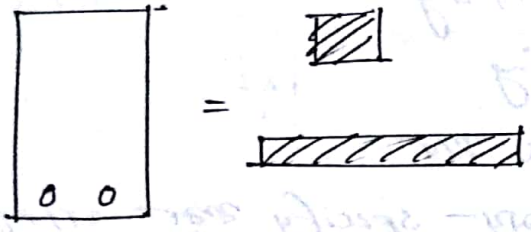
Lec-1

Date – 02.04.18

CE-415.

Sekender Ali

Why Prestressed concrete ?



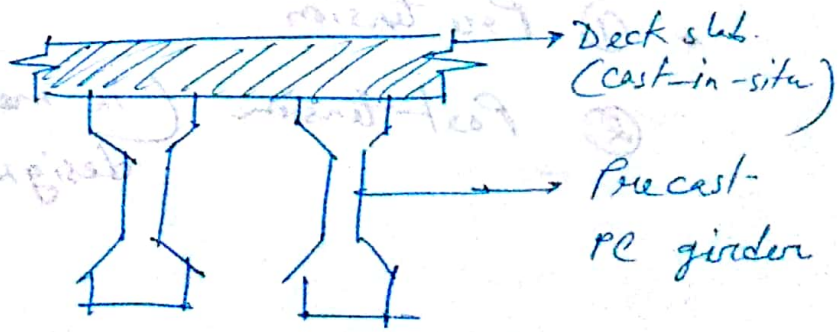
* Long span → RC → ব্যবহার করা যায় But depth বেড়ে যায়। এই কারণে Navigation → problem হতে পারে।

Design :

(1) Preliminary design
(2) final Design.

* Design করার ক্ষেত্রে Flexural strength দেখতে হবে.
  → how to ~~calculate~~ calculate $M_u \geq \phi M_n$.
  (RCC-তে যেভাবে)

* flexural strength বের করতে composite section properties দেখতে হবে.



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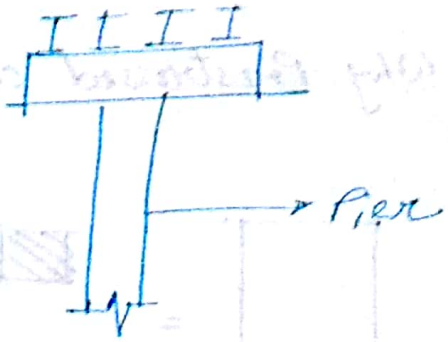
* PC girder cantilever করা, তাহলে করা difficult তার precast নাকি হতে পারে।

* At the end of the day u have to consider cost.

* 2 point lifting, 3 point lifting or single point lifting করলে handling stress হবে তার precast এর time specify করা লাগবে হবে।

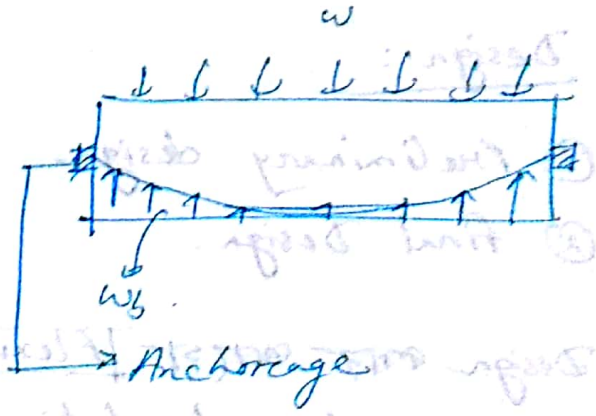


* PC girder এ shear তেমন effect করে না।

w_b → balancing load

$$w_b = w$$

$$f = \frac{F}{A}$$



* shear এর জন্য reinforcement লাগেনা But min^m reinforcement লাগবে temp shrinkage এর জন্য।

* ① Pre tension
② Post-tension (in most cases u have to design anchorage system)

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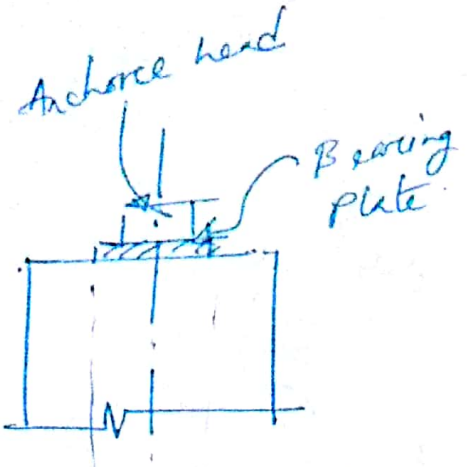
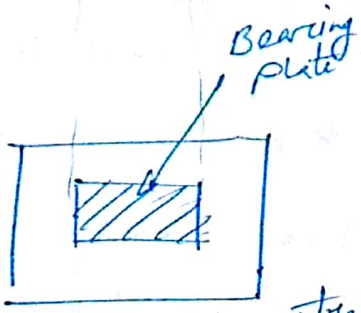
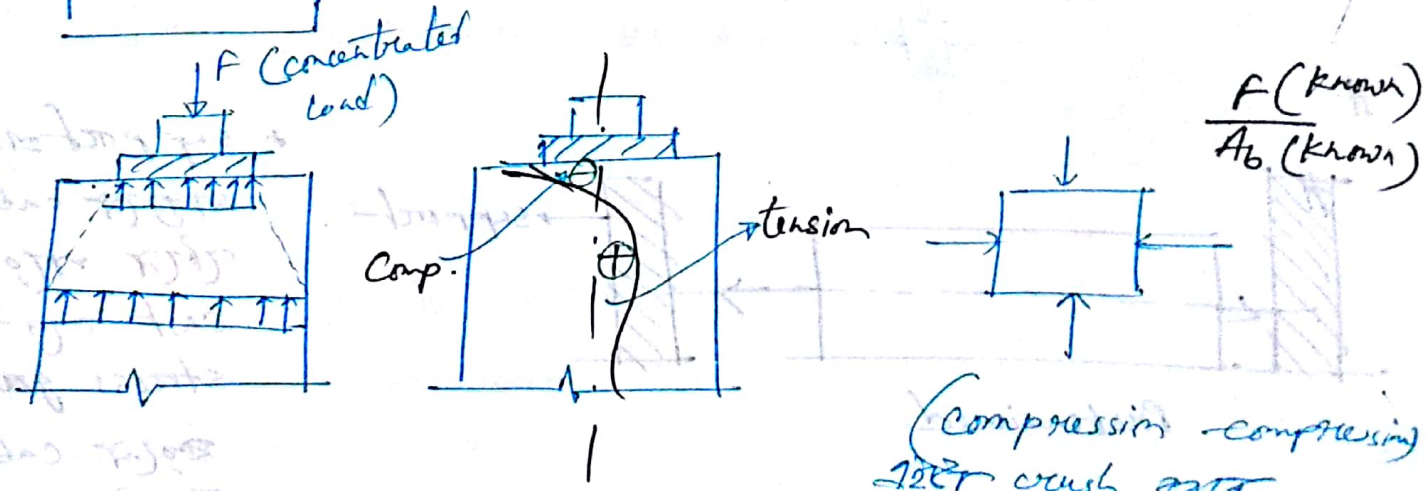


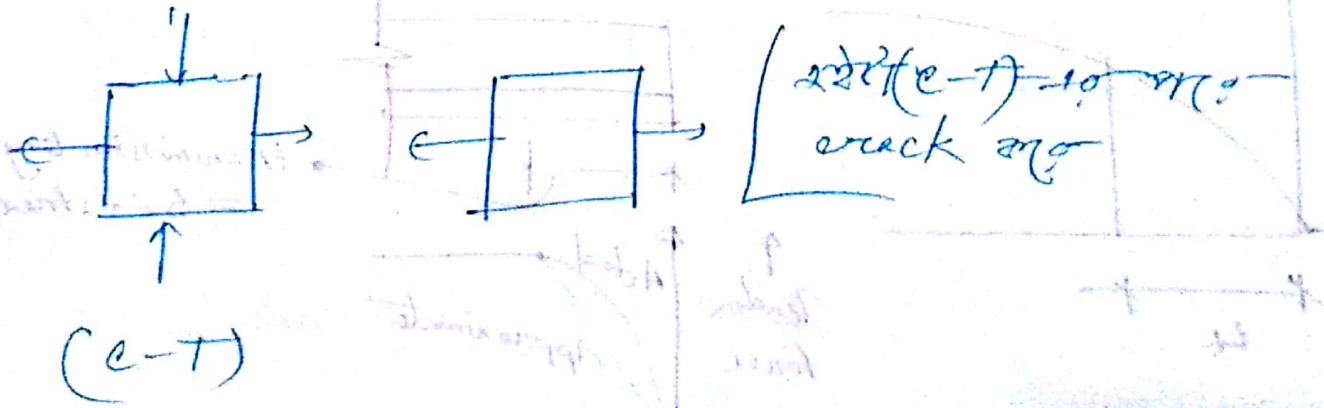
* Post tensioning এ কোন most of the load is transferred through bearing → Bearing plate
* Bearing plate এর thickness, dimension কত হবে।



* A huge stress is transferred through a small area → B.P.



* Bearing plate যত end এ pressure এর → strength তত বেশি হয় concrete এর।
* Concrete cube এ flatening effect এর জন্য → strength বাড়ে।



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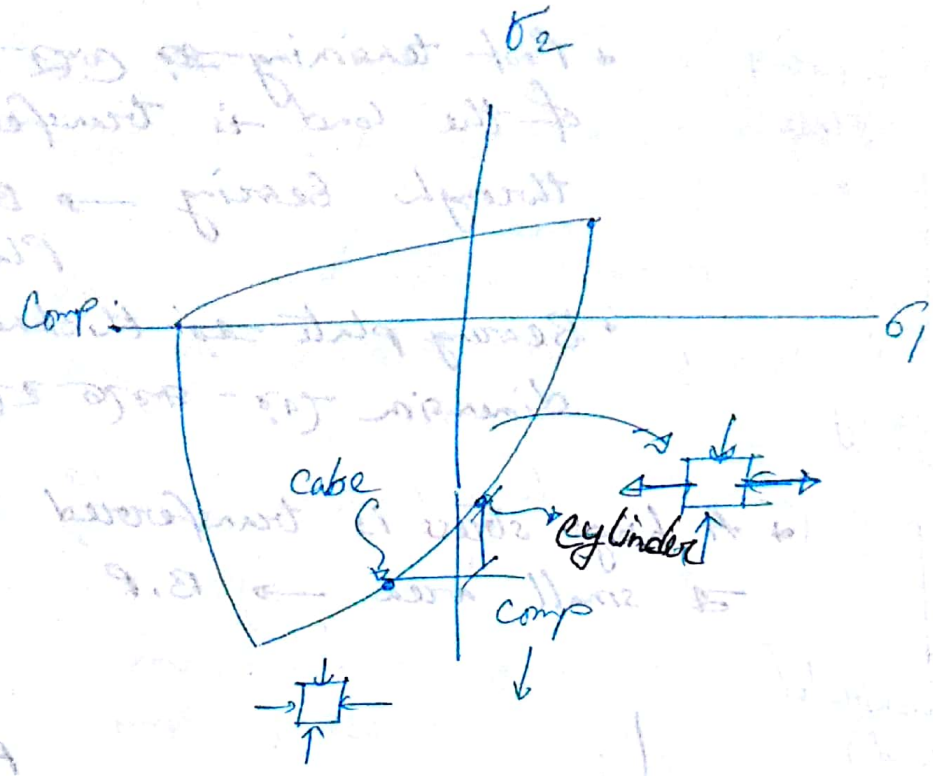

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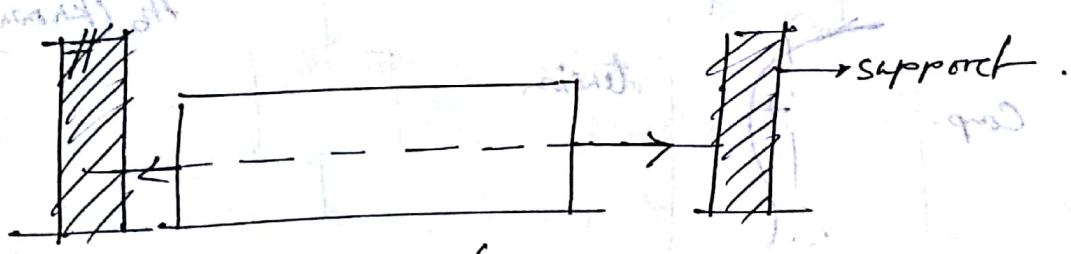
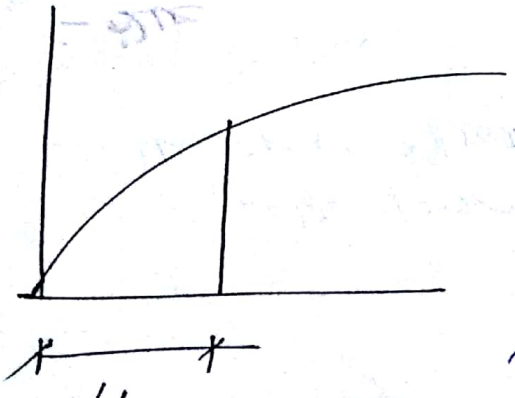
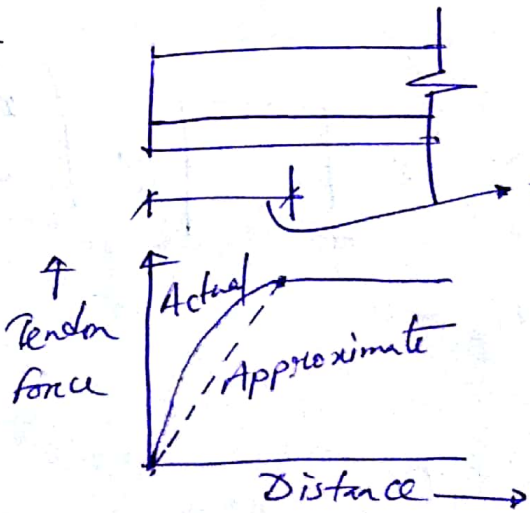


* support-এর সাহায্যে cable-কে টেনে পরে conc. cast করে stress gain করলে cable যেভাবে থাকে।

* End-এ transfer হয়ে bonding between concrete and tendon.

* transfered bond





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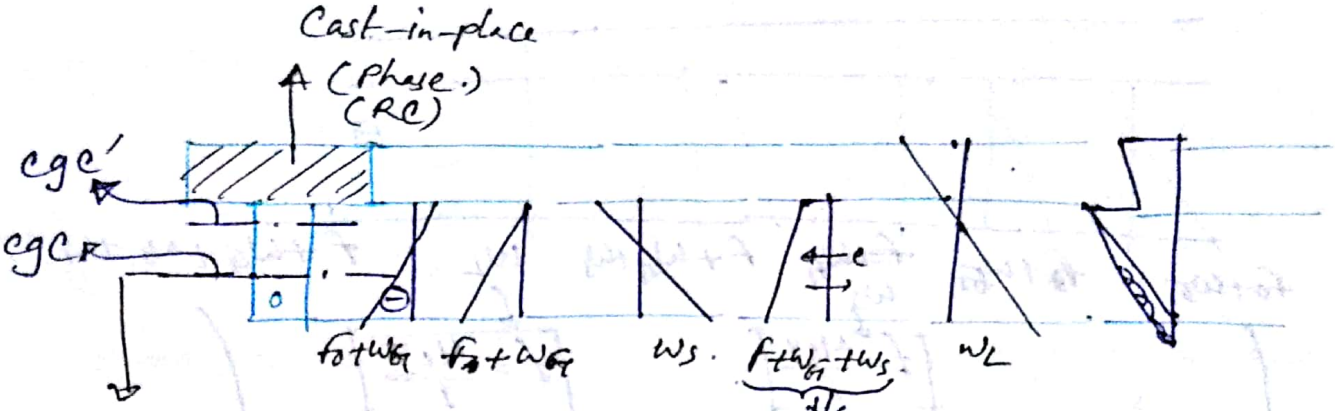
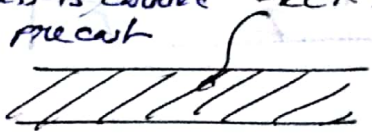
Lec – 2.

Date – 07.04.18



Precast → normally post-tensioned
stem. But pre tensioned ও হতে পারে

এখানে composite হয়েছে
–OR– full portion of
stress is carried by precast

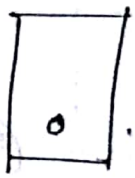


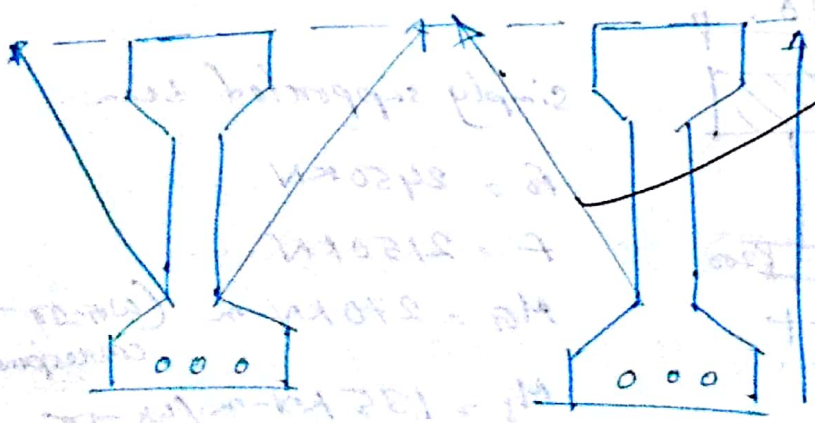
f_0 → prestress at transfer.
($f_0 \approx 0.9f_i$)

W_G → Due to girder self wt

f → Effective prestress.

W_S → Due to slab wt





এভাবে পেনা দিলে - shear strength বাড়বে,

from river bed

W_L → stress due to live load

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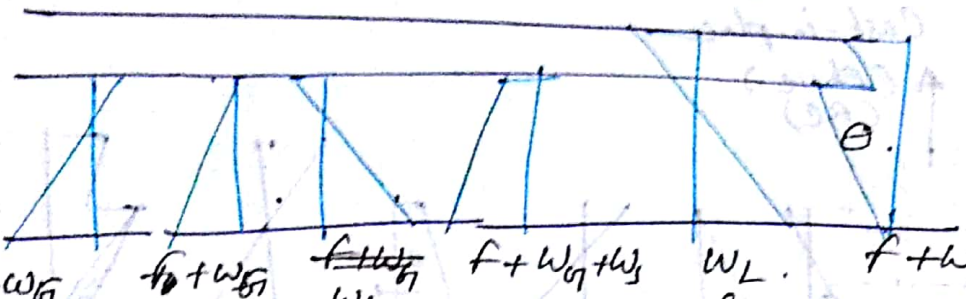
* After certain strength is gained it will be open for traffic (composite হওয়ার পর এই WL)

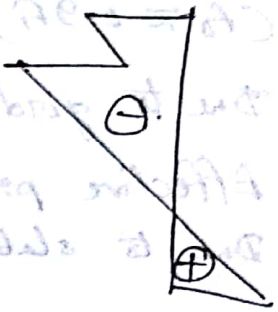


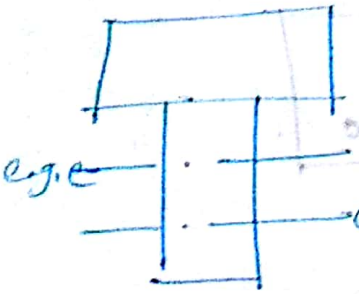
$$f = \frac{M_s y}{I}$$

$$f = \frac{M_c y}{I}$$

$$f = \frac{f_o}{A} + \frac{f_G e y}{I} \pm \frac{M_c y}{I}$$

or.

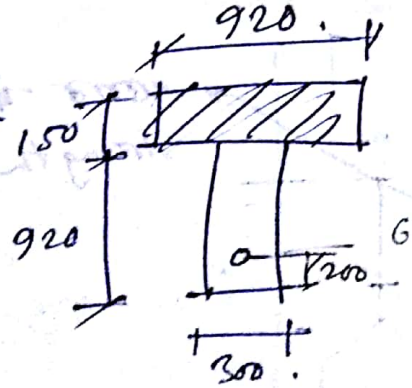




(composite এর cg)

(precast এর cg)

Problem:



simply supported beam

f_o = 2450 KN.

f = 2150 KN.

M_G = 270 KN.m (WG এর corresponding)

M_s = 135 KN-m. (Ws এর corresponding)

M_L = 750 KN-m

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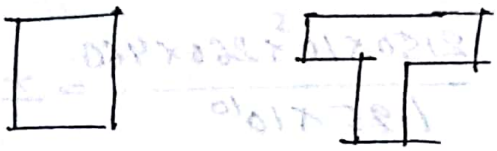
$A_{ps} = 2400\ mm^2$.

$f_{pu} = 1650\ MPa$.

$f_c' = 34\ MPa$.

compute ultimate moment, $M_u = ?$

$\Rightarrow$



$A(mm^2)$	2.76×10^5.	4.14×10^5.
$I(mm^4)$	1.95×10^{10}	9.62×10^{10}

$$f = \frac{F}{A} \pm \frac{Fey}{I} \pm \frac{My}{I} \rightarrow M_G / M_S / M_L .$$

$$= \frac{F}{A} \pm \left(\frac{M - Fe}{I}\right) y .$$

① $$f = \frac{F_o}{A} \pm \frac{F_o e y}{I} \pm \frac{M_G y}{I} . \rightarrow \text{precast.}$$

$e = 460 - 200 \left(\frac{920}{2}\right)$.

$= 260$.

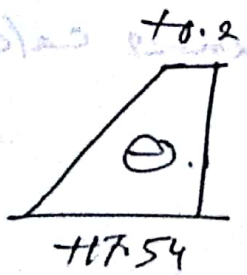
$$= \frac{2450 \times 10^3}{2.76 \times 10^5} \pm \frac{2450 \times 10^3 \times 260 \times 460}{1.95 \times 10^{10}} \pm \frac{270 \times 10^6 \times 460}{1.95 \times 10^{10}}$$

$$= \cdot -8.88 \pm 15.03 \pm 6.37 .$$

comp $\rightarrow$ (-ve)
tension $\rightarrow$ (+ve) .

$f_{bot} = -8.88 - 15.03 + 6.37 = -17.54\ MPa$

$f_{top} = -8.88 + 15.03 - 6.37 = -0.22\ MPa$



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$\frac{8.88 \times 2150}{2450}$ → চাইলে এভাবে কেও করা যায়।

Just $\frac{My}{I}$ portion এই-এটাই

তাহলে,

$$f = -\frac{2150\times10^3}{2.76\times10^5} \pm \frac{2150\times10^3\times260\times460}{1.95\times10^{10}} \pm \frac{270\times10^6\times460}{1.95\times10^{10}}$$

(composite).

$f_{bot} = -14.61 MPa$

$f_{top} = +.97 MPa$

$$f_{sab} = \frac{135\times10^6\times460}{1.95\times10^{10}}$$

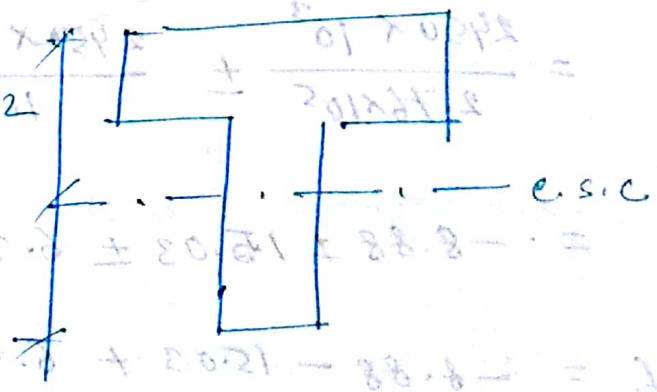
[top → comp.
bottom → tension

$f + f_{sab}$ → composite section.

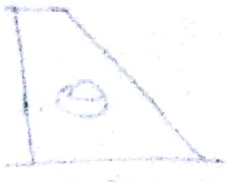
$M_L \rightarrow f = 705\times10^6 \times c$

$$f_b = \frac{705\times10^6\times c_b}{I(=4.62\times10^6)}$$ $c_b = 638$

$$f_t = \frac{705\times10^6\times c_t}{I(=4.62\times10^6)}$$ $c_t = 432$



* composite section হওয়াতে যখন load বারের ওপর এই portion এ থাকবে (exam এ calculate করতে হতে পারে)



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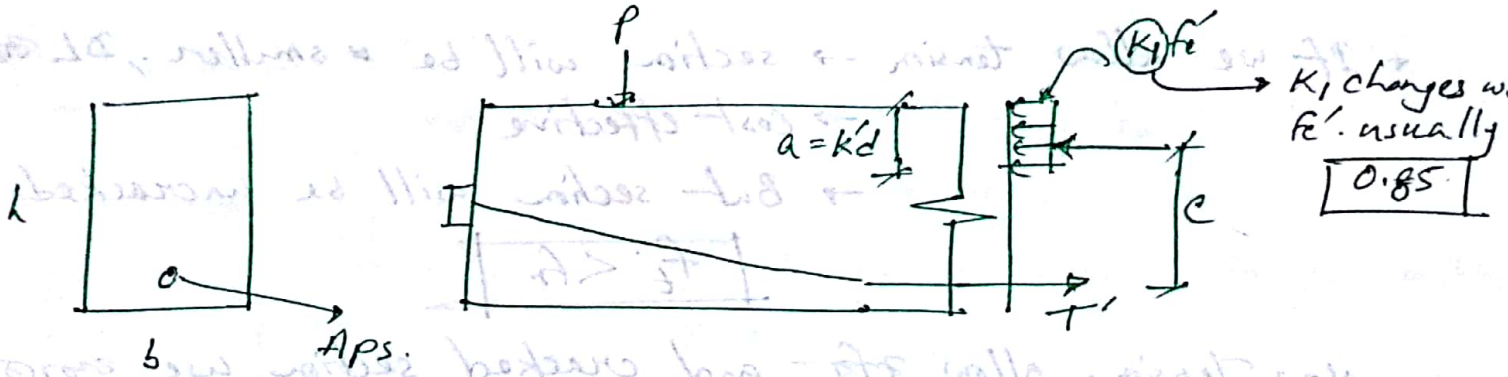
Lec – 3.

Date – 16.04.18

$$M_u = \phi M_n$$

$$f = \frac{F}{A} \pm \frac{f_{ey}}{I} \pm \frac{M_y}{I}$$

How to calculate M_u :



$T' = A_{ps} f_{ps}$. [f_{ps} → not yield strength

high strength steel

high " concrete

Ref : Design of prestressed concrete structure. (T. Y. Lin)

$$\Rightarrow f_{ps} = f_{pu}\left(1 - 0.5 \rho_p \frac{f_{pu}}{f_c'}\right)$$ valid only when $f_{se} > 0.5 f_{pu}$

$$\Rightarrow \rho = \frac{A_{ps}}{bd}.$$

$$\Rightarrow \omega_p = \frac{\rho_p \times f_{ps}}{f_c'} \leq 0.30$$ [সর্বদা satisfy করবে or yield region এ থাকবে]

f_{se} → Effective prestress
= Initial prestress – Loss of prestress.

ω_p → reinforcement Index

fy we নয়তে পারি.

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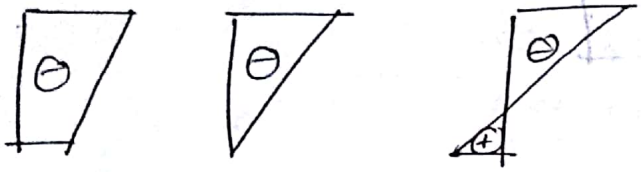
fully prestressed. (কোনো tension allow করা হয় না)

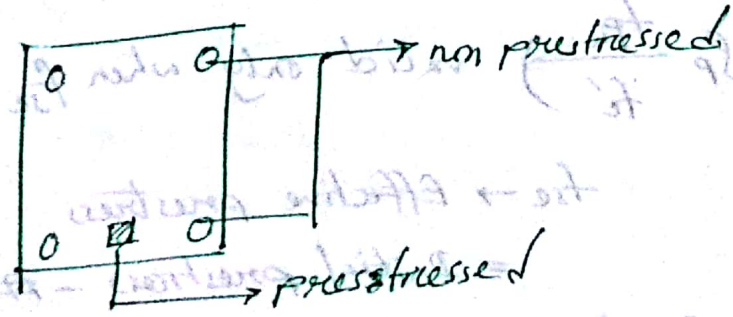
$$f = -\frac{F}{A} \pm \frac{Fey}{I} \pm \frac{My}{I}.$$



কোনোটায় কিছু tension allow করা হচ্ছে না, fully compression.

* If we allow tension → section will be smaller, DL কম
  → cost effective
  → But section will be uncracked
  $f_t < f_r$

* Now tension allow করি — and cracked section use করতে পারি। $f_t > f_r$
  → section crack করলে load will be transferred to non-prestressed steel.



for non-prestressed.

$$\omega + \omega_p - \omega' \leq 0.3$$

$$\omega = \frac{\rho f_y}{f_c'}, \quad \omega' = \frac{\rho' f_y}{f_c'}$$

$$\rho = \frac{A_s}{bd}, \quad \rho' = \frac{A_s'}{bd}.$$

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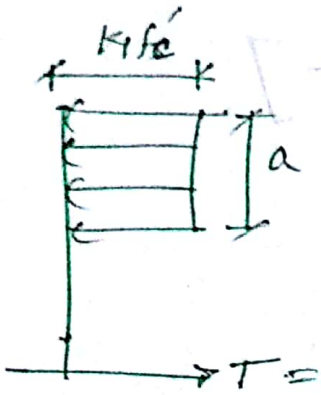
$M_n = A_{ps} f_{ps} \left(d - \frac{a}{2}\right)$ [ACI-ASCE]



$\Sigma H = 0$.

$A_{ps} f_{ps} = k_1 f_c' a b$.

$\Rightarrow (a) = \frac{A_{ps} f_{ps}}{0.85 f_c' b}$.

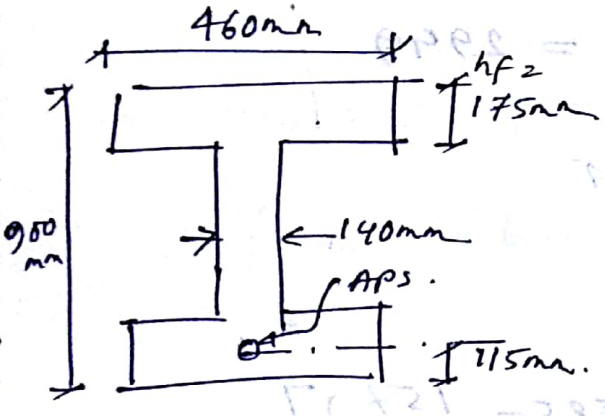
$\rho_p = \frac{A_{ps}}{bd}$

$\Rightarrow (A_{ps}) = \rho_p b d$

#Problem: $A_{ps} = 1750 mm^2$; $f_{se} = 1100 psi$, $f_{pu} = 1860 MPa$

$f_c' = 48 MPa$

Ultimate resisting moment for the section of design. = ?



$\Rightarrow M_u = \phi M_n$. [$\phi = 0.9$].

$= \phi \left[A_s f_{ps} \left(d - \frac{a}{2}\right)\right]$. —(i)

$\rho_p = \frac{A_{ps}}{bd} = \frac{1750}{460 \times 785} = 0.00485$.

$d = 900 - 115 = 785 mm$

Let, $a \leq h_f$ [Comp. will be within the flange]

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$f_{se} = 1100 psi > 0.5 f_{pu} = 0.5 \times 1860$.

$\therefore f_{ps} = 1860 \left[1 - 0.5 \times 0.00485 \times \frac{1860}{48}\right]$..

$= 1685 MPa$

Now, $\omega_p = \frac{0.00485 \times 1685}{48} = 0.17 < 0.3$.

$\therefore a = \frac{A_{ps} \times f_{ps}}{0.85 f'_c b} = \frac{1750 \times 1685}{0.85 \times 48 \times 460} = 157mm < 175$

সহজ-সূত্র $\Rightarrow C' = 0.85 f'_c \times 18 \times a = 2949$.

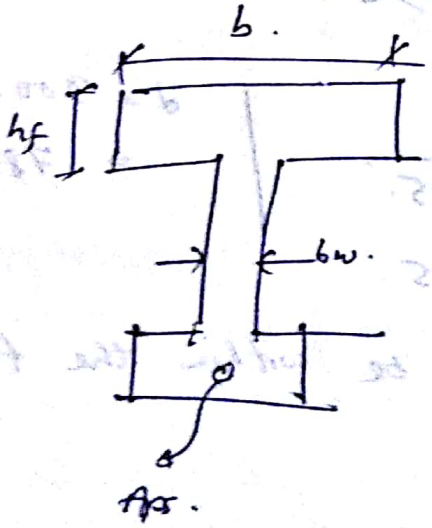
460 মিমি

so assumption is correct.

(i) $\Rightarrow M_u = 0.9 \times \left[1750 \times 1685 \times \left(785 - \frac{157}{2}\right)\right]$

=

#T-beam :



$\& a > h_f \Rightarrow$ T-section.

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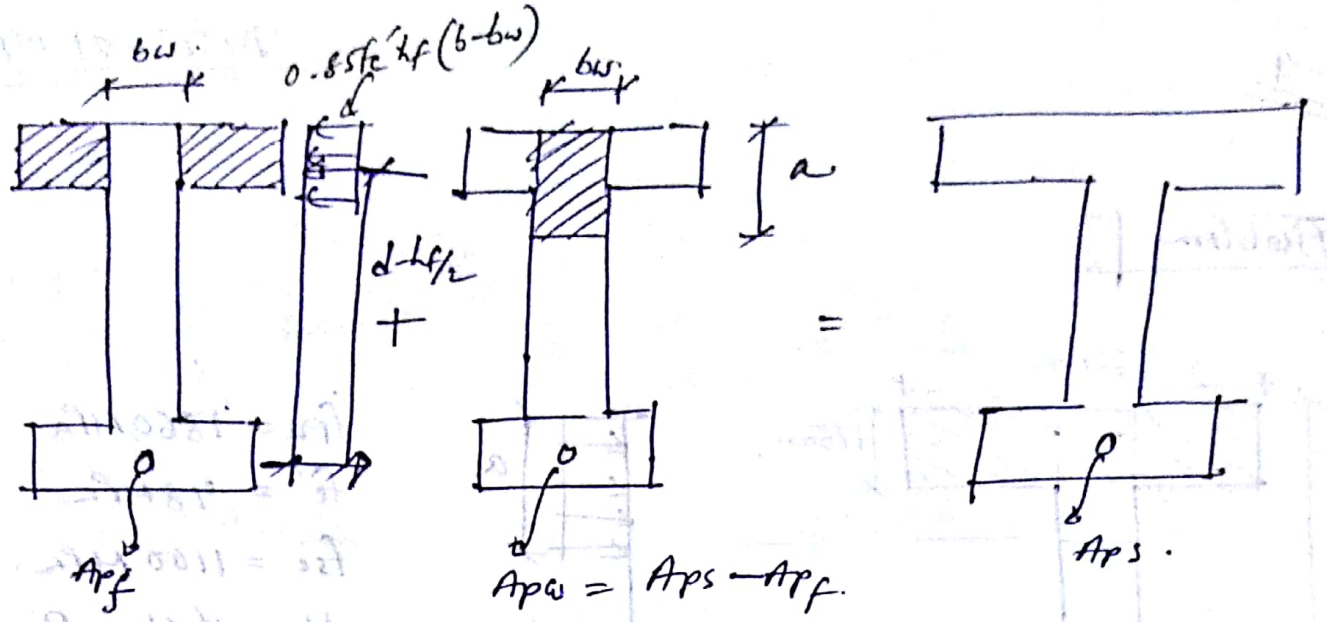

flange part - (Mnp)

web part (Mn2)

$$M_u = \phi M_n = \phi (M_{n1} + M_{n2})$$

$$= \phi \left[0.85 f_c' (b - b_w) h_f (d - h_f/2) + A_{pw} f_{ps} (d - a/2) \right].$$

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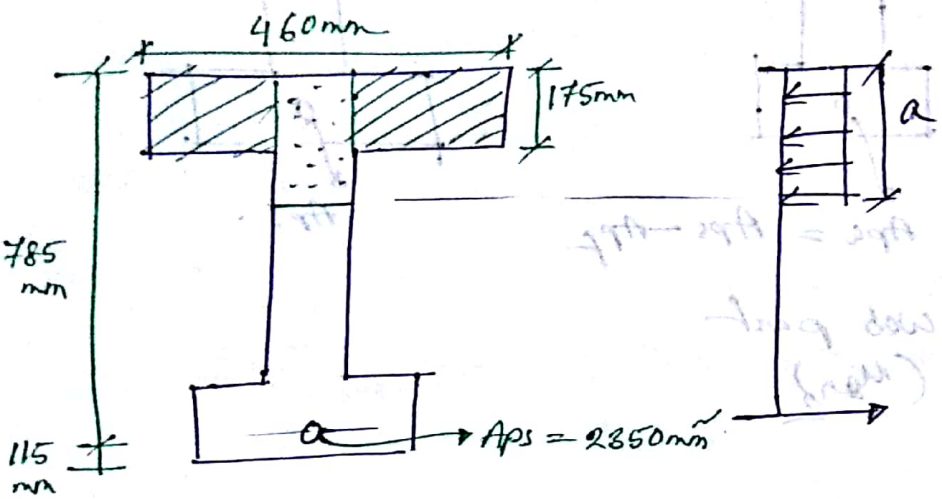
Date - 21.04.18

Lec-4

Problem



$f_{pu} = 1860 MPa$

$f_c' = 48 MPa$

$f_{se} = 1100 MPa$

$M_u = \phi M_n = ?$

$$\Rightarrow \rho_p = \frac{A_s}{bd} = \frac{2350}{460 \times 785} = 0.00651$$

$$f_{ps} = 1860 \left[1 - 0.5 \times 0.00651 \times \frac{1860}{48}\right] = 1625 MPa$$

$$M_u = \phi \underbrace{\left[0.85 f_c' (b - b_w) h_f (d - h_f/2)\right]}_{M_{n1}}$$

$$A_{ps} = A_{pf} + (A_{ps} - A_{pf})$$

If rectangular section $\rightarrow a \leq h_f$

$$\Rightarrow 0.85 f_c' \times ab = A_{ps} \times f_{ps}$$

$$\Rightarrow a = \frac{A_{ps} \times f_{ps}}{0.85 f_c' b} = \frac{2350 \times 1625}{0.85 \times 48 \times 460}$$

$$= 203.47 mm < h_f \ (= 175 mm)$$

so T-beam section

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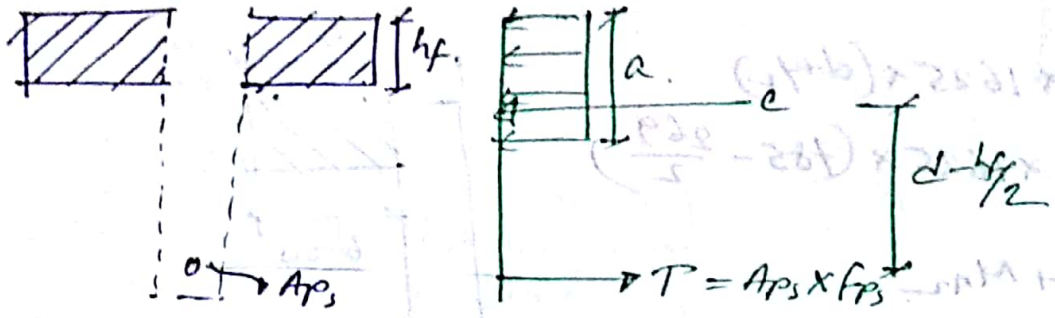
1st part



$$M_{n1} = 0.85 f_c'(b-b_w)\cdot h_f\,(d-h_f/2)$$

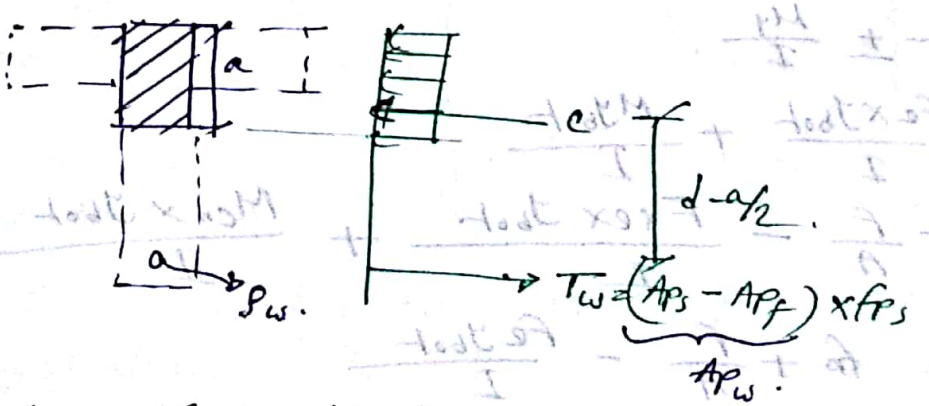
$$= 0.85 \times 48 \times (460-140) \times 175 \times \left(785-\frac{175}{2}\right)$$

$$=$$

Again, $0.85 f_c'(b-b_w) \times h_f = A_{pf} \times f_{ps}$. [$T = C$].

$$\rightarrow A_{pf} = \frac{0.85 \times 48 \times (460-140) \times 175}{1625} = 1406\ mm^2.$$

2nd part:



$$A_{pw} = 2350 - 1406$$

$$= 944\ mm^2.$$

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Now, $\Sigma H = 0 \Rightarrow 0.85 f_c' \times b_w \times a = A_{ps} \times f_{ps}$.

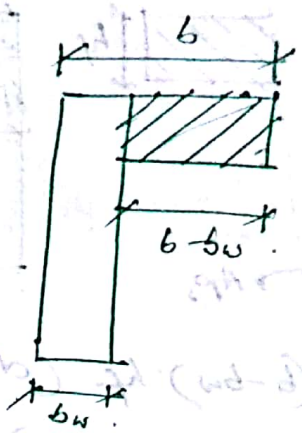
$$\Rightarrow a = \frac{944 \times 1625}{0.85 \times 48 \times 140} = 269 \text{ mm}$$

$$M_{n_2} = 944 \times 1625 \times (d - a/2)$$

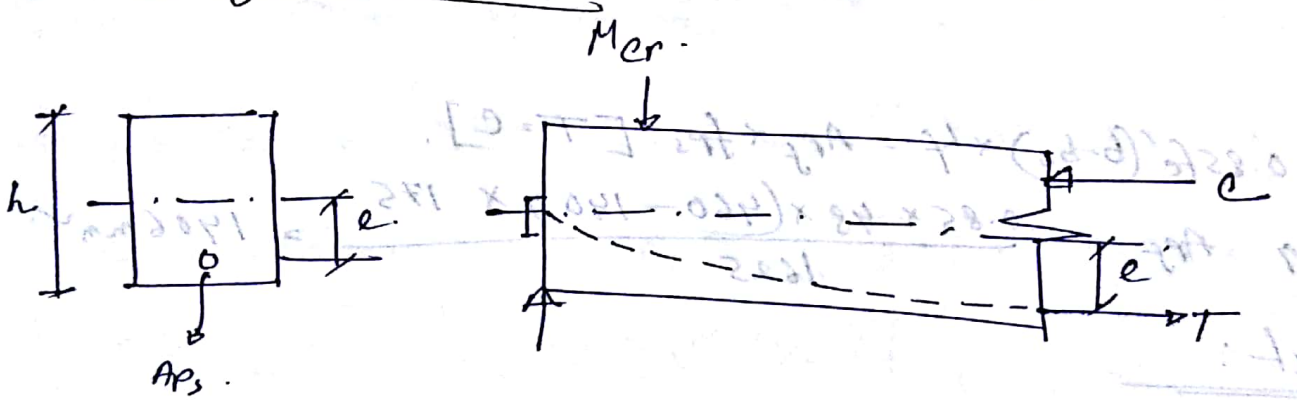
$$= 944 \times 1625 \times \left(785 - \frac{269}{2}\right)$$

$$M_n = M_{n_1} + M_{n_2}$$

$$M_u = 0.9 \times M_n$$



Cracking moment = ?



$$f_c = -\frac{F}{A} \pm \frac{F e y}{I} \pm \frac{M y}{I}$$

$$f_{bot} = -\frac{F}{A} - \frac{F e y_{bot}}{I} + \frac{M y_{bot}}{I}$$

$$\Rightarrow f_{bot} = f_n = -\frac{F}{A} - \frac{F \times e \times y_{bot}}{I} + \frac{M_{cr} \times y_{bot}}{I}$$

$$\Rightarrow \frac{M_{cr} \times y_{bot}}{I} = f_n + \frac{F}{A} - \frac{F e y_{bot}}{I}$$

$$\Rightarrow \frac{M_{cr} \times e}{I} = f_n + \frac{F}{A} - \frac{F e c}{I}$$

$$\Rightarrow M_{cr} = \frac{I}{c}\left[f_n + \frac{F}{A} - \frac{F e c}{I}\right]$$

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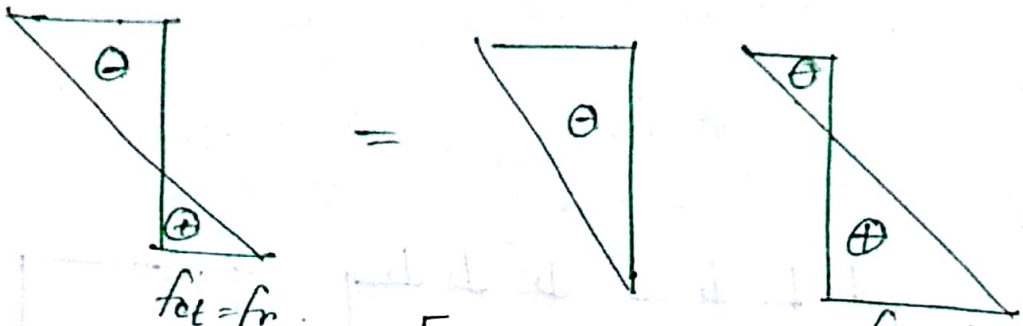
#



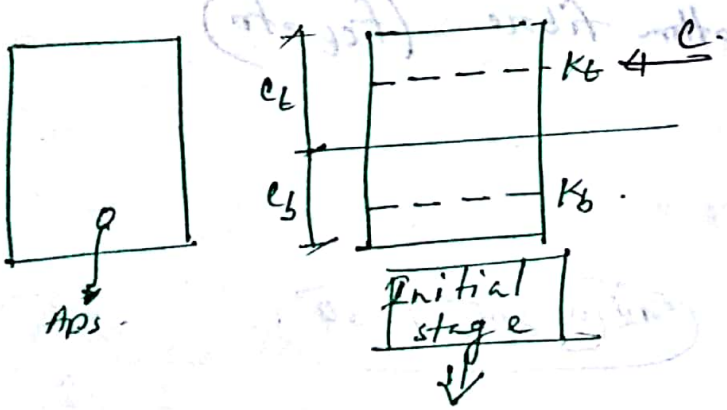
$f_{ct} = f_r$.

$f_{ct} = f_r$.

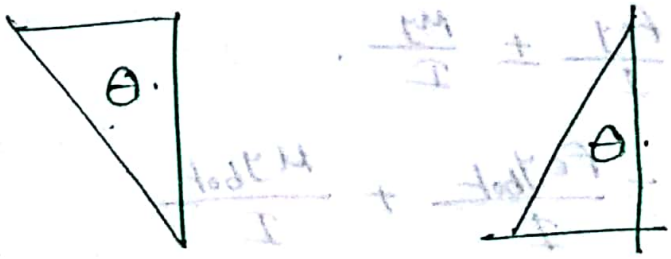
[Modulus of rupture = f_r corresponding moment = cracking]

[Compression @ top kern point]

$$M_{cr} = f_r \times I/c + P/c \left[\frac{f}{A} - \frac{f_{ec}}{I}\right].$$



2124T location of comp. @ top kern point then 2nd type stress distribution



location of comp. @ bottom kern point

* CTR- kern point-a comp. ಆಗಿ opposite kern point will experience zero stress.

* $k_t = \frac{r^2}{c_b}$, $r = \sqrt{\frac{I}{A}}$.

* $k_b = \frac{r^2}{c_t}$.

1st crack moment @ any point.

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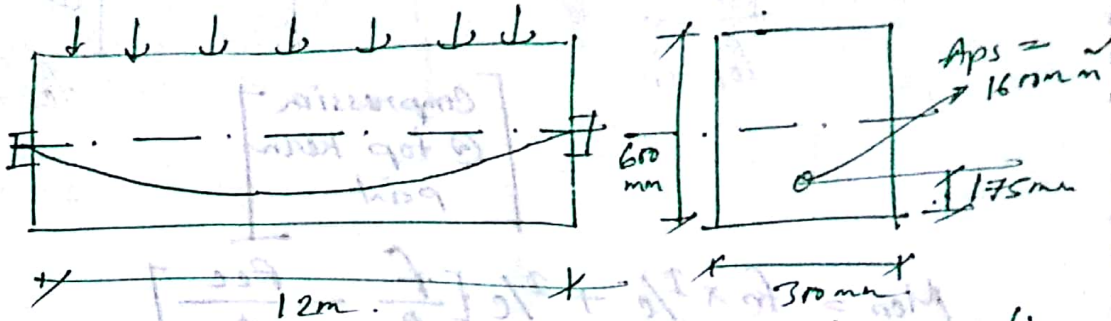
Lec-5

Date – 23.04.18

PP-146

Ex-5.7

$f_t = 4.2 MPa$



① zero tensile stress in the bottom fibre

② for cracking in the bottom fibre ($f_{ct} = f_r$)

$\Rightarrow f = 1600 \times 820 = 1312 kN.$ (বাস্তবে দুর্ন 1350)

$$f = -\frac{F}{A} \pm \frac{Fey}{I} \pm \frac{My}{I}.$$

$$f_{bot} = -\frac{F}{A} - \frac{Fey_{bot}}{I} + \frac{My_{bot}}{I}.$$

① $\Rightarrow 0 = -\frac{F}{A} - \frac{Fey_{bot}}{I} + \frac{My_{bot}}{I}.$

$\Rightarrow M = ?$

Again, for midspan, $M = \frac{wL^2}{8}$.

$\Rightarrow w =$

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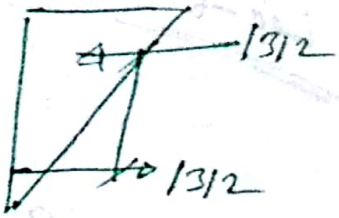
② ⇒ $4.2 = -\frac{f}{A} - \frac{f e y_{bot}}{I} + \frac{M y_{bot}}{I}$

$= -\frac{1312}{600\times300} - \frac{1312\times10^3\times125\times300}{-\quad-} + - -$



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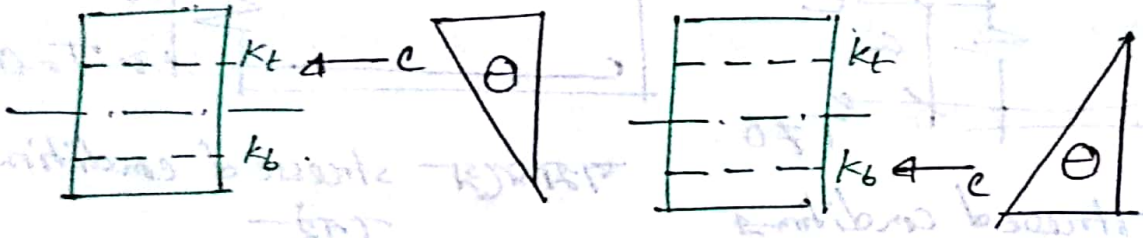
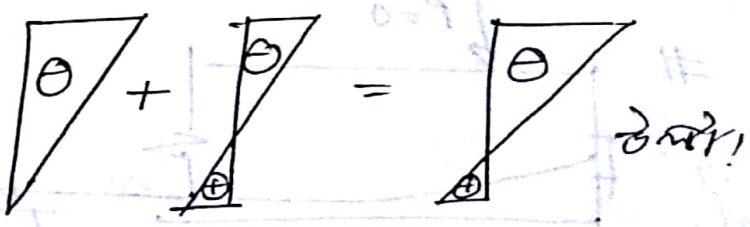


or, $M_1 = f(e+k_t)$

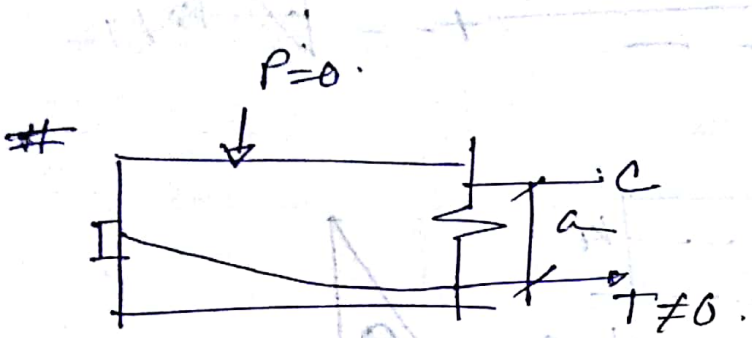


হলো।

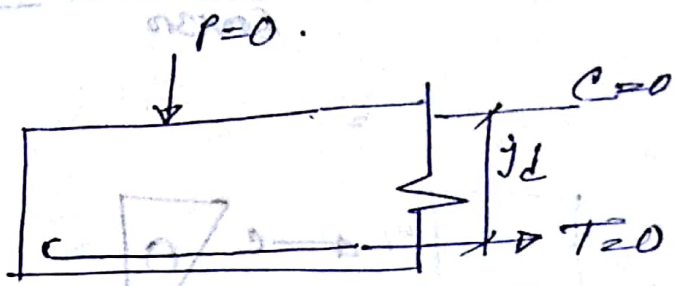
$\frac{fr\ I}{c}$ ⇒ last part.

Date – 05.05.18

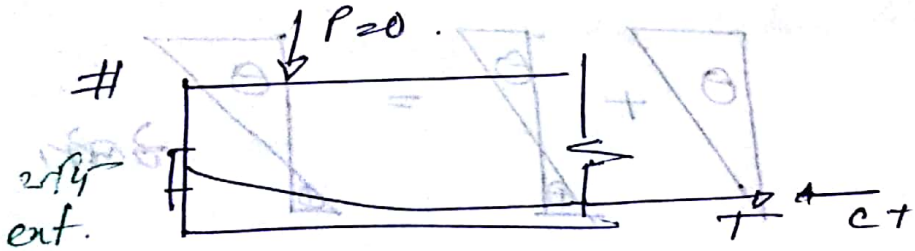
Lec-6.



এখানে stressed condition



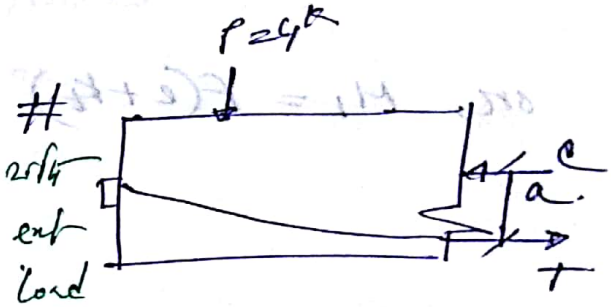
এখানে stressed condition নেই.



এখানে ext. load না থাকে. $M = 0$.

$M = Ca = Ta = 0$.

$C = T \neq 0$.



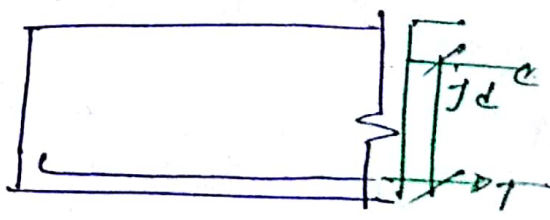
এখানে ext. load থাকে.

$M = Ca = Ta$.

* location of C will be changed with the change of load. (Lever arm change)

$M = C j d$ (fc)

$= a T j d$ (fs) ⇐



* load change হলে strain change হবে কারণ r. jd almost same, C & T change হয়।

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#Diff. between prestressed concrete & RC

① PC initially stressed condition-এ, RC initially stressed না।

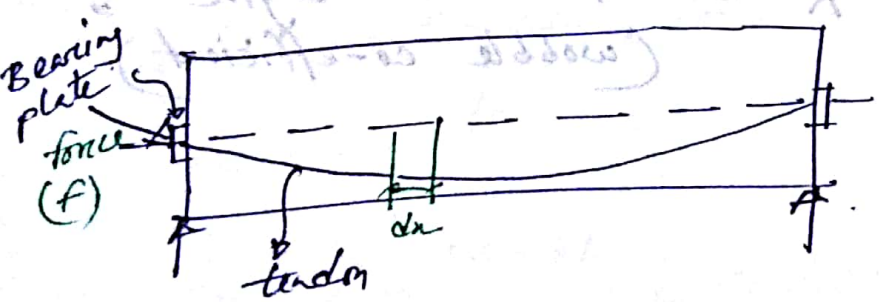
② PC-তে with the ↑ of load. Localin of force (=C) or lever arm changes. But in RC. with the ↑ of load. stress for concrete & steel change

Load & Prestress:

$F_{eff} = f_i \cdot$ (~~—~~) loss.

* after achorage → initial prestress.
* Jacking force < $0.8 f_{pu}$ → initial prestress.

Frictional Loss:



+ During achoring there will be some loss → negligible calculate করা difficult.
+ সর্বদা slip করে থাকবে (কম-বেশি সমস্যা)
+ friction through the sapan is important.

sheath → সাধারণ (যে pipe-এর ভিতর-দিয়ে tendon যে সমস্যা)

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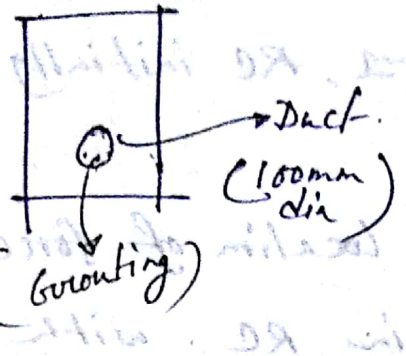
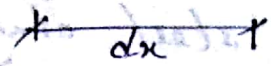


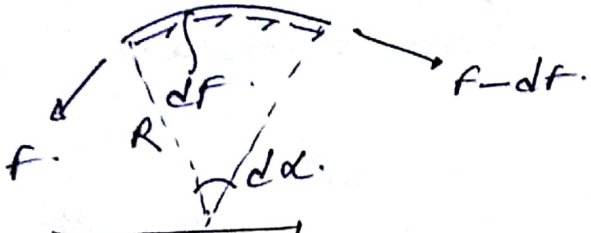
0 wire.

7-wire strand (normally most used)

large dia ⇒ tendon (more than one strand)



* সমস্যা- Beam frictional loss ↑
+ curvature ↑ friction ↑.



① Length effect
② Curvature effect } দুই দুইটা effect এর জন্য friction loss.

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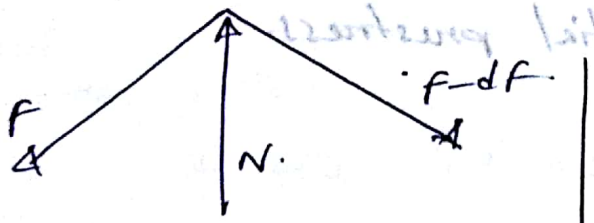
#|Table 4.7|



friction co-efficient const. নয়। mat. এর উপর depend করে।

μ → co-eff. for curvature effect

K → " " length " (wobble co-efficient)

+ দুইপাশের force এর vertical বরাবর Normal force create হয় এবং friction সৃষ্টি করে।

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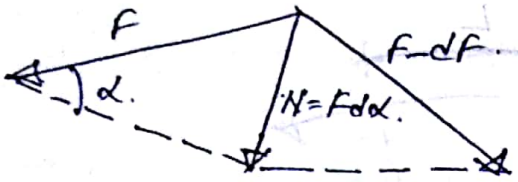
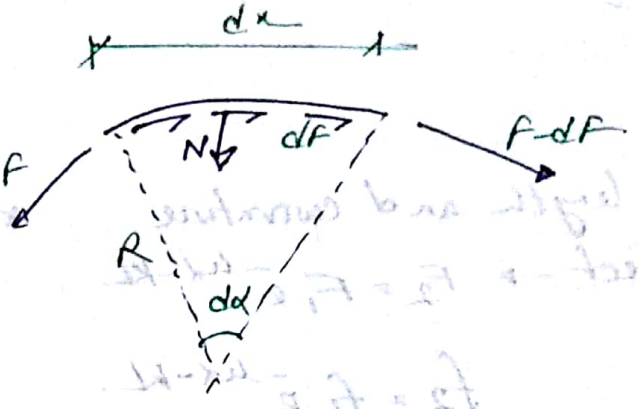
#





Here,

$$d\alpha = \frac{dx}{R}.$$

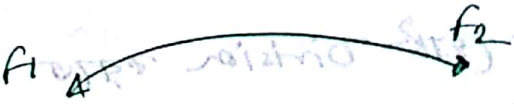
and $dF = -\mu N$

Again, $N = F d\alpha$

$$\Rightarrow -\frac{dF}{\mu} = F \times \frac{dx}{R}.$$

$$\Rightarrow \frac{dF}{F} = -\mu \times d\alpha.$$

$$\Rightarrow \log_e F = -\mu\alpha \quad (\alpha = L/R).$$



$$\log_e F = -\mu\alpha$$

$$\Rightarrow \log_e f_2 - \log_e f_1 = -\mu\alpha$$

$$\Rightarrow \log_e \frac{f_2}{f_1} = -\mu\alpha$$

$$\Rightarrow f_2 = f_1 e^{-\mu\alpha}$$

$$= f_1 e^{-\mu L/R}$$ [for curvature effect].

+ length effect $\rightarrow \log_e F = -kL$

$\therefore \log_e F = -\mu\alpha - kL$. [total]

$$\Rightarrow f_2 = f_1 e^{-\mu\alpha - kL}.$$

$f_2 = f_1 e^{-\mu\alpha - kL}$ [in terms of stress].

$$\boxed{fR = f_1 - f_2}$$

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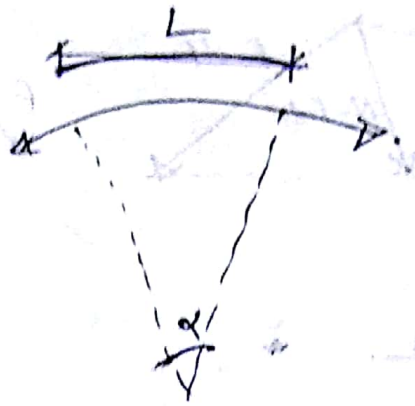
Lec-7

Date - 07.05.18



for length and curvature effect → $F_2 = F_1 e^{-\mu\alpha - kL}$

$f_2 = f_1 e^{-\mu\alpha - kL}$.

+ ছোট-ছোট Division করলে পার্থক্য তাতে accurate value পাওয়া যাবে।

$F_2 - F_1 = -\mu F_1 \alpha = -\mu \frac{F_1 L}{R}$. [Here $F_1 \approx F_2$]

$\frac{f_2 - f_1}{f_1} = -\mu\alpha$. $[\alpha = \frac{L}{R}]$ (curvature)

——(i)

Again, $f_2 - f_1 = -kL f_1$ (length)

$\Rightarrow \frac{f_2 - f_1}{f_1} = -kL$ ——(ii)

[(i) + (ii)] $\Rightarrow$ $\frac{f_2 - f_1}{f_1} = -\left(\mu\frac{L}{R} + kL\right)$.

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simplify করার পরবর্তে কতটা ফলাফল হতে পারে তা নিয়ে problem ২ check করব।

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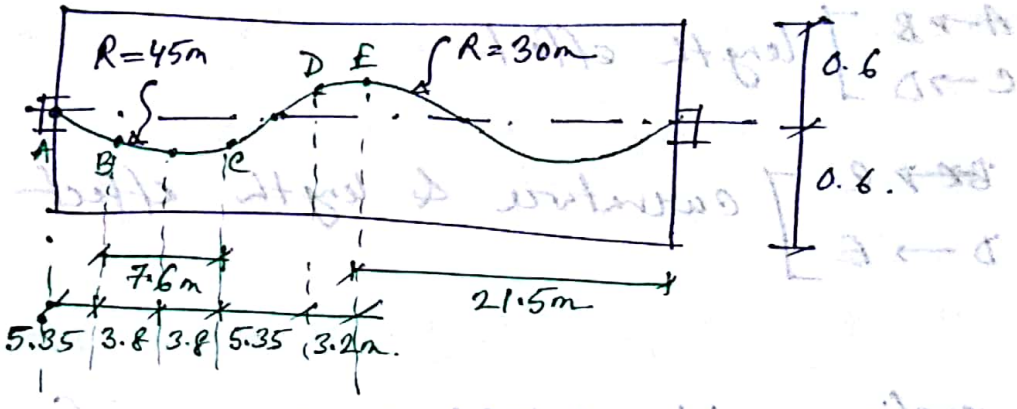
Problem

Here,

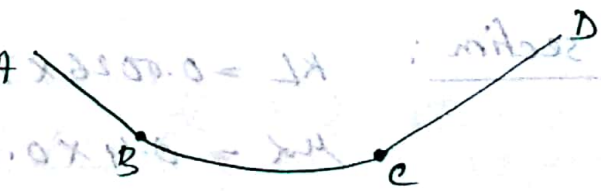
$\mu = 0.4$

$K = 0.0026/m$



⇒ AB, CD → straight line (no curvature effect)

BC, DE → curve.



$$\frac{f_2 - f_1}{F_1} = -kL - \mu\alpha$$

$$= \left[0.0026 \times 21.5 + 0.4\left(\frac{7.6}{45} + \frac{3.2}{30}\right)\right]$$

[বহুৎ-কুল আর্ক- 70]

$\frac{7.6}{45} \downarrow 0.169$ $\quad \frac{3.2}{30} \downarrow 0.107$

$= -0.166.$

$\therefore$ **Loss = 16.6%.** ⇒ Extreme crude method

or, $f_2 = f_1 e^{-0.166} = 0.847 F_1$

→ % Loss = $f_1 - f_2$ = **15.3%.**

* section to section বের করে more accurate. So 1st method less accurate

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2nd method :

section গুলো- গুলো- নাও → A → B → C → D → E.

A → B, C → D] length effect

B → C, D → E] curvature & length effect

i) AB section. $KL = 0.0026 \times 5.35 = 0.014$ [length effect]

∴ stress @ B = 1 − 0.014 = 0.986 f_1

ii) BC section: $KL = 0.0026 \times 7.6 = 0.020$. [length effect].

$\mu\alpha = 0.4 \times 0.169 = 0.068$ [curvature effect].

0.088

$0.088 \times 0.986 = 0.087$ [AB তে $f_2 = 0.986 f_1$ so B point-এ f changed]

∴ stress @ C ; $f_2 = (0.986 - 0.087) f_1 = 0.899 f_1$

iii) CD section: $KL = 0.0026 \times 5.35 = 0.014$ [length effect]

$0.014 \times 0.899 = 0.013$.

∴ stress @ D = $(0.899 - 0.013) f_1 = 0.886 f_1$

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iv) DE section: $KL = 0.0026 \times 3.2 = 0.008$ [length effect]

$\mu\alpha = 0.4 \times 0.107 = 0.043$ [curvature effect]

0.051

loss $= 0.051 \times 0.886 = 0.045$.

$\therefore$ stress @ E $= (0.886 - 0.045) f_1 = 0.841 f_1$.

$\therefore$ % loss $= 15.9\%$.

since difference in loss is negligible, 2nd method is not needed

crude method is applicable → when diff. betn f_1 & f_2 is 20%.

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segment	L	KL	α	$\mu\alpha$	KL+$\mu\alpha$	$e^{-(KL+\mu\alpha)}$	stress @ end segment
AB →					0.014	$e^{-0.014} = 0.986$	$0.986 f_1$
BC →					0.088	$= 0.916$	$0.903 f_1$
CD →					0.014	$= 0.986$	$0.89 f_1$
DE →					0.051	$= 0.95$	$0.846 f_1$

* $0.986 f_1 \times 0.916 = 0.903 f_1$

$\therefore$ % loss $= 1 - 0.846 = 0.154$

$= 15.4\%$

+ → যদি full length consider করি → loss $= 15.3\%$.

যদি section-wise যাই → loss $= 15.4\%$.

so দুই ভাবে Bothered হওয়া লাগবে না,

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Effective prestress, f_{se}. = Initial prestress − loss.

+ - Initial prestress যদি jacking force হয় তবে অনেক loss হবে, elastic shortening, bending, cracking, anchorage loss সব থাকবে।
  - But initial prestress হবে [jacking stress − anchorage loss] এমন বললে anchorage loss হিসাব করা না।

+ অনেক সময় f_i = elastic shortening বাদ।

+ আমরা normally jacking force কে f_i ধরি, so all losses are there.

+ আগের দিনে post-tension = loss 20%, pre-tension = loss 25% } crude method = loss আগে কম হতে পারে।

+ frictional loss এর ক্ষেত্রে → যদি দুইপাশ থেকে টানি- তা loss হবে একপাশ থেকে টানলে loss প্রায় half হবে।

+ Preliminary design, Detailed Design > elastic method

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Date- 14.05.18

Lec-8

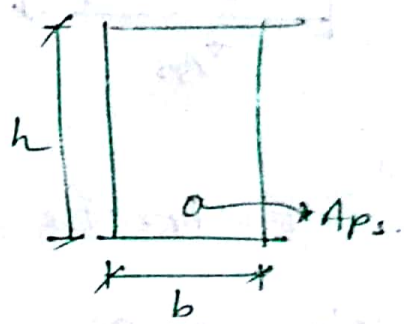
chapter-6 (Design of section for flexure)

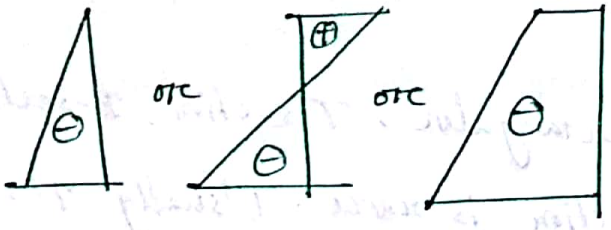
Preliminary design :

i) $f = -\frac{F}{A} \pm \frac{Fey}{I} \pm \frac{My}{I}$. [initial stage)

$M_T = M_G + M_L$.

↳ moment due to self wt of girder.

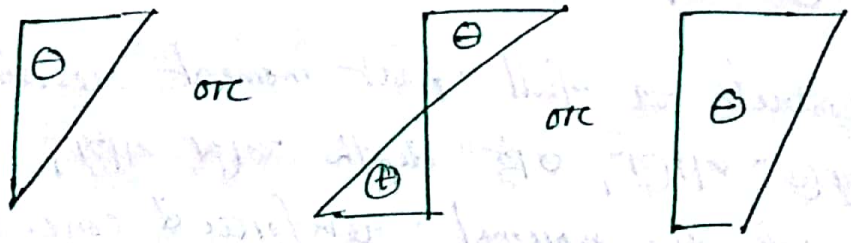




+ যেকোনো type stress distribution হতে পারে।

+ Initially prestress effect থাকবে না।

ii) $f = -\frac{F}{A} \pm \frac{Fey}{I} \pm \frac{M_T y}{I}$ (final stage)



⇒ stress distribution

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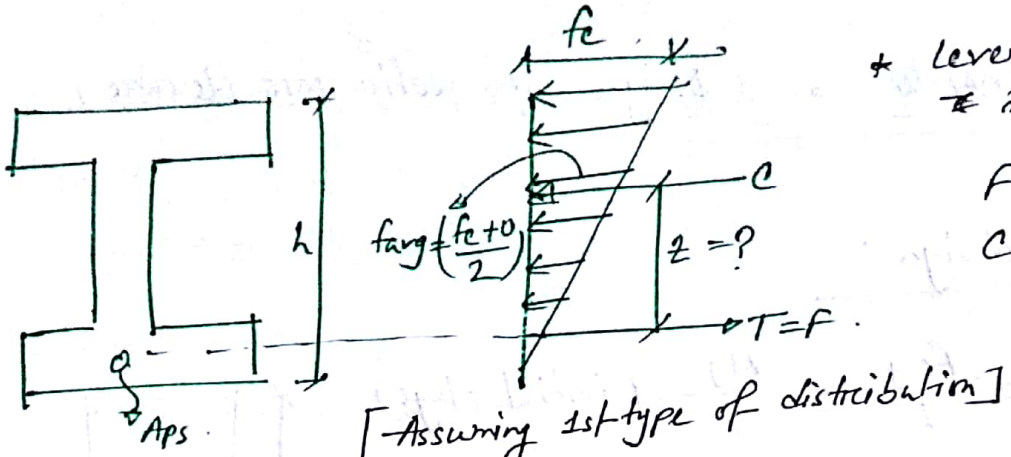

* lever arm = z ধরে নিতে হবে.

$F.z = M_T$

$C.z = M_T$ $\Big\}$ $z = 0.65h$

[Assuming 1st type of distribution]

$F = Aps \cdot f_{se} = \frac{M_T}{z\,(=0.65h)}$ $\Rightarrow Aps = ?$

Now, $C = F$ $\Rightarrow \frac{1}{2} \times f_c \times A_c = F$.

$\Rightarrow A_c = ?$

* সাধারণত section দেওয়া থাকে (rectangular, T section, I-section)

* Prestress-এ rectangular section is rare. Usually T-section & I-section are used (কারণ cost কমে)

* Rectangular-এর ক্ষেত্রে span এর সাথে corresponding depth মিলিয়ে 10' হলে depth = 10" assumed

* Prestressed concrete-এ full part moment resisting-এ participate করে না, তাই depth বেশি লাগে, So depth can be 70% of the normal reinforced conc. depth.

* $\boxed{h = k\sqrt{M}}$

M → total max^m moment in bending

h → in inch

k → varies from 1.5 ~ 2.0.

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① $f = \frac{M_L}{0.5h}$ ·($M_G \rightarrow$ small).

② $f = \frac{M_T}{0.65h}$ (বেশি — confusion থাকলে girder moment (বেশি ধরতে হবে)

① & ② — যা) — বেশি হবে তা — design.

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Ex — 6.1 :

$M_T = 435\ kN\text{-}m$. $h = 920\ mm$, $f_{se} = 860\ MPa$.

$f_c = -11\ MPa$ (allowable stress সবসময় compression হবে)

$f_c' \Rightarrow$ 28 days cylinder strength.

f_{ci}'

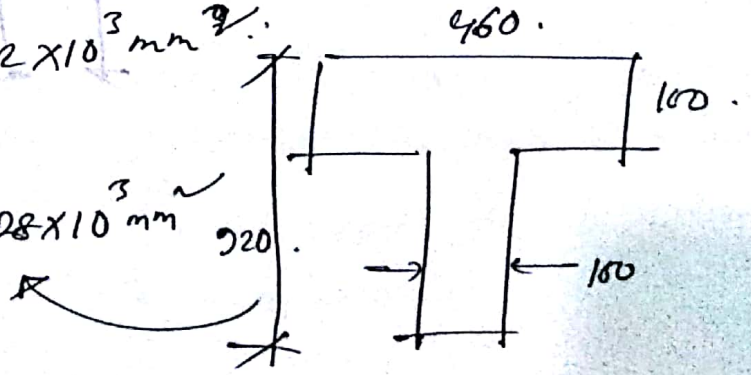
$$F = T = \frac{M_T}{0.65h} = \frac{435 \times 10^3}{860} = 845\ mm^2.$$

$$= \frac{435 \times 10^3}{0.65 \times 920}$$

$$= 727\ kN.$$

Now, $A_{ps} = \frac{F}{f_{se}} = 845\ mm^2 \left(\frac{727 \times 10^3}{860}\right)$.

$$\therefore A_{c\,req} = \frac{727}{0.5 \times 11} = 132 \times 10^3\ mm^2.$$



$A_c = 128 \times 10^3\ mm^2$

provide করা সম্ভবনা।

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2nd trial

$M_T = 435\ kN\text{-}m$

$M_G = 55\ kN\text{-}m$

$h = 920\ mm$

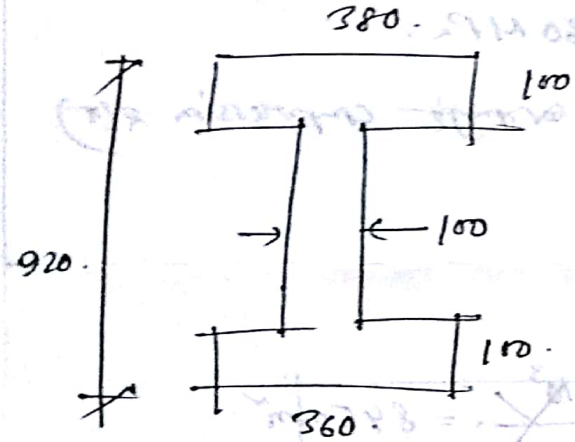
$F = \frac{435 \times 10^3}{0.65 \times 0.92} = 727\ kN$

$P = \frac{M_L}{0.5h} = \frac{438.55 \times 10^3}{0.5 \times 0.92}$

$= 826\ kN$ (governing)

$A_{ps} = 960\ mm^2 \cdot \left(\frac{826 \times 10^3}{860}\right)$

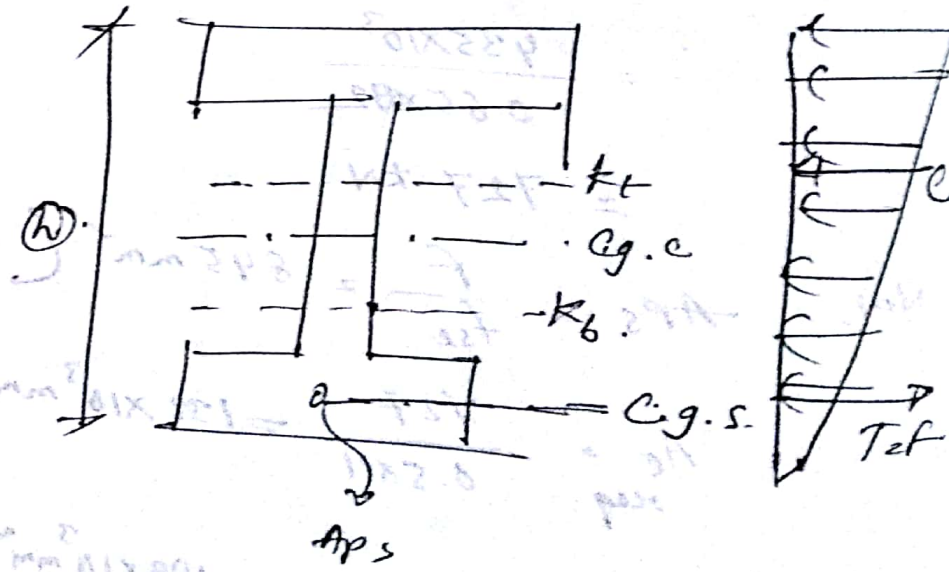
$A_c = \frac{826}{0.5 \times 11} = 150 \times 10^3\ mm^2$



$A_c = 148.\text{---}$

+ ফ্লাঞ্জ কভারেজ নিয়ে.

Detailed Design:



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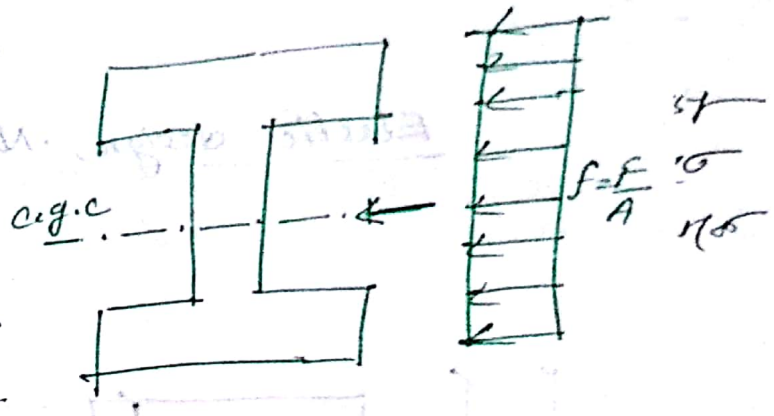
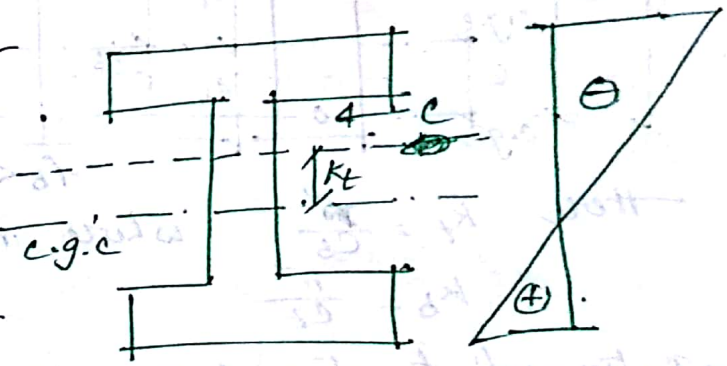
Resultant force যখন c.g.c দিয়ে pass করে তখন :

$$\text{stress} = \frac{\text{force}}{\text{area}}$$



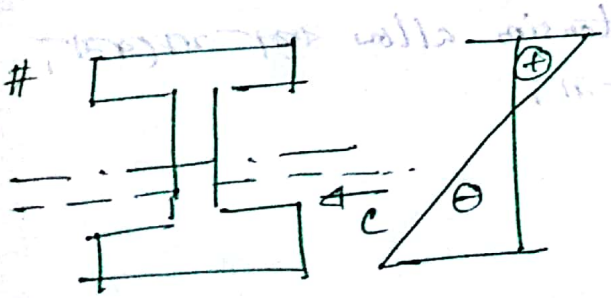
- e-এর position change হলে (top kern/bottom kern) stress change

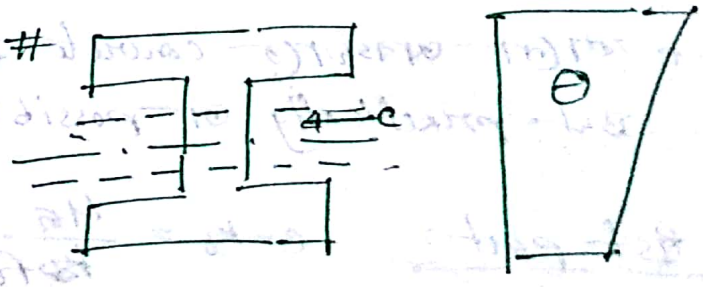
– compression (c), K_t-এর বাইরে উপরে হবে তার উপর depend করে tension কম বেশি হতে পারে।

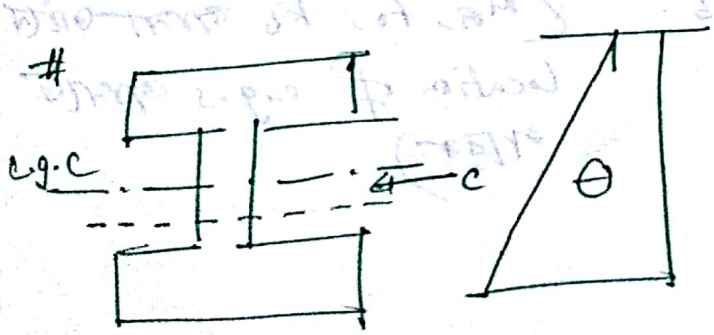


– যদি tension allow করি তবে e, K_t-এর ভিতরে হবে।

– Allowable tension কত হবে তার উপর depend করে e, K_t-এর কত ভিতরে হবে।







যদি full prestressing হয় বা যত ভাইভারে no tension is allowed (e - is betⁿ top & bottom kern point)

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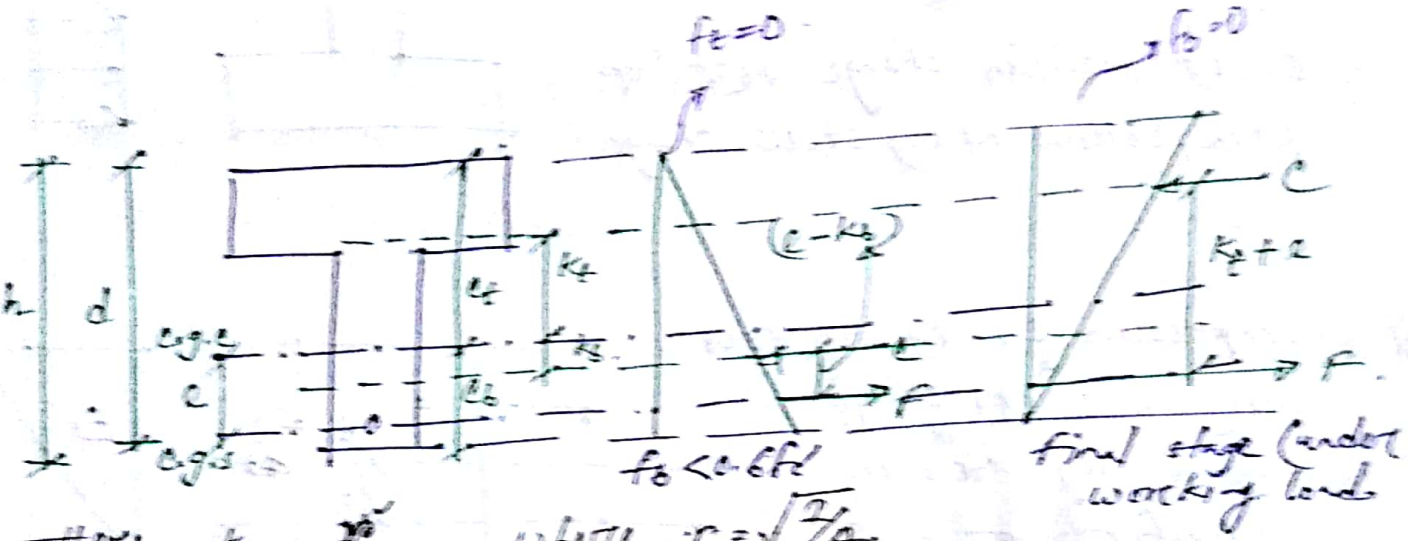
Elastic design, No Tension in concrete



Here $k_t = \frac{r^2}{c_b}$ where $r = \sqrt{I/A}$

$k_b = \frac{r^2}{c_t}$

* Intermediate stress খাকাতে পারবে না,

→ Initial stage (F_0, f_{ci}', $f_t = 0.6f_{ci}'$, M_E) → allowable

→ final stage (F, f_c', $f_c = 0.45f_c'$, $M_T = M_D + M_L$, $f_t < 0.45f_c'$)

* কোনো অবস্থাতে concrete কে tension allow করা যাবেনা,
But practically ei possible হয়না.

1st part: $e - k_b = \frac{M_G}{F_0}$

$\Rightarrow e = \frac{M_G}{F_0} + k_b$ (M_G, F_0, k_b জানা থাকলে location of c.g.s জানতে পারব)

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2nd part: $e + k_t = \frac{M_T}{F}$

$F = \frac{M_T}{e + k_t}$. (effective prestress এবার যা ছিল তা change হতে পারে, এই formula থেকে তা বের করতে পারবো)

Now, for $f_t = 0$. $\Rightarrow f_b = \frac{F_0}{A_c} \times \frac{h}{c_t} \leq 0.6 f_{ci}'$

$\therefore A_c = \frac{F_0 h}{f_b c_t}$ —(i)

H.W

$-f_b = -\frac{F_0}{A} - \frac{F_0 e \cdot c_b}{I} + \frac{M_G \cdot c_b}{I}$.

$\Rightarrow f_b = \frac{F_0}{A} + \frac{F_0 e \cdot c_b}{I} - \frac{M_G \cdot c_b}{I}$.

for compression,

$-f_b = -\frac{F_0}{A} - \frac{F_0 e \cdot c_b}{I} + \frac{M_G \cdot c_b}{I}$.

$\boxed{f_b = \frac{F_0}{A_c} \times \frac{h}{c_t}}$.

Here, $e = \frac{M_G}{F_0} + k_b$

$k_b = \frac{I}{A c_t}$.

$\Rightarrow \boxed{f_b = \frac{F_0}{A_c} \times \frac{h}{c_t}}$ ⇒ একই।

$I/A = k_b \cdot c_t$

$c_b + c_t = h$.

Again, for $f_b = 0$.

$\Rightarrow f_t = \frac{F}{A_c} \cdot \frac{h}{c_b} \leq 0.45 f_c'$

$A_c = \frac{F h}{f_t \cdot c_b}$ —(ii) .

(i) এবং (ii) নং এ যেটা বড় হবে সেটা govern করবে।

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Again

$$e - k_b = \frac{(M_G)}{f_0} \rightarrow$$ এখানে যার large হবে তার e এর value large হবে এবং c.g.s এর location concrete এর বাইরে চলে যাবে not acceptable

$$\Rightarrow e = \frac{M_G}{f_0} + k_b.$$

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Date – 21.05.18

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Ex–6.2 (Final design)

$M_T = 435$ KN-m
$M_G = 55$ KN-m
$f_b = -12.5$ MPa
$f_t = -11$ MPa

$f_{se} = 860$ MPa
$f = 826$ KN.
$f_0 = +1035$ MPa

$\Rightarrow c_b = c_t = 460$ mm

$A_c = 148 \times 10^3$ mm^2.

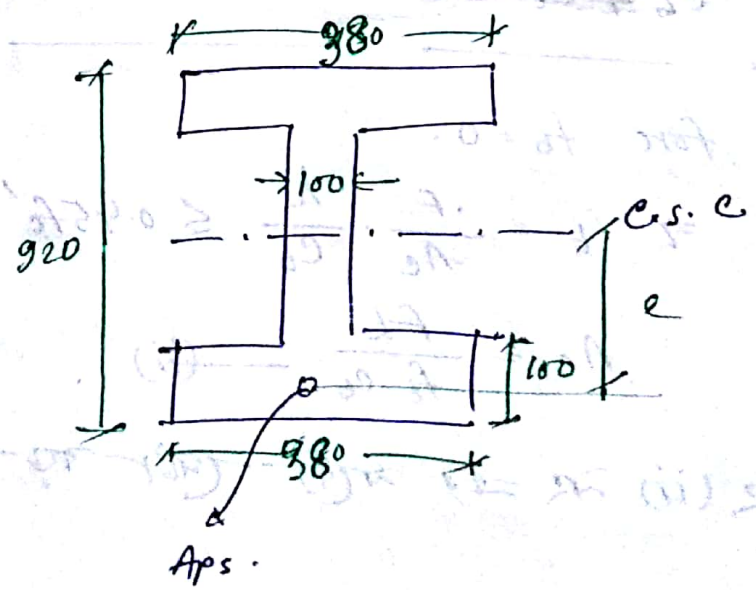
$I = 15.95 \times 10^9$ mm^4

$r^2 = I/A_c$.

$= 108 \times 10^3$ mm

$$k_t - k_b = \frac{r^2}{c_b \text{ or } c_t}.$$

$$= \frac{108 \times 10^3}{460} = 235 \text{ mm}$$



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Now,

$f = 826$ kN (effective prestressing force)

$$f_0 = f \times \frac{f_0}{f_{se}} = \frac{826 \times 1035}{860} = 994 \text{ kN}.$$

$$e - k_b = \frac{M_G}{f_0} = \frac{55 \times 10^3}{994} = 55 \text{ mm}$$

$$\therefore e = k_b + 55 = 235 + 55 = 290 \text{ mm}.$$

Again $$f = \frac{M_T}{e + k_t} = \frac{435 \times 10^3}{290 + 235} = 829 \text{ kN}.$$

$$f_0 = \frac{1035}{860} \times 829 = 998 \text{ kN}.$$

$$A_c = \frac{f_0 h}{f_0 c_t} = \frac{998 \times 10^3 \times 920}{12.5 \times 460} = 160 \times 10^3 \text{ mm}^2 \text{ (required)}$$

$$A_c = \frac{f h}{f_t c_b} = \frac{829 \times 10^3 \times 920}{11 \times 460} = 151 \times 10^3 \text{ mm}^2.$$

So, for new section

$A_c = 158 \times 10^3$ mm² (assumed)

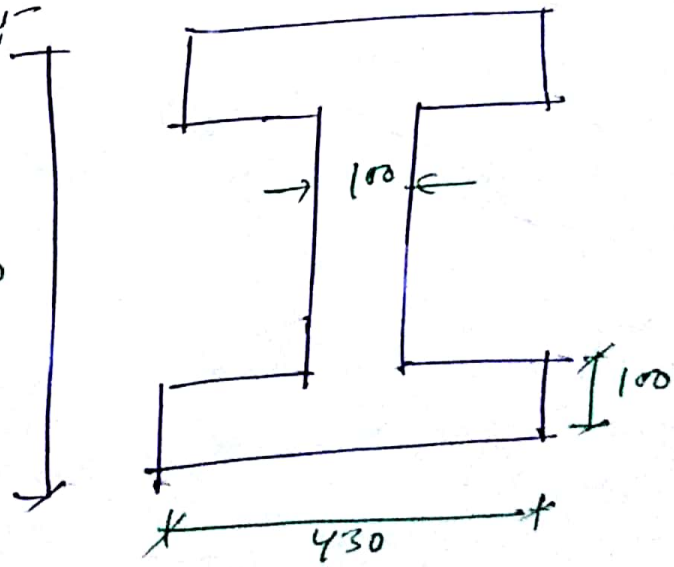
$k_b = k_t = 243$ mm.

$e - k_b = 55$ mm

$\Downarrow$

$\frac{M_G}{f_0}$.

$e = 55 + 243 = 298$ mm



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$$\therefore F = \frac{M_T}{c+t} = \frac{435\times10^3}{298+243} = 804\,kN.$$

$$\therefore f_b = F \times \frac{f_b}{f_{bc}} = 804 \times \frac{1035}{860} =$$

$$A_c = \frac{F_b}{f_c C_b} =$$

$$A_c = \frac{F_b}{f_b \times C_t} =$$

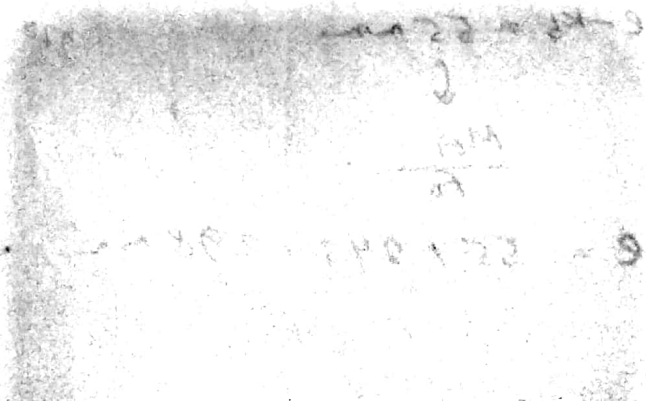
$\therefore A_c =$ ~~$146\times10^3\ mm^2$~~ $155\times10^3\ mm^2$ (governing)

A_c provided $= 158\times10^3\ mm^2$

A_c required = ~~146×10^3~~ $155\times10^3\ mm^2$.

No need for further trial.

* Area এর difference খুব বেশি হলে আবার trial.



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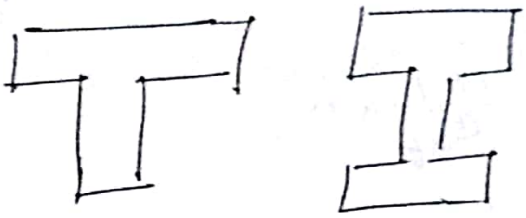
section two types.

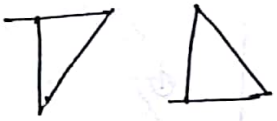


এটা Depend করে $\frac{M_G}{M_T}$ ratio এর উপর,

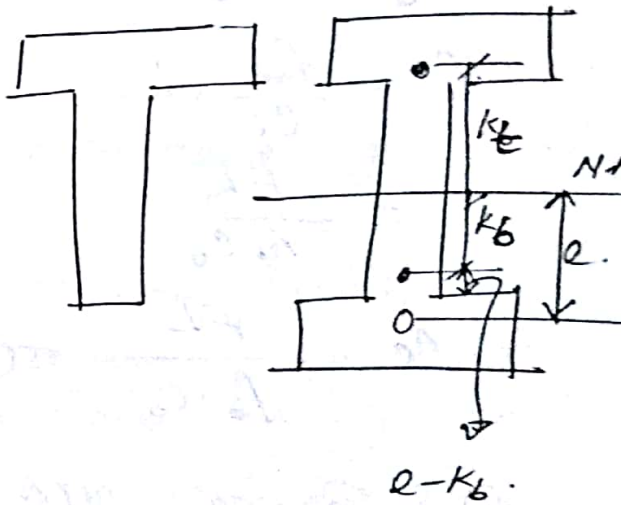
$\frac{M_G}{M_T} = 20 \sim 25\%$ | Here, M_G = Girder moment, M_T = Total moment

বা 30% এর বেশি হতে পারে, এর অনুযায়ী section change করব,

+ $\frac{M_G}{M_T}$ → small হলে I-section use করব,

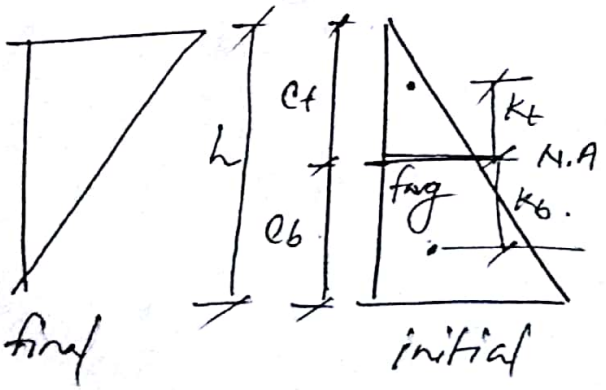
 ⇒ stress diagram

Basic formula. $f = -\frac{P}{A} \pm \frac{My}{I}$



$f_t = -\frac{P}{A} + \frac{My}{I}$.

Allowing no tension, $f_t = 0$.



K_b, K_t → kern point distance

e_b, e_t → top & bottom fibre distance.

Here, $e - K_b = \frac{M_G}{f_0}$

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For rectangular section, $f_{avg} = \frac{F}{bh}$.

$\therefore f_b = \frac{f_{avg}}{c_{bt}} \times h$

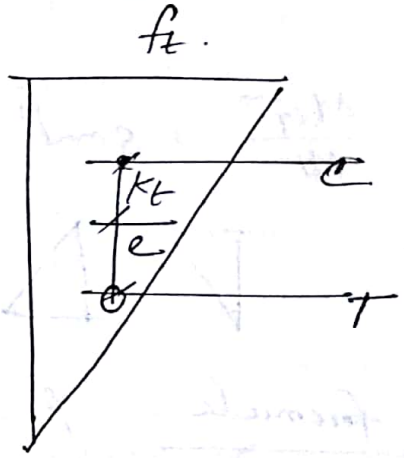
$\Rightarrow f_b = \frac{F_o}{A_c} \times \frac{h}{c_t}$. $\left[f_{avg} = \frac{f_o}{A_c}\right]$

$\Rightarrow A_c = \frac{F_o h}{f_b c_t}$ — (i)

Here, F_o = initial stress.
F = final stress (after all the losses)

final stress

$(e + k_t)$



$\therefore M = F(e + k_t)$

$f_{avg} = \frac{F}{A_c}$.

$\therefore f_t = \frac{f_{av}}{c_b} \times h$

$= \frac{Fh}{A_c c_b}$

$\Rightarrow A_c = \frac{FL}{f_t \cdot c_b}$ — (ii).

* (i) & (ii) - eqn কোথায় ব্যবহার করা হয়েছে - trial & error করতে হবে।

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Steps

1. $\frac{M_G}{M_T}$ = small ≤ 252

2. $\boxed{e - k_b = \frac{M_G}{f_b}}$ → Location of prestressing steel.

3. $f = \frac{M_T}{e + k_t}$

4. $A_c(i) = \frac{f_b \cdot L}{e_t \cdot f_b}$

5. $A_c(ii) = \frac{f \cdot L}{e_b \cdot f_t}$

+ trial এর পর $A_c(i)$ & $A_c(ii)$ এর মান কাছাকাছি হয় তবে ঐটা নিব, trial 1টা করতে হবেনা exam এ.

+ A_c এর মধ্যে diff এর মান 10,000 mm^2 এর বেশি হয় তবে area আবার কাছাকাছি ধরা যাবে,

$f_{ci}' = 28 MPa$ —

$f_c' = 35 MPa$ — 28 days cylinder crushing strength.

ASTM std ⇒ $6" \times 12"$ → 150×300 mm cylinder

(2~4%) 100×200 mm. permitted

75×150 → not permitted

$f_c = 0.45 f_c'$

$f_t = 0.45 \times 35$ | $f_b = 0.6 f_{ci}'$

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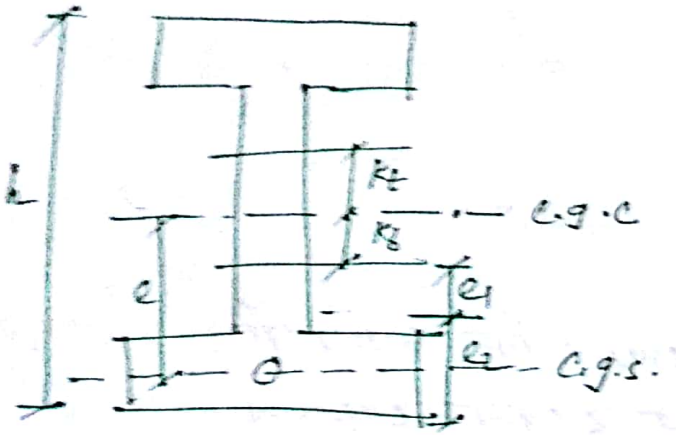
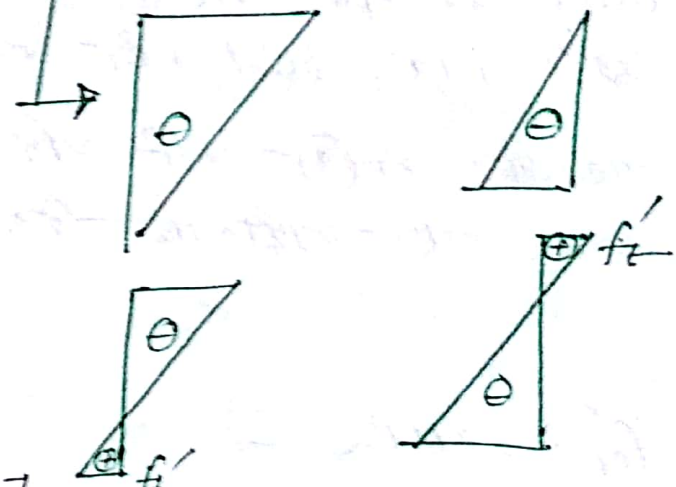


- Initial stage.
- working load (service)

$$f = \frac{F}{A} \pm \frac{Fey}{I} \pm \frac{M_T y}{I}$$

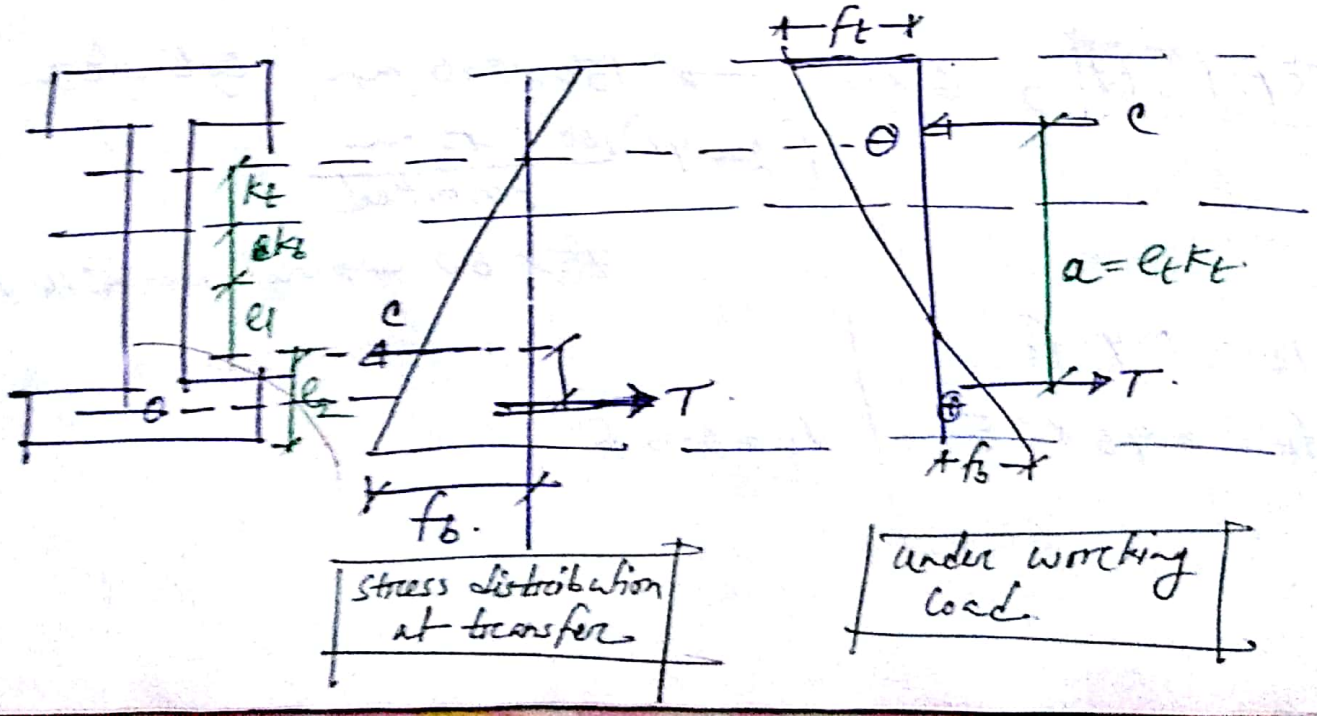
$$f = \frac{f_0}{A} \pm \frac{f_0 ey}{I} \pm \frac{M_G y}{I}$$



f_b' and $f_t' < f_n$.

$$e_2 = e - k_b = \frac{M_T}{f_0}.$$

$$\Rightarrow e = \frac{M_G}{f_0} + k_b \text{ . [allowing no tension]}$$



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$$e_1 = \frac{f_t' I}{f_0 c_t} \quad \text{Initial} \qquad \left[f = \frac{My}{I} = \frac{M c_t}{I} \right]$$

$$= f_t' A K_b / f_0 .$$

$$M_{cr} = f_0 e_1 .$$

$$f = \frac{M_T}{e + k_t} \quad \text{Effective}$$

+ সাধারণ tension allow করব না তাহলে formula same থাকবে just M_T change হবে. M_T → Conc. M_T will be reduced
→ Aps.

$$f_b = M \cdot \frac{c_b}{I} .$$

∴ The moment carried by the concrete $= \frac{f_b' I}{c_b} = f_b' A K_t$

$$F = \frac{M_T - f_b' A K_t}{a} .$$

$$f_b = \frac{f_0}{A} + \frac{f_0 e c_b}{I} - \frac{M_G c_b}{I} .$$

$$f_b = \frac{f_0}{A_c c_t} - f_t' \cdot \frac{c_b}{c_t} .$$

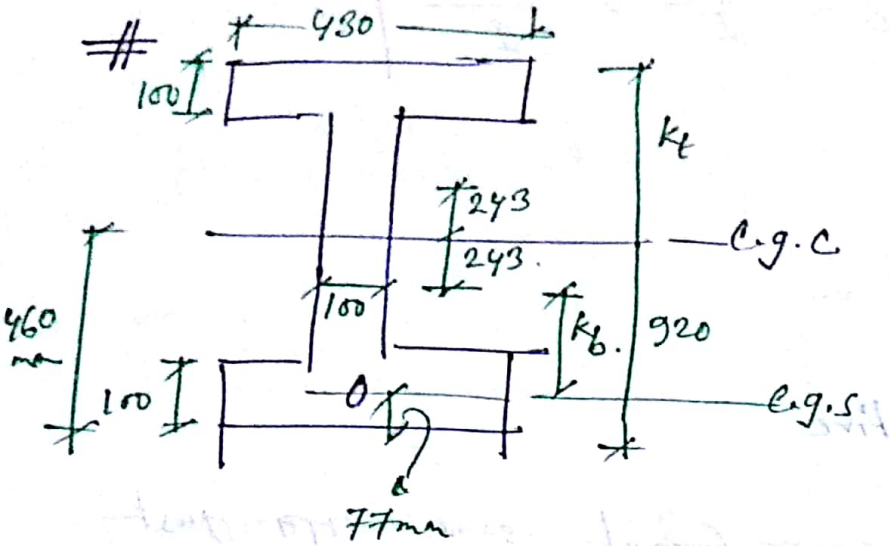
f_0 ↓ Allowing no tension; f_t' ↓ tension

$$\Rightarrow A_c = \frac{f_0}{f_b c_t - f_t' c_b} .$$

$$f_t = \frac{F}{A_c \cdot c_b} + f_b' \cdot \frac{c_t}{c_b} .$$

$$\Rightarrow A_c = \frac{f}{f_t' c_b - f_t' c_t} .$$

Scanned by CamScanner



$f_t' = 2.1 MPa$

$f_b' = 1.65 MPa$.

$M_T = 435 kN.m$

$M_G = 55 kN.m$

$f_t = -11 MPa$

$f_b = -12.5 MPa$

$F = 804 kN$

$f_0 = 968 kN$.

$\Rightarrow k_b = k_t = 243 mm$

$A_c = 1.58 \times 10^3 mm^2$.

$e_1 + e_2 = \dfrac{55 \times 10^6 + 158 \times 10^3 \times 243}{968 \times 10^3}$ | $\dfrac{M_c + f_t' A k_b}{f_0}$

$= 140 mm$

Cover কম হলে area বাড়িয়ে- দিতে করা যায়,

$M_T - f_b' A k_b = 435 - 1.65 \times 158 \times 10^3 \times 243$.

$= 372 kN-m$.

$f = \dfrac{372 \times 10^6}{626}$ → e+kt

$= 594 kN-m$.

→ 968 — হাতে- দুরু

$f_0 = \dfrac{594 \times 1035}{860} = 715 kN$.

at transfer → $f_b = -12.5 MPa$

$A_c = \dfrac{715 \times 920 \times 10^3}{12.5 \times 460 - 2.1 \times 460} = 1.38 \times 10^3$.

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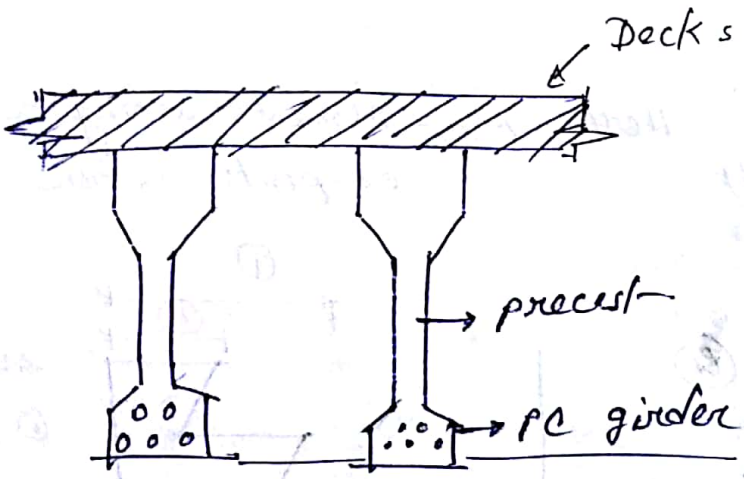
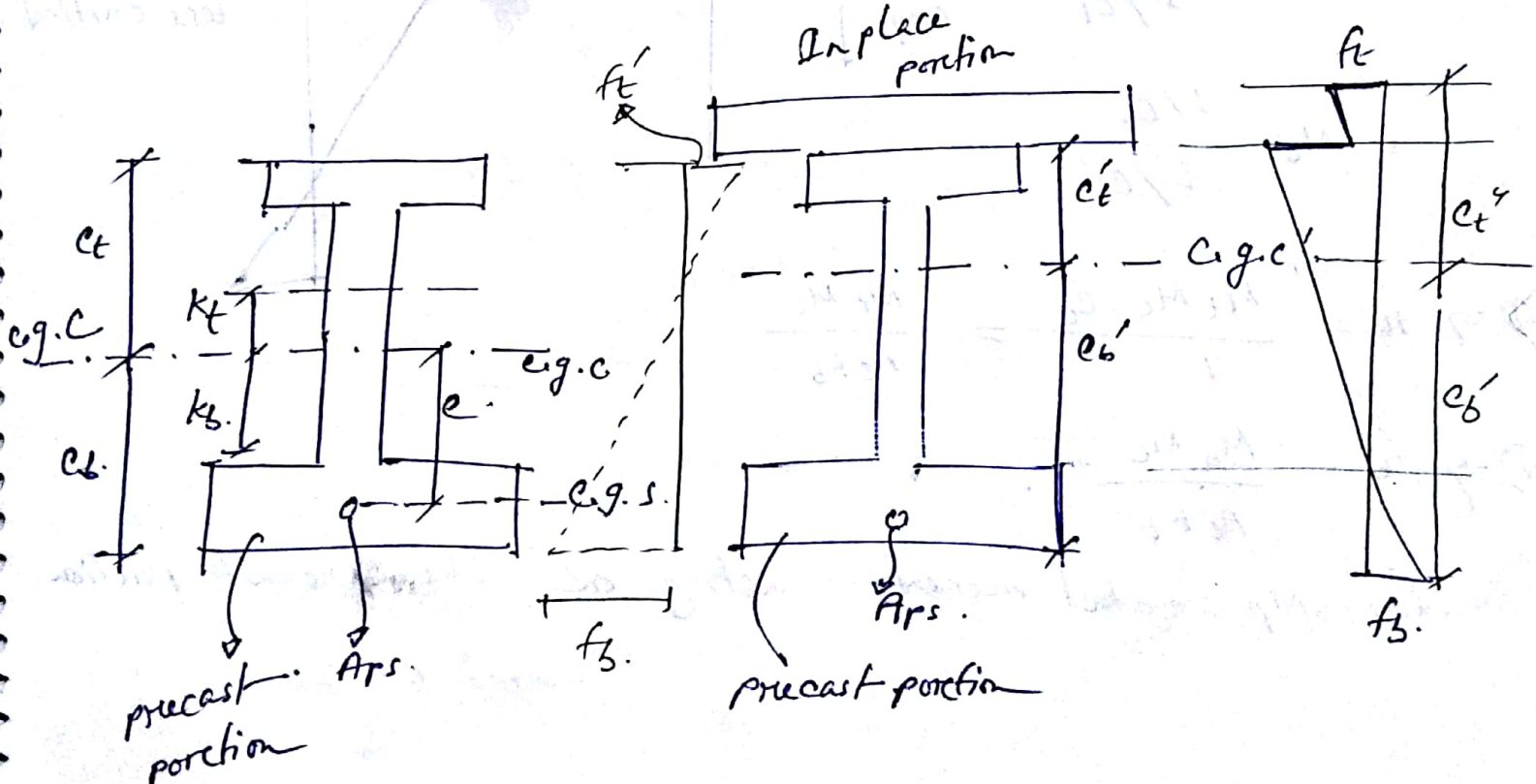
$f_t = -11.0 \text{ MPa}$.

$$A_c = \frac{594 \times 10^3 \times 920}{11 \times 460 - 1.65 \times 466} = 127 \times 10^3 \text{ mm}^2.$$

Lec-13

Date - 30.06.18.





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+ Effective stress, f
eccentricity, e
M_G, M_S.

$e = k_b + e_1 + e_2$.

$e_1 = \frac{f_t' I}{c_t f_b}$.

$e_2 = \frac{M_G}{f_b}$

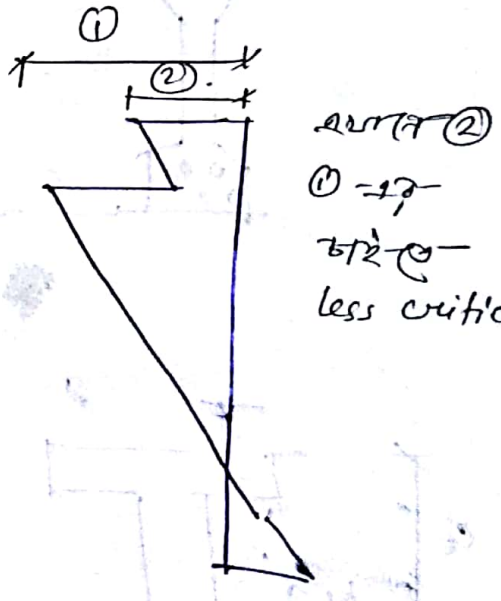
composite section (SRC):

$f_t = \frac{M_c \cdot c_t'}{I'}$ — (i) Here, M_c = Moment acting on the composite section

$f_b = \frac{M_c c_b'}{I'}$ — (ii).

$M_t = \frac{I/c_t}{I'/c_t'}$ [I', c_t' for comp]

& $M_b = \frac{I/c_b}{I'/c_b'}$



(i) $\Rightarrow f_t = \frac{M_t M_c c_t}{I} = \frac{M_t M_c}{A_c k_b}$.

(ii) $\Rightarrow f_b = \frac{M_b M_c}{A_c k_t}$.

Now, M_p = total moment acting on the precast portion

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$$\frac{F}{A_c}\left(-1-\frac{e}{K_t}\right)+\frac{M_p}{A_c K_t}+\frac{m_p M_c}{A_c K_t}=f_b'$$

$$\Rightarrow f_b' = -\frac{F}{A_c}-\frac{F e c_b'}{I'}+\frac{M_p c_b'}{I'}+\frac{M_c c_b'}{I'}$$

Now, $f = \dfrac{M_p + m_g M_c - (f_b' k_t A_c)}{e+k_t}$ → tension zero ∴ $f_b' = 0$.

$f(e+k_t) = M_T$

for compression, $f_b = \dfrac{f_o}{A_c}+\dfrac{f_o e - M_G}{A_c k_t}$ ...

$$f = \frac{f_o}{A}+\frac{f_o e c_b}{I}-\frac{M_G c_b}{I}$$

$M_G + M_c$

$$f_t = \frac{F}{A_c}+\frac{(M_p + m_t M_c) - F\cdot e}{A_c \cdot k_b}$$

[Comp] $f_t = \dfrac{F}{A}-\dfrac{F e c_t}{I}$

M_p

$$f_t = \frac{F}{A}-\frac{F e c_t'}{I'}+\frac{(M_G+M_s)c_t'}{I'}+\frac{M_c c_t'}{I'}$$

$M_G + M_s$

$$\Rightarrow A_c = \frac{1}{f_t}\left[\frac{F + M_p + m_t M_c - f e}{K_b}\right]$$

[CT-2]

Elastic Design (not composite) (Allowing no tension)] next week-1 wednesday.

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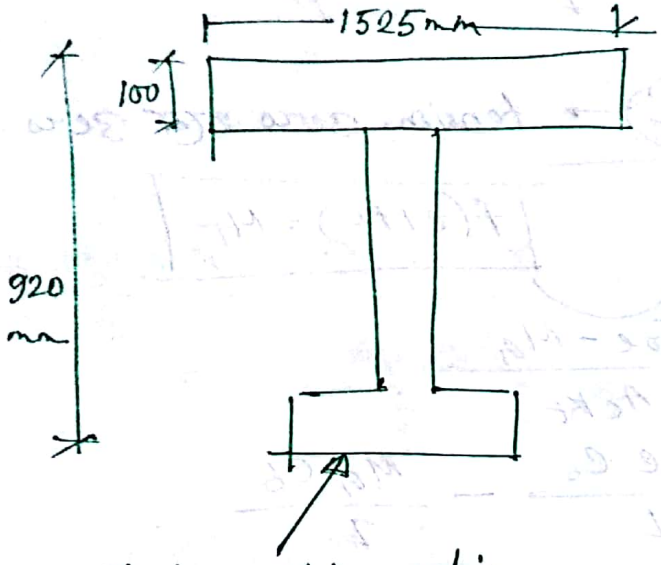
Lec-14

Date - 02.07.18

PP 210



Design this section

A_{ps} = ?

A_c = ?

Initial prestress = 1035 MPa

Effective " = 860 MPa.

M_T = 435 KN-m

M_G = 55 KN-m

M_P = 135 KN-m

f_t = -11 MPa

f_b = -12.5 MPa

f_t' = 2.1 MPa

f_b' = -1.1 MPa.

M_c = 300 KN-m

+ Effective prestress এবং area বের করো

$$F = \frac{M_T}{0.65h} = \frac{435 \times 10^3}{0.65 \times 920} = 727 \text{ KN.}$$

$$f_b = \frac{727 \times 1035}{860} = 875 \text{ KN.}$$

$0.5 f_b A_c = f_b$.

$\rightarrow A_c = \frac{2 f_b}{f_b}$ [very conservative]

So assume $\rightarrow$

$A_c = \frac{1.5 f_b}{f_b}$.

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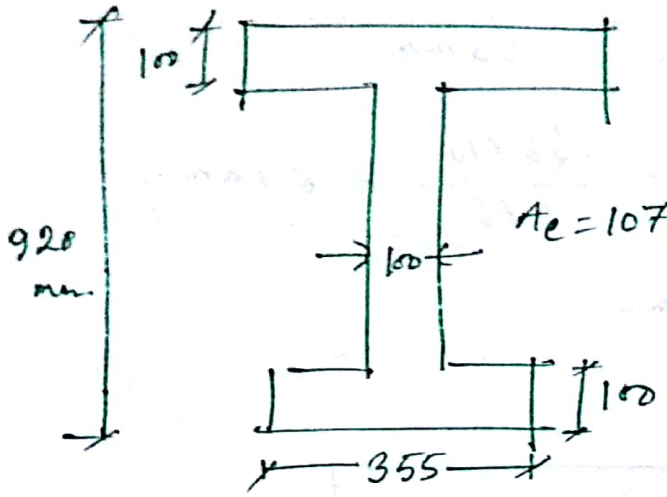
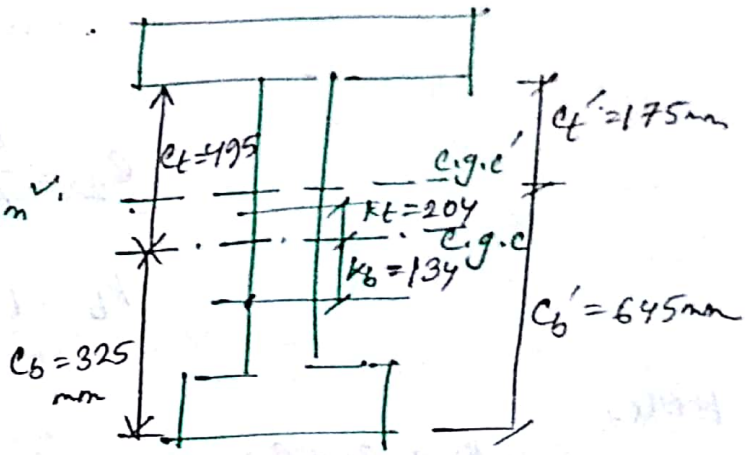
$$\therefore A_e = \frac{1.5 \times 875 \times 10^3}{12.5} = 105 \times 10^3 \text{ mm}^2$$





$$I = \frac{bh^3}{12} + Ad^2 = \frac{bh \times h^2}{12} + Ad^2$$

$$= \frac{Ah^2}{12} + Ad^2$$

$$= A\left(\frac{h^2}{12} + d^2\right) \Rightarrow$$ यह (यू-आई formula.

$$I = 71.37 \times 10^8 \text{ mm}^4$$

$$I' = 260 \times 10^8 \text{ mm}^4$$

$$M_t = \frac{I/c_t}{I'/c_t'} = \frac{71.37 \times 10^8 / 495}{260 \times 10^8 / 175} = 0.10$$

$$M_b = \frac{I/c_b}{I'/c_b'} = \frac{71.37 \times 10^8 / 325}{260 \times 10^8 / 645} = 0.54$$

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step-1:

Location of c.g.s. $e_1 = \frac{f_t' I}{c_t + f_b} = \frac{2.1 \times 71.37 \times 10^8}{495 \times 875 \times 10^3}$

$= 35 mm$

$e_2 = \frac{Mc}{f_b} = \frac{.55 \times 10^3}{875} = 63 mm$

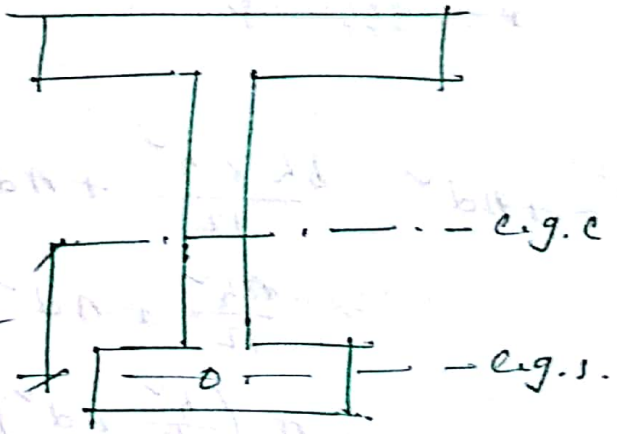
$k_b = 134 mm$

Here,

$e = k_b + e_1 + e_2$

$= 134 + 35 + 63.$

$= 232$



So, $e_b - e = 325 - 232$

$= 93 mm$

(এই steel বসানোর পরিমাণ
বলে)

step-2: $m_t = 0.10$

$m_b = 0.54.$

step-3: এবার composite section এর $\boxed{F = \frac{M_T}{e + k_t}}$ হবে।

$F = \frac{M_p + m_b M_c - f_b' k_t A_c}{e + k_t}$ [tension not allowed then $\Rightarrow f_b' = 0$]

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$$= \frac{135\times10 + 0.54\times 300\times10^{3} - 1.1\times10^{-3}\times204\times107(500}{232+234}$$

$$= 626\ KN.$$

$$f_0 = \frac{626\times1035.}{860} = 753\ KN.$$

$e_1, e_2 = ?$ $\quad e_1 = 35\times\frac{875}{753} = 41\ mm.$

$$e_2 = 63\times\frac{875.}{753} = 73\ mm$$

$\therefore e = e_1 + e_2 + K_b = 134 + 41 + 73 = 248mm.$

$\therefore c_b - e = 325 - 248 = 77mm.$

$e + k_t = 248 + 204 = 451$ ~~451~~ 45mm

f can be revised by $\cdot 626\ KN. \times \frac{436.}{452} = 604\ KN.$

$$f_0 = \frac{604\times1035.}{860} = 727KN.$$

Now,

$$A_c = \frac{1}{f_b}\left[f_0 + \frac{f_0 e - M_G}{f_t}\right]$$

$$= \frac{1}{12.5}\left[727 + \frac{727\times248 - 55\times10^{3}}{204}\right]$$

$$= 107\times10^{3}\ mm^{2}.$$

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Again,

$$A_e = \frac{1}{f_t}\left[f_c + \frac{M_p + m_t M_c - f_e}{K_b}\right]$$

$$= \frac{1}{11}\left[604 + \frac{135\times10^3 + 0.1\times300\times10^3 - 604\times248}{134}\right]$$

$$= 65\times10^3\ mm^2$$

$A_e = 107\times10^3\ mm^2$ (governs)

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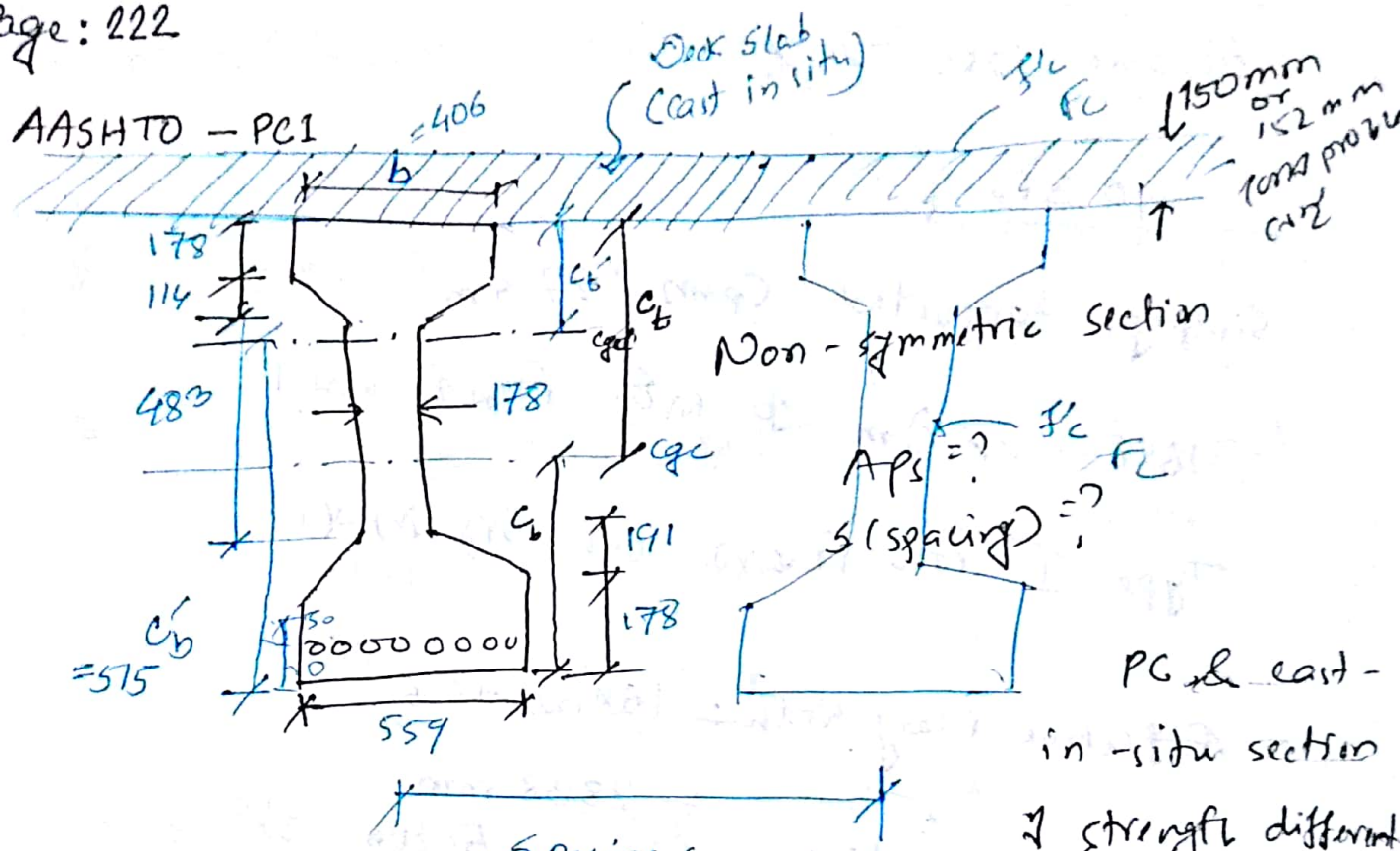
Lecture-15

07-07-18
Saturday

Page: 222



b → effective width = 16t + b'

6" x 5·y = 152 mm

Type III

$A = 361.3 \times 10^3$ mm²

$I = 522 \times 10^8$ mm⁴

$c_b = 515$ mm

$c_t = 1143 - 515$

$= 628$ mm

$f_{ph} = 1860$ MPa

$g = 12.8$ m/s²

Design Load

Unit wt = 24 kN/m³

$W_{G1}, W_D = 960$ Pa

$W_{LL} = 2400$ Pa

Precast Beam:

$f'_{ci} = 31$ MPa

$f'_c = 42$ MPa

$f'_{c\,slab} = 28$ MPa

Healthcare
Neopenem
Scanned by CamScanner

Unshored Beam

Assume loss = 20%

$\therefore$ $F = 0.8 F_0$

Simply supported Span. = 27.5 m

(16.8 ~ 24.4) m এর মধ্যে নিলাম।

Type II এর জন্য নেওয়া হয়েছে।

Effective Flang width = 16 × 152 + 406

= 2838 mm

Modified Effective width = $\frac{E_{c\,deb}}{E_{c\,girder}}$

= 0.81 × 2838

= 2299 mm

$f_{ci\,initial} = 0.2\sqrt{f'_{cc}}$

$f_{c\,initial} = 0.6 f'_{cc}$

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Composite behavior (final stage)

$f_c = 0.45 f'_c$

$f_t = 0.5\sqrt{f'_c}$

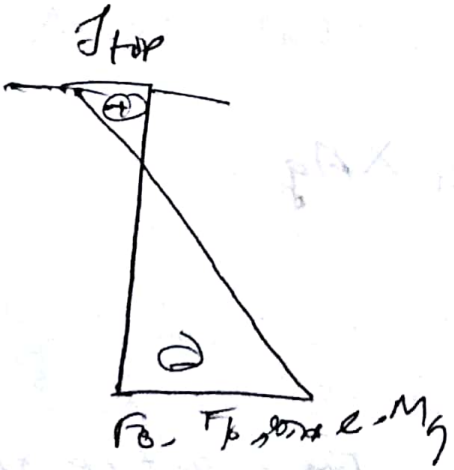
$W_G = 0.36 \times 1 \times 24 = 8.67$ ~~kN/m~~ kN/m $0.36 m^2 \times 24 kN/m^3 = 8.67 kN/m$

$W_G = 8.5$ kN/m

$M_G = \frac{8.51 \times 27.1^2}{8}$

Section Modulus: $S_b = C_b/L = 101 \times 10^6$ mm^3

$S_t = \frac{I}{L} = 83 \times 10^6$ mm^3



$f_{top} = 0.25\sqrt{f'_c} = 0.5\sqrt{31}$

$= 2.79$ MPa

$1.39 = \frac{F_0}{A_c} + \frac{F_0 e}{L} - \frac{M_G C_t}{L}$

$\Rightarrow F_0 = ?$

~~Ans of a mm tons~~

Healthcare

Neopenem
meropenem

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$M_q = 600$ kN·m

$e = 515 - 127 = 388$ mm

Using F_0 = 5796 kN

$$f_{bot} = 0.0 = \frac{-F_0}{A_c} + \frac{F_0 e c_b}{I} + \frac{M_q c_b}{I}$$

$\Rightarrow -10\%$ $\Rightarrow F_0 = 4021$ kN

No of strands

ϕ 12.7 mm ϕ strands. $\Rightarrow A_g = 98.7\ mm^2$

15.2 mm dia $\rightarrow A_g = 140$.

Any $A_g = 98.7\ mm^2$

F_0 / Tendon

$0.7 \times 186.0 \times 98.7$ $\leftarrow 0.7 f_{pu} \times A_g$

$= 128.2$ kN

$\simeq 130$ kN

$\frac{4021}{140} \simeq 15$ nos

$F_{req} = 0.7 f_{pu} \times A_g$

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No of stirrups $= \frac{4021}{130} = 31.3 \approx 32$

M_{11} : ~~$12 \times 80 = 10,000$ mm~~ $8 \times 1000 = 8000$

$M_{13} = 8 \times 150 = 1200$

~~$6 \times 1150 = 1200$~~

$6 \times 200 = 1200$

~~3×3~~ & $2 \times 250 = 500$

$32^{\#}$ 41000

Actual $f_{bot} = -\frac{4114}{361 \times 10^3} - \frac{4114(387)}{179 \times 86} + \frac{800}{101 \times 10^6}$

$= -19.1 MPa$

$\frac{1}{C_b}$

$f_{all} = 18.6 MPa$.

$= \frac{400}{32} = 12.8$ mm

2)

Healthcare

Neopenem meropenem

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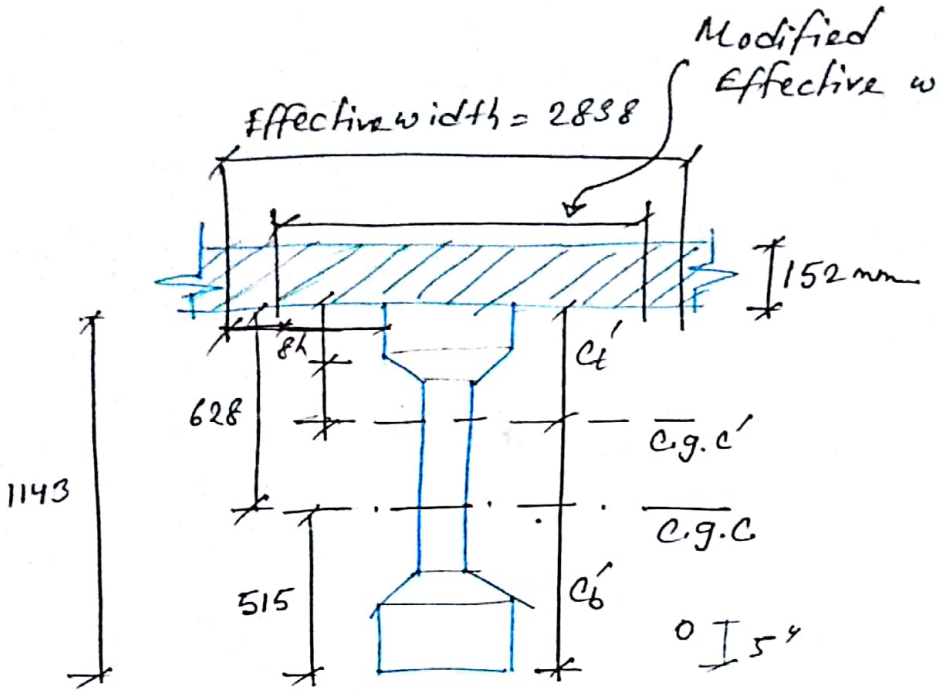
Lec - 16

Date : 09.07.18



$2838 = 2 \times (81) + 406$

$= 2 \times 8 \times 152 + 406.$

$$c_b' = \frac{152 \times 2299 \times \left[1143 + \frac{152}{2}\right] + 361 \times 10^3 (515)}{152 \times 2299 + 361 \times 10^3}$$

(152/2 = 76; 361 × 10³ : Area of precast girder)

$= 863$ mm

$c_t' = 1143 - 863 = 280$ mm

$A' = 714 \times 10^3$ mm² (710.5×10^3)

$$I' = 522 \times 10^8 + 361 \times 10^3 \times (348)^2 + \frac{2299 \times 152^3}{12} + 152 \times 2299 \times (356)^2$$

$= 141 \times 10^9$ mm⁴.

(348 = 863 − 515; 356 = 280 + 76; 522 × 10⁸ → I_0)

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s = 1 m.

$$M_D = \frac{960 \times 5 \times 27.5^2}{8 \times 1000} = 90.855 \text{ KN-m.}$$

$$M_L = \frac{2400 \times 5 \times 27.5^2}{8 \times 1000} = 226.955 \text{ KN.m}$$

$$M_{slab} = \frac{3600 \times 5 \times 27.5^2}{8 \times 1000} = 340.35 \text{ KN.m.}$$

$3600 = \boxed{152 \times 5 \times 24}$ → unit wt, $\delta_c = 24 \text{ KN/m}^3$.

thickness, spacing

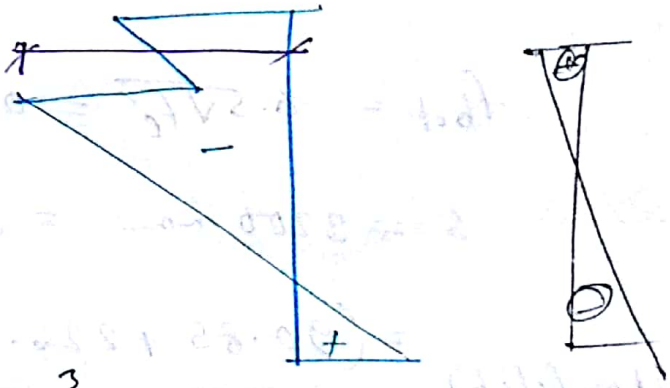
$w_{slab} = 152 \times 24 \times (5)$ → m

$= \text{KN/m.}$

$F = 0.8 f_0.$

$= 0.8 \times 4114$

$= 3292 \text{ KN.}$



$$f_{top} = \frac{-3292 \times 10^3}{361 \times 10^3} + \frac{3292 \times 388 \times 10^3}{83 \times 10^6}$$

final stress.

S_t = section modulus.

$= I/c_t$

$$-\frac{(800 + 340.35) \times 10^6}{83 \times 10^6} \oplus \frac{(90.855 + 226.95) \times 10^3}{5.04 \times 10^8}$$

$S_t' = 1.63 \times 10^6.$

$\frac{M_G + M_{slab}}{S_t}$ $\quad$ $\frac{M_D + M_L}{S_t'}$

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$f_{bot} = 0.45 f_c' = 0.45 \times 42 = (18.9)$

$s = 3226$ mm [spacing].

$$f_{bot} = -\frac{3292 \times 10^3}{361 \times 10^3} - \frac{3292 \times 388 \times 10^3}{101 \times 10^6}$$

$$\boxed{S_b = 101 \times 10^6} = I/c_b$$

$$+\frac{(800 + 340.35) \times 10^6}{101 \times 10^6} + \frac{(90.855 + 226.95) \times 10^3}{163 \times 10^8}$$

$$\boxed{S_b' = \frac{I'}{c_b} = 1.63 \times 10^8}$$

$f_{bot} = 0.5\sqrt{f_c'} = 0.5\sqrt{42} = 3.20$ MPa.

$s = 3200$ mm $= 3.2$m [spacing].

$$f_{bot\,(slab)} = \frac{(90.85 + 226.9) \times 5 \times 432}{141 \times 10^9}$$

$= -3.10$ MPa $< 0.45 f_c'$.

* checking the strength:

$A_{ps} = 32 \times 98.71 = 3159$ mm^2.

$d = 1295 - 128 = 1167$ mm

(h ↓, c.g.s ⇓)

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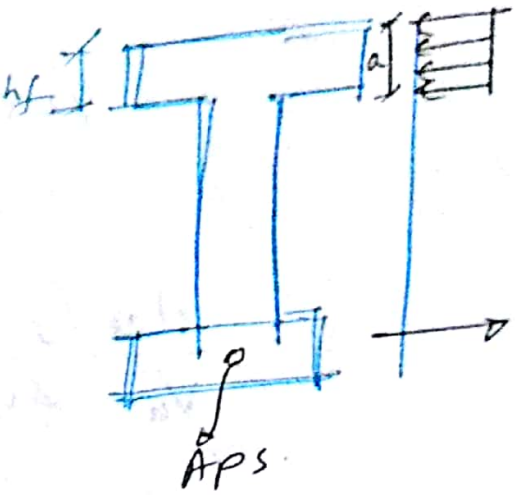
$$\rho_p = \frac{A_{ps}}{bd} = \frac{3159}{2838 \times 1167}$$ → 2299.

$$= 0.000954.$$



$$f_{ps} = f_{pu}\left[1 - 0.5\rho_p \frac{f_{pu}}{f'c}\right]$$

$$= 1860\left[1 - 0.5 \times 0.000954 \times \frac{1860}{28}\right] \rightarrow (\text{slab.})$$

$$= 1801 \text{ MPa.}$$ [practically 100 stress ধরা হয়না]

$$a = \frac{3159 \times 1801}{0.85 \times 28 \times 2838} = 84 \text{ mm} < 152 \text{ mm.}$$

(A_{ps}, f_{se}, f'_{slab}, b_{slab})

$0.85 f'_{cb} = A_{ps} \times f_{se}$

$$M_u = \phi M_n = 0.9\left(1801 \times 3159 \times \left[1167 - \frac{84}{2}\right]\right)$$ (f_{ps}, A_{ps})

$$= 5761 \text{ KN-m.}$$

$$M_u = 1.2 \times \left[800 + (90.8 + 30 + 40.35) \times 3.2\right] + 1.6 \times 2296 \times 32$$

(M_G, M_D, M_{slab}, S)

$$= \boxed{1.2 M_{DL} + 1.6 M_{LL}}$$

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$= 4286 \text{ kN-m} < 5761 \text{ kN.m}$

$$S = \frac{A_{ce} f_y d}{V_u - \phi V_c}$$

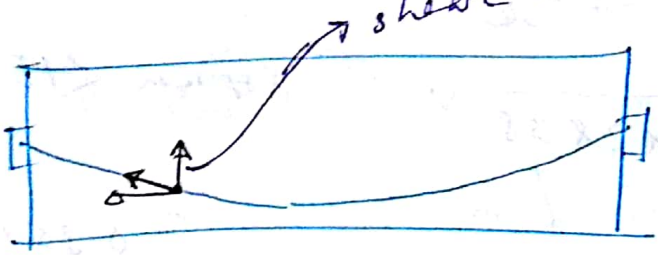
$2\sqrt{f_c'} b_w d$

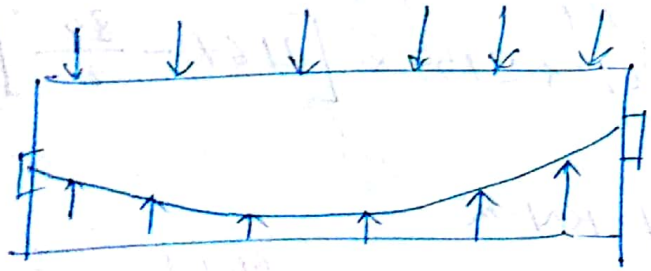
$1.4 + 2500.$

$\phi V_c \rightarrow$ shear resistance of concrete.

$A_{ce} \rightarrow$ Area of shear reinforcement.

+ Prestressed shear strength > RCC shear strength





+ Normally shear reinforcement দেয়া লাগেনা, But তাও minimum reinforcement দিতে-দিবা।

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14.07.18

Lec-17

Chapter -7

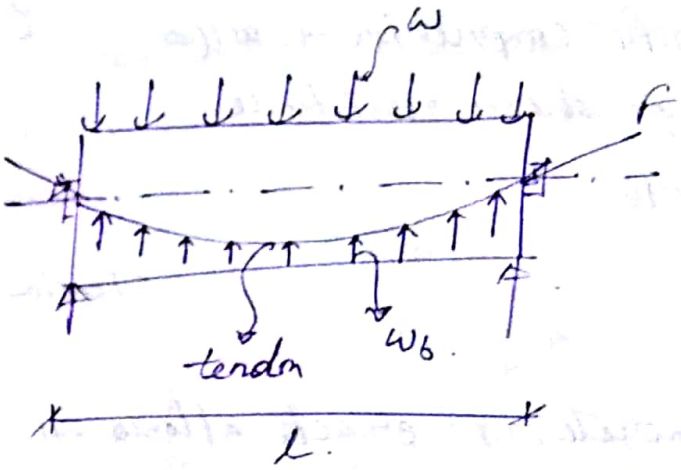
SHEAR, BOND, BEARING

Transfer of prestress to the member

- Through bond → Pre tensioned member
- " bearing → Post tensioned member

$$f_{y_0} = \frac{w_b L^2}{8}$$

$$\boxed{w_b = \frac{8Fh}{L^2}}$$



* $w_b = w$ হলে balanced section বলে।

$$w_b = \frac{8Fh}{L^2}$$

* F & h change করলে w_b ও w হতে পারে।

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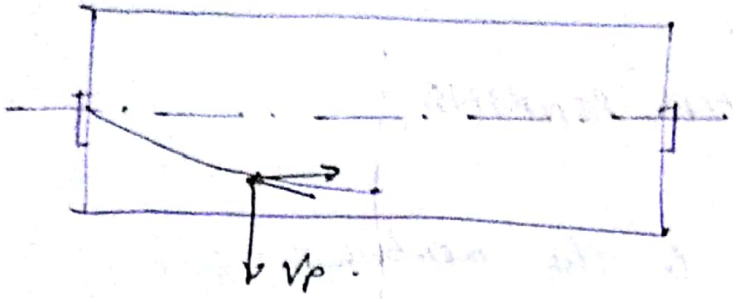
$V_u = V_p + V_s + V_c$

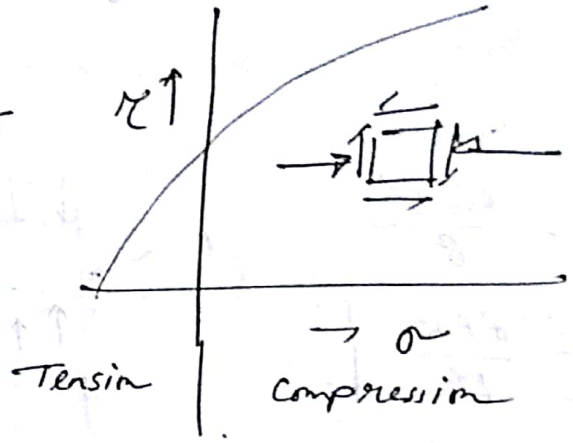


+ Prestressing steel থেকেই সাধারণ V_s মাত্রায় shear resistance করে থাকে.

V_c → concrete এর shear resistance

$V_c = 2\sqrt{f_c'}\, b_w d$

+ Concrete এর compression এ থাকে তার থাকে shear resistance বেড়ে যায়.



+ ~~Bar~~ concrete এর crack allow না করলে flexural bond important না.

+ crack allow করলেও flexural bond negligible মানের development bond থাকে.

+ সবচেয়ে important · transfer bond (transfer length)

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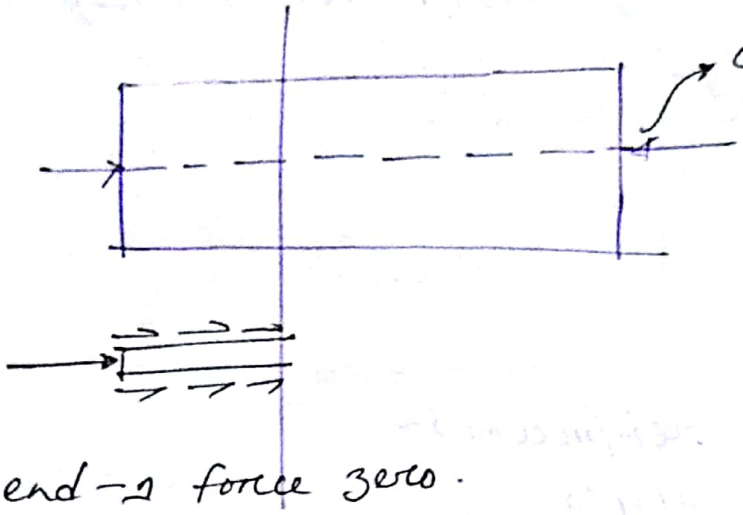
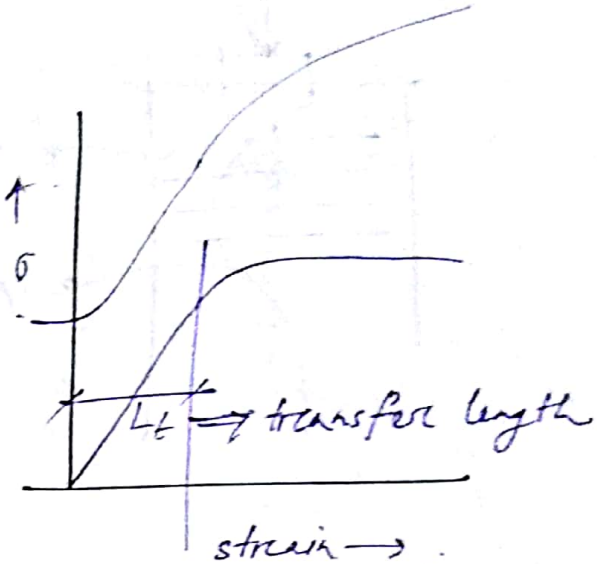
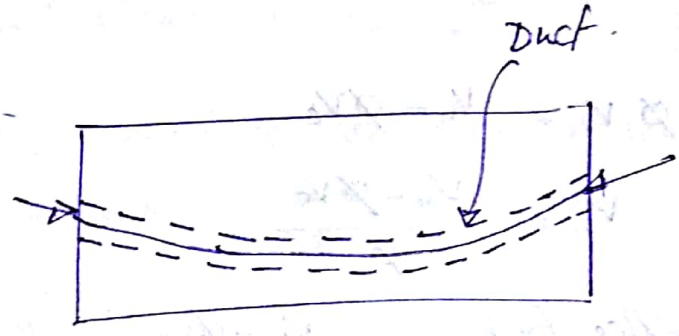
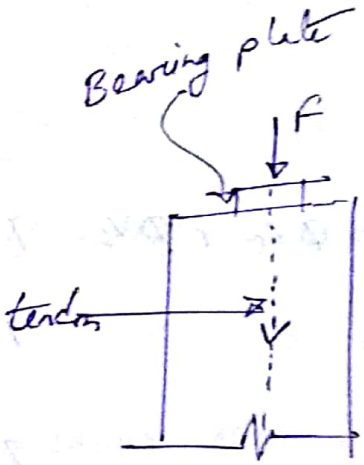


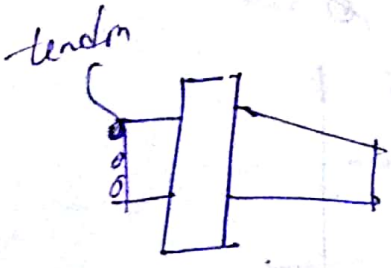
- end-এ force zero.
- stress transfer হওয়ার পর যতটা length প্রয়োজন → transfer length
- tendon-এর end-এ কোন থেকে stress Development-এর slip বা slip or কিছুটা sink করে,





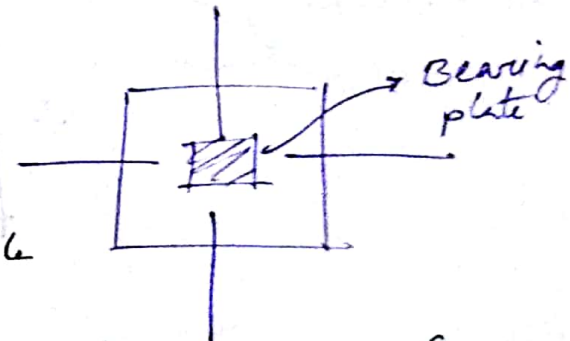


& force-transfer through bearing.



$\therefore f = \frac{F}{A}$.

Here, $f > f_{allowable}$



+ Bearing plate-এর area বড় করে stress কমান হয়, $f > f_{allowable}$ হলে concrete fail করতে পারে, তাই

P.T.O.

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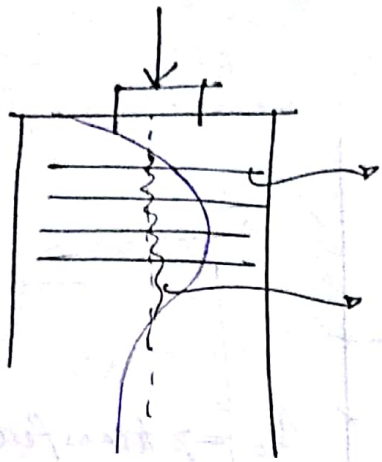
Bearing zone → compression এর ক্ষেত্রে concrete এর strength (f_c') বেড়ে যায়।



এখানে reinforcement বেশি লাগবে।
splitting হতে পারে সহজে।

Date – 16.07.18

Lec – 18

$V_u = \phi V_c + \phi V_s$. $\Rightarrow \phi V_s = V_u - \phi V_c$

$\Rightarrow V_s = \dfrac{V_u - \phi V_c}{\phi}$.

$\Rightarrow \dfrac{A_{ce} f_{yd}}{s} = \dfrac{V_u - \phi V_c}{\phi}$.

$\therefore \boxed{s = \dfrac{\phi A_{ce} f_{yd}}{V_u - \phi V_c}}$.

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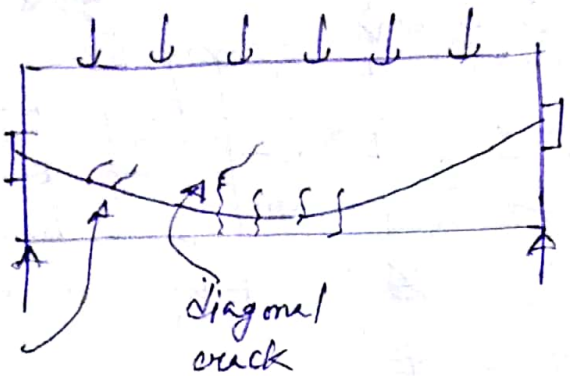


diagonal crack (flexure-shear crack)

web shear crack.

$$V_c = 2\sqrt{f_c'}\, b_w d$$

$$= \left(1.9\sqrt{f_c'} + \frac{2500\rho V}{d}\right) b_w d$$

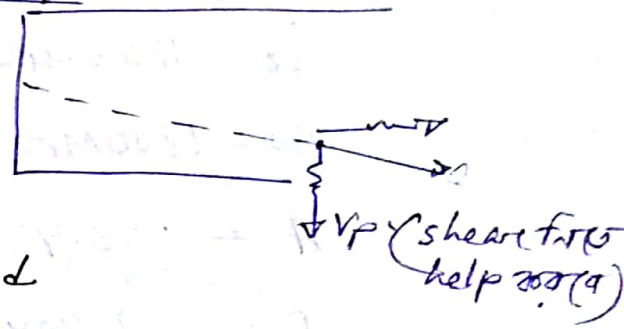
$$f_{pc} = -\frac{F}{A} - \frac{f_{ey}}{I}$$

Precompression

$$V_{cw} = \left(0.29\sqrt{f_c'} + 0.3 f_{pc}\right) b_w d + V_p$$

$$V_{ci} = 0.05\sqrt{f_c'}\, b_w d + V_d + \frac{V_i M_{cr}}{M_{max}}$$

$$\geq 0.14\sqrt{f_c'}\, b_w d$$



* Web shear → V_{cw} (mainly support এর কাছে)

* V_d composite section এর ক্ষেত্রে সাধারণত শূন্য, non-composite এ থাকলে থাকবে, $\frac{V_i}{M_{cr}}$

* $\frac{V_i}{M_{max}}$ → যে section এর shear কের করতে চাই সে section এ shear এবং moment ratio.

P-256.

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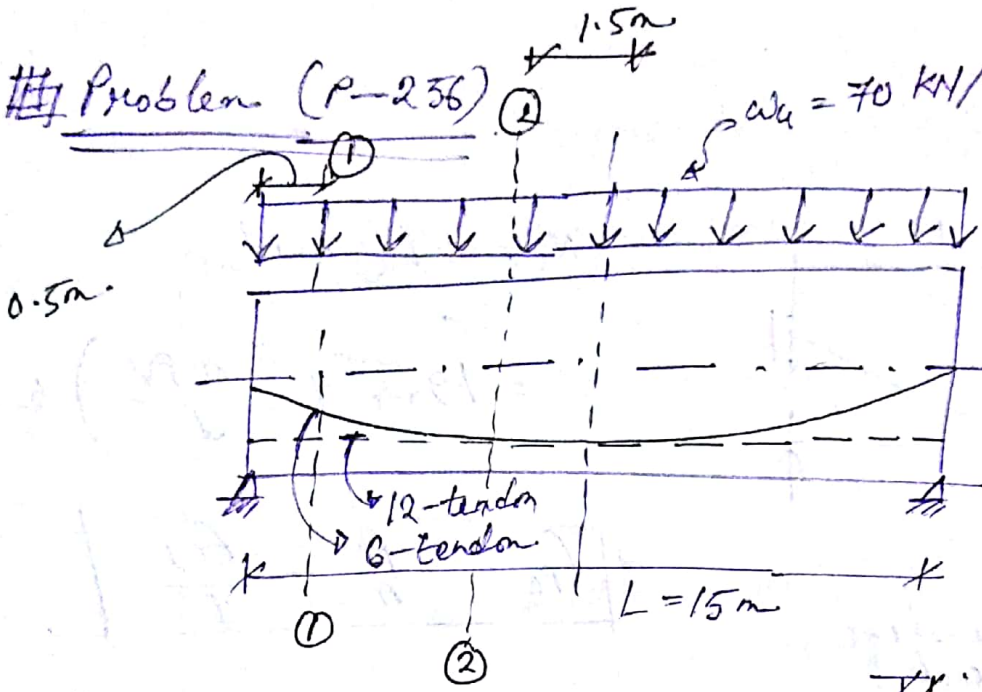
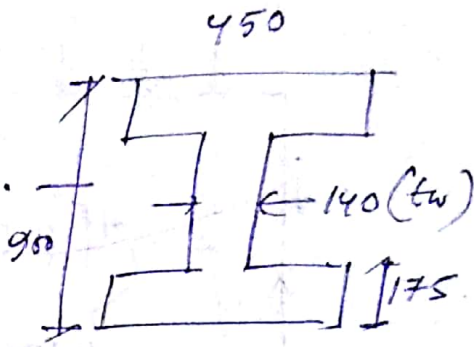
Problem (P-236)





Here,

$f_c' = 49 MPa$

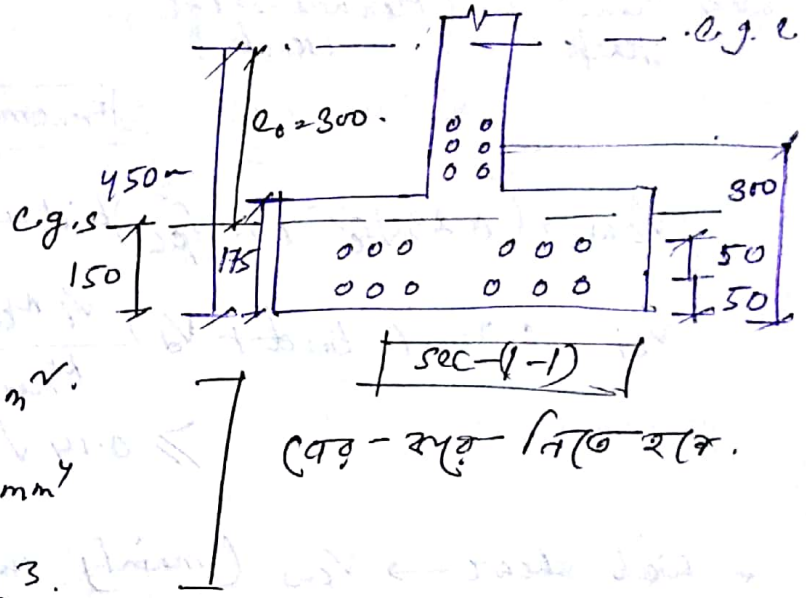
$f_{se} = 1105 MPa$

$f_{ps} = 1800 MPa$.

$A = 23.45 \times 10^4 mm^2$.

$I = 2.304 \times 10^{10} mm^4$

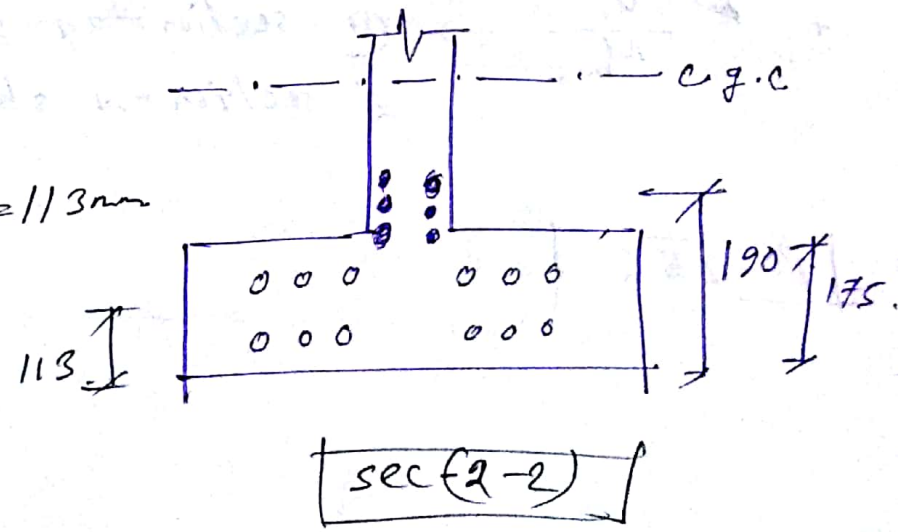
$S = 5.12 \times 10^7 mm^3$.



বেড় - সমূহ নিতে হবে.

$$\frac{6\times50 + 6\times100 + 6\times300}{18} = 150\,mm$$

$$\frac{6\times50 + 6\times100 + 6\times190}{18} = 113\,mm$$



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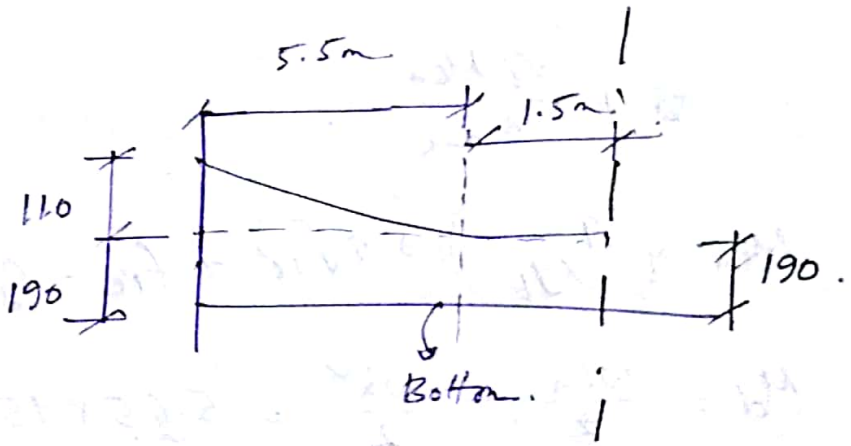
$$V_{cw} = (0.29\sqrt{49} + 0.3 f_{pc}) b_w d + V_p.$$

$$F_{se} = 1105 \times 1800 \cdot = 1989\ kN.$$

(f_{se} A_{ps})

$$f_{pc} = \frac{1989 \times 10^3}{23.45 \times 10^4} = 8.48\ MPa.$$

উক্ত নির্ণয় হয়েছে sec (1-1) [support ~~এ~~ হতে] V_{cw} ও V_p given আছে; BM - দুইটার check করতে হবে।



$$V_p = \frac{0.11}{5.5} \times 663 = 13.26.$$

$$\frac{V_{cw}}{A} = v_{cw(1-1)} = [0.29\sqrt{49} + 0.3 \times 8.48] + \frac{13.26 \times 10^3}{140 \times 750}$$

(stress, stress, force/area)

$$= 4.7\ MPa.$$

$140 \times 750 = bd$

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$V_{u(1-1)} = (7.5 - 0.5) \times 70 = 490$ KN.

$\theta_{u(1-1)} = \frac{490 \times 10^3}{140 \times 750} = 4.67 \text{ MPa} > \phi \theta_{cw}$.

$= 0.75 \times 4.7$.

$\therefore$ shear reinforcement required

$f_{pe} = \frac{1989 \times 10^3}{23.45 \times 10^4} + \frac{1989 \times 10^3 \times 327}{5.12 \times 10^7} = 21.57 \text{ MPa}$.

↳ section modulus.

$V_{ci} = 0.05 \sqrt{f_c'} b_w d + V_d$.

$+ \frac{V_i M_{cr}}{M_{max}}$.

$M_{cr} = \left(\frac{I}{y_t}\right)\left(0.5\sqrt{f_c'} + f_{pe} - f_d\right)$

$M_d = \frac{\omega L_n}{2} - \frac{\omega x^2}{2} = \frac{5.65 \times 15 \times 6}{2} - \frac{5.65 \times 6^2}{2}$.

self wt of beam

$= 153$ KN-m

$f_d = \frac{153 \times 10^6}{5.12 \times 10^7} = 2.99 \text{ MPa}$.

$V_{d\,2-2} = 5.65 \times 1.5 = 8.48$ KN.

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$$\frac{M_{max}}{V_i} = \frac{L_x - x}{L - 2x} = \frac{15 \times 6 - 6}{15 - 2 \times 6} = 18\,m$$

$$M_{cr} = \frac{I}{y_t}\left(0.5\sqrt{f_c'} + f_{pe} - f_{ci}\right)$$

$$= 5.12 \times 10^7 \left(0.5 \times \sqrt{49} + 21.57 - 2.99\right) = 1130\ KN\text{-}m$$

$$V_u = 70 \times 1.5 = 105\ KN.$$

$$V_{ci} = 0.05\sqrt{49} \times 140 \times 787 + V_d$$

$$= 48.48 + \frac{1130}{(18)} \rightarrow \frac{M_{max}}{V_i}$$

$$= 110\ KN$$

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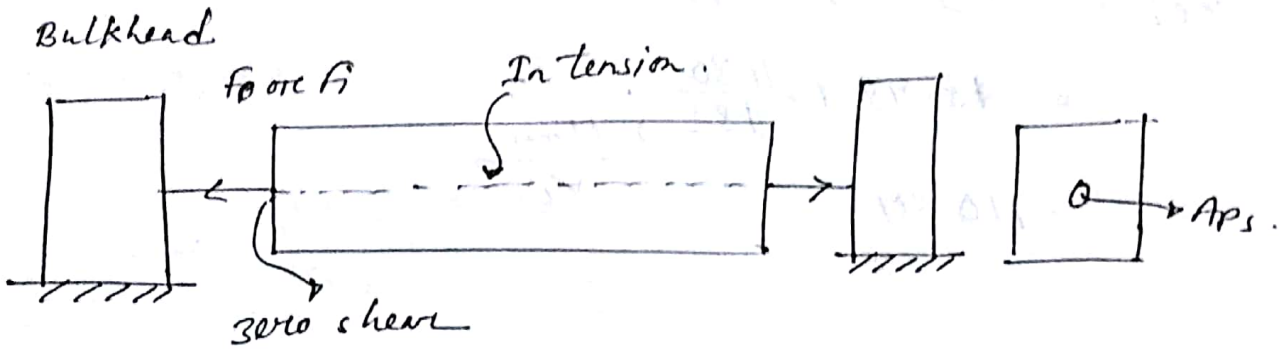
Lec-19

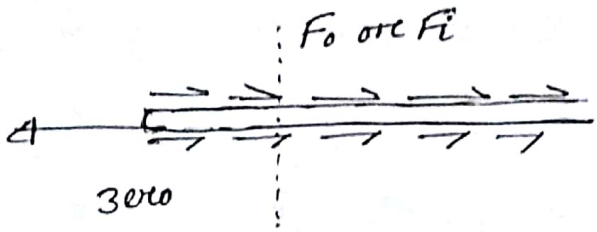
Date - 21.07.18

Bond :

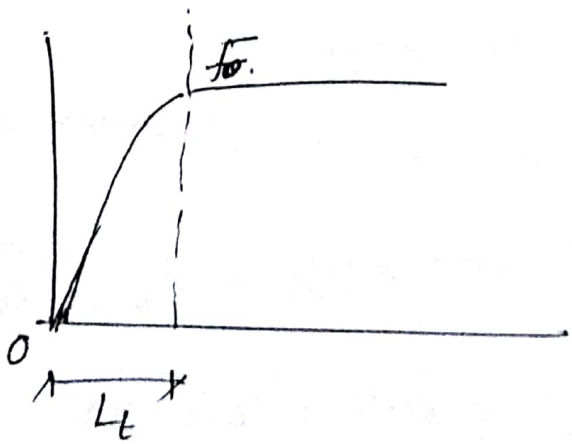
- Flexural bond
- Development "
- Bond at transfer

Page-267, 268, 269, 270, 271





$f = \frac{Fo}{A}$.



Transfer of stress through bond between steel & concrete.

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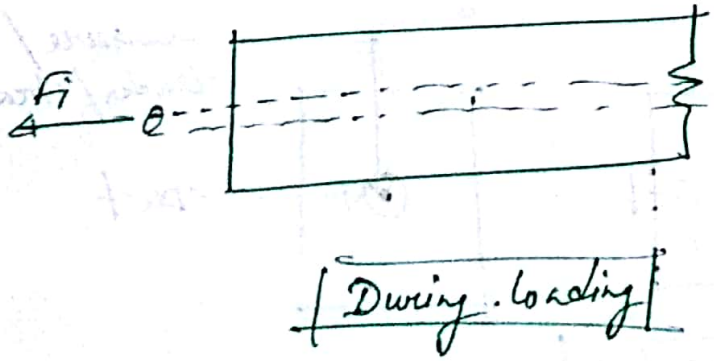
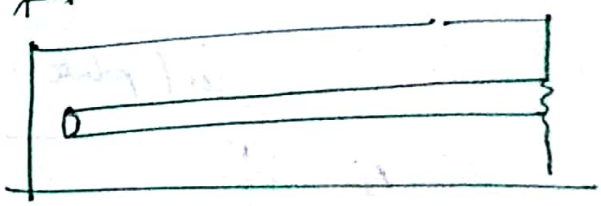
L_t depends on various factors —

- Individual ~~wire~~ wire
- Type of steel
- size of , (d_b)
- stress ~~of~~ level of steel.
- surface condition of steel.
- Concrete strength ($\sqrt{f_c'}$).
- Type of concrete.
- , , Release
- Confining reinforcement around steel.
- Time dependent effect (shrinkage)
- Consolidation and consistency of concrete around steel.
- Amount of concrete coverage around steel.



During loading

sinking of wire after transfer.



After release

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Dia of wire/strand — Initial

$$L_t = \frac{d}{2\mu}(1+m_c)\left(\frac{n}{m_s} - \frac{f_i}{E_c}\right)\frac{f_e}{2f_i - f_e}$$

f_e — Effective prestress in steel.

m_s — Poisson's ratio of steel.

μ — frictional co-efficient between steel and concrete.

#

Here,

$m_c = 0.1$

$m_s = 0.3$.

$n = 6$

$E_c = 35000\ MPa$

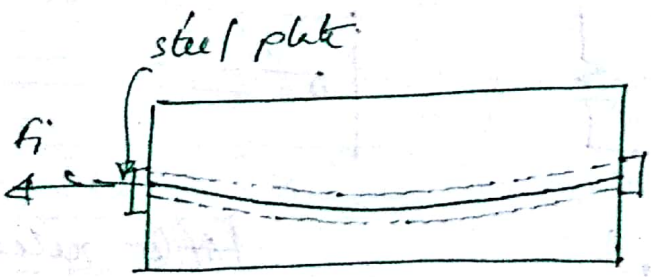
$f_i = 1035MPa$. (x)

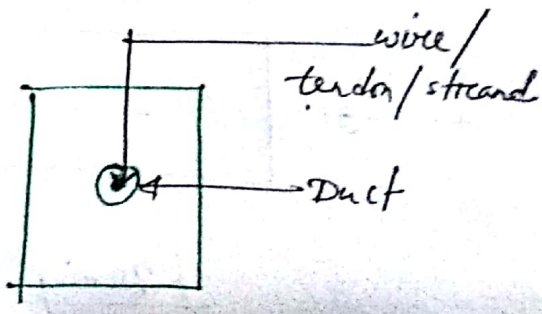
$f_e = 860MPa$.

$$L_t = \frac{8d}{\mu}.$$

value সূত্রে এমন হলে L_t এর formula use করা যাবে, তবে full formula এনে বসানো better

+ Pre-tensioned member এ prestress transfer হবে,





post-tensioned member

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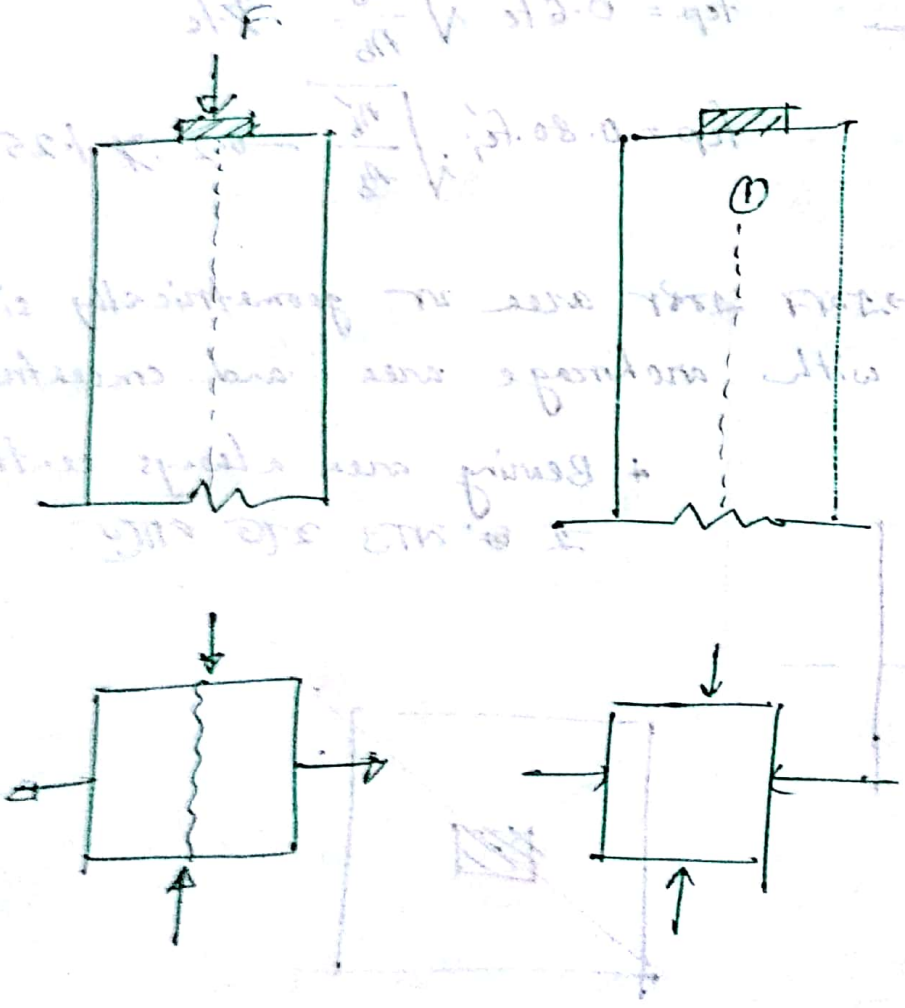
* Post-tensioned member → force transfer হয় through bearing

Lec-20

Date - 23.07.18

Bearing at Anchorage:

PP-274



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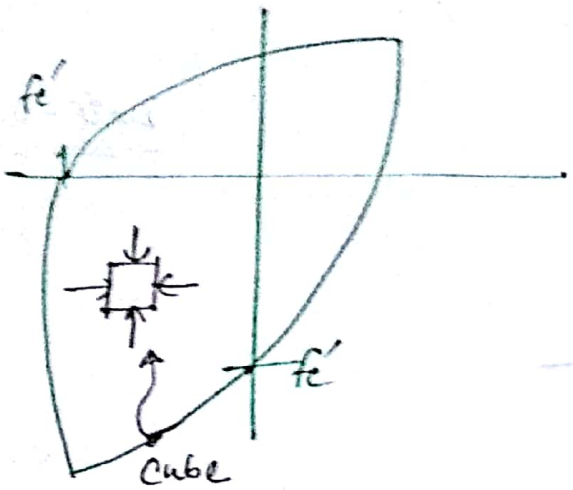
* f_c' তে fail করবে না
বরং bi-axial loading
এর সাপেক্ষে capacity
বেড়ে যায়।



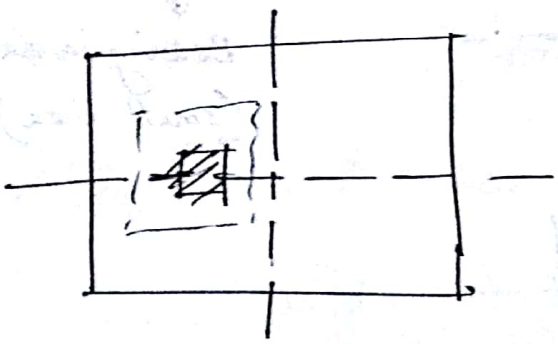
service load :

$$f_{ep} = 0.6 f_c' \sqrt{\frac{A_b'}{A_b}} \quad \not> f_c'$$

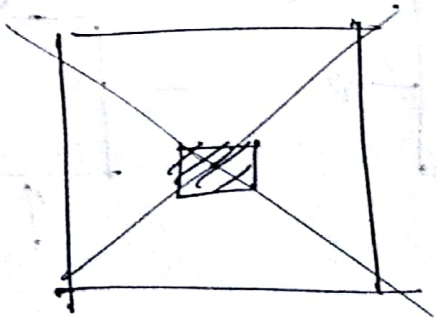
$$f_{ep} = 0.80 f_{ci}' \sqrt{\frac{A_b'}{A_b}} \quad -0.2 \quad \not> 1.25 f_{ci}'$$

$A_b' \geq A_b$. [A_b' → এমন এলাকা যা geometrically similar with anchorage area and concentric

+ Bearing area always center
এ থাকা ভাল।



geometrically symmetric



concentric

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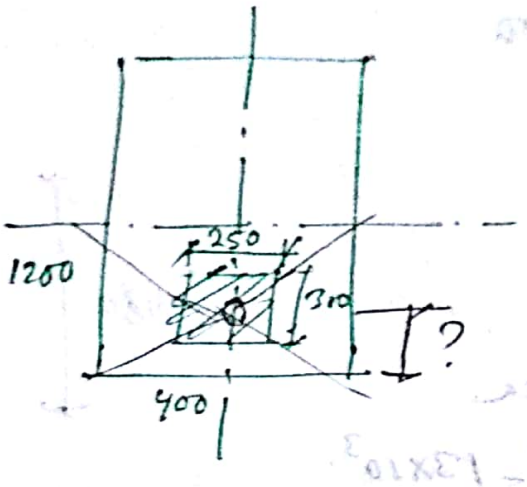
Problem



* 7-wire strand.
* tendon-12
* Dia 12.7mm.
* $f_{ci}' = 28\ MPa$
* $f_c' = 38\ MPa$.
* Tendon force. = ~~1700~~ 1770 kN. (jacking force)
  = 1320 kN (after losses)

Try 250×300 mm plate. $\frac{A_b'}{A_b} = 1.0$.

$$A_b = \frac{1320 \times 10^3}{22.8}$$

$$= 58 \times 10^3\ mm^2.$$

gross area = $58 \times 10^3 + 13 \times 10^3$ (13×10³ = 125Ø)

$$= 71 \times 10^3\ mm^2.$$

$$f_{cp} = 0.6 f_c' \sqrt{\frac{A_b'}{A_b}}.$$

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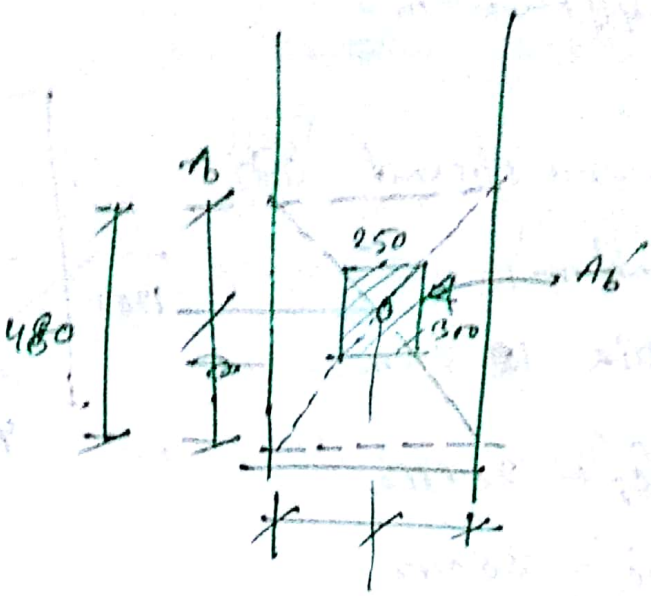
$A_b' = 480 \times 400$.

$= 192 \times 10^3$.



~~$f_{cp} = 0$~~.

A_b - net area

$= 75 \times 10^3 - 13 \times 10^3$.

$= 62 \times 10^3$.

$$f_{cp} = 0.80 f_{ci}' \sqrt{\frac{A_b'}{A_b}} - 0.2.$$

$$= 0.8 \times 28 \sqrt{\frac{192 \times 10^3}{62 \times 10^3}} - 0.2$$

$= 38 MPa > 1.25 f_{ci}'$

$1.25 f_{ci}' = 1.25 \times 28 = 35 MPa$

$f_{cp} = 35 MPa$.

$$A_b = \frac{1770 \times 10^3}{35} = 50 \times 10^3. \text{ [governs]}$$

$$f_{cp} = 0.6 f_c' \sqrt{\frac{A_b'}{A_b}} = 38 MPa \not> f_c'$$

$$A_b = \frac{1320 \times 10^3}{38} = 34.7 \times 10^3$$

net area $= 62 \times 10^3$.

further trial is required

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Lec-21

Date - 28.07.18

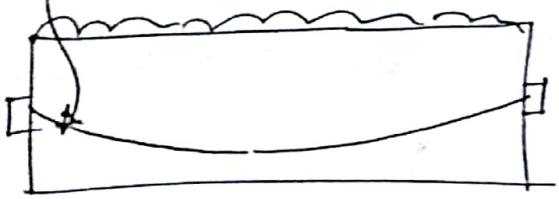
Chapter-8

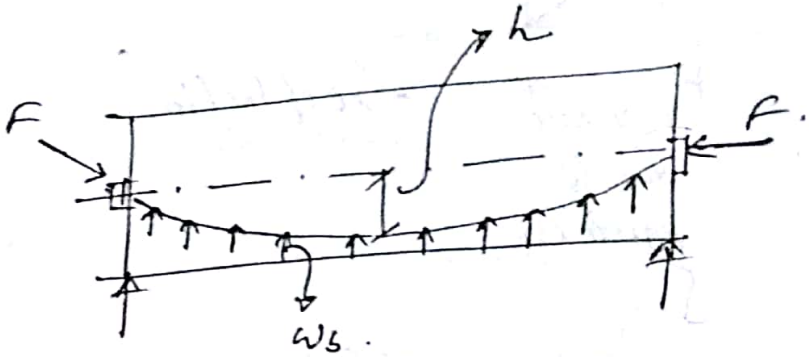
PP-290.

Camber, Deflection

Cable Layout.

Parabolic profile

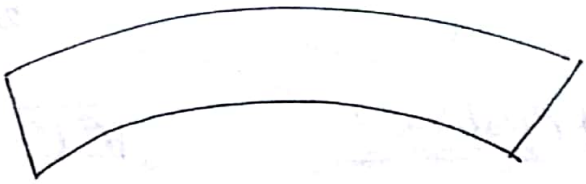




$$w_b = \frac{8Fh}{L^2}.$$

Here,

$h \rightarrow$ max^m sag.



$$w_{net} = w - w_b \quad [w_b < w]$$

Qs. calculate the value of P that will produce 1st crack in beam.

$$f = \frac{F}{A} \pm \frac{Fey}{I} \pm \frac{Mc}{I}.$$

$$f_{bot} = -\frac{F}{A} - \frac{Fey_{bot}}{I} + \frac{My_{bot}}{I}.$$

P.

$f_{bot} \rightarrow f_r$.

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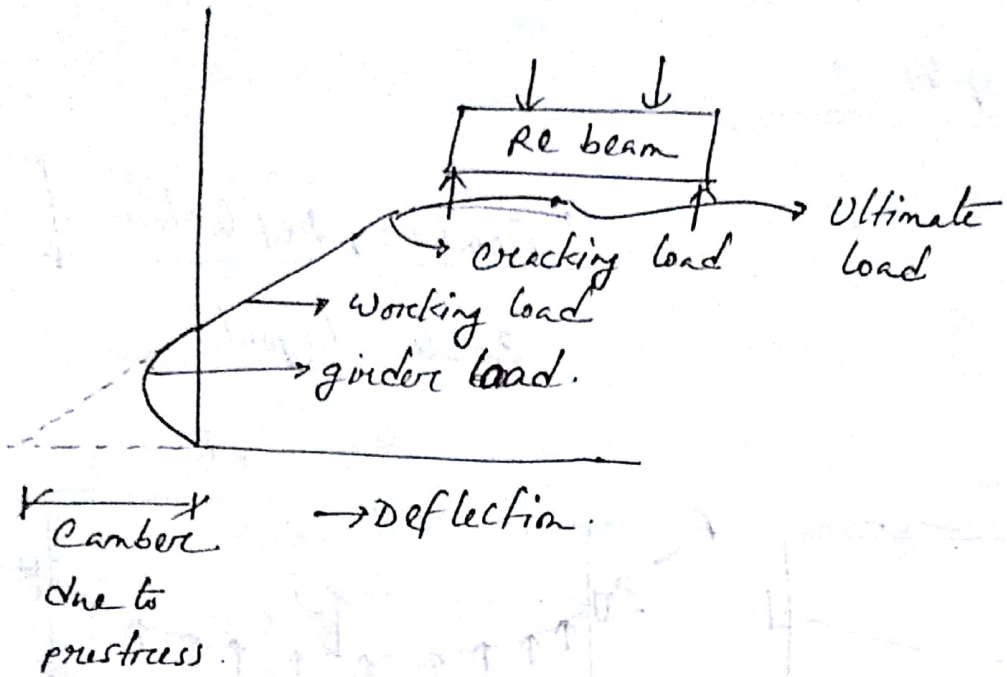
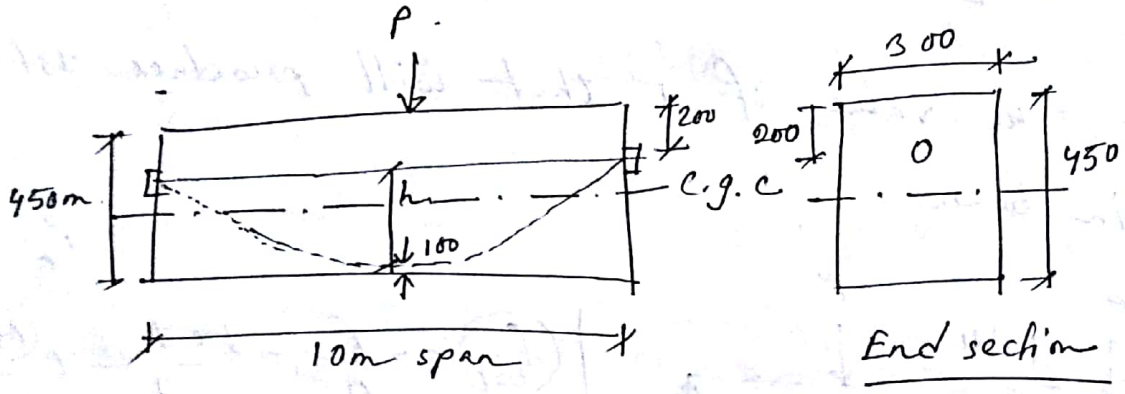


Creep effect → সময়ের concrete const. compression → সময়ের সাথে কমে,

Problem ÷ PP-295



Here, $A_{ps} = 780 mm^2$

$f_i = 965 MPa$

$f_{se} = 825 MPa$

$E_c = 28 \times 10^3 MPa$.

$C_c = 1.8$

∴ Deflection after 1.5 months.

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+ h → c.g. থেকে প্রান্ত পর্যন্ত দূরত্ব.

+ f মানের c.g. যদি উপরে থাকে the beam will experience downward deflection.

- Addition moment ; M = fe
- moment rectangular → fe
- moment-টি constant throughout the beam

Q.s. what will be the deflection at midspan

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Lec - 22

Date - 30.07.18

$w_{SLAB} = 1 \times 0.3 \times 0.45 \times 24 = 3.25 \text{ kN/m}$.

$M = 965 \times 720 \times 25 \times 10^{-6}$

$= 18.8 \text{ kN-m}$ (↓)

$\Delta_{prestress} = \frac{5}{384} \times \frac{(9.03 \times 10^3)(10^3)(10^3)^3}{2.8 \times 10^3 \times (22.8 \times 10^9)}$ → $(10 \times 1000)^3 \Rightarrow$ kN/m

$= (14.7 \text{ mm} \uparrow) \Rightarrow 14.43 \text{ mm}$.

$\Delta_{self} = \frac{5}{384} \times \frac{(3.25 \times 10^3) \times 10^3 \times (10^3)^3}{(28 \times 10^9) \times (22.78 \times 10^9)} = 6.6 \text{ mm}$

$\Delta_{self} = \frac{14.7 \times 3.25}{9.03}$

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for const. moment — $\Rightarrow \Delta_{max} = \frac{ML^2}{8EI} = \frac{18.8\times10^3\times1000\times(10\times1000)^2}{8EI}$

$= 3.7\text{mm}.$

$18.43 - 3.7 = 14.7\text{mm}$

$\Delta_{net} = 14.7 - 6.6 = 8\text{mm}$ [immediate deflection].

After 1.5 months $\Rightarrow C_t = 1.8$

Here, $18.43 \longrightarrow$ for w_6.
$3.7 \longrightarrow$ for moment (fixed)
$14.7(\uparrow)$.

$\left(14.7 \times \frac{825}{965} \longrightarrow \text{fcts} - 6.6\right) \times 1.8 = 10.7\text{mm}\ (\uparrow)$.
$\hookrightarrow f_i$

P = 45KN, calculate displacement:

$\Delta = \frac{PL^3}{48EI} = 14.7\text{ mm}\ (\downarrow)$.

section uncracked হলে এই formula applicable

— E will be changed due to material non-linearity.

— I " " " " " cracked section

1.5 months pore $\Rightarrow$ $14.7 - 10.7 = \boxed{4\text{mm}}$

P = 45 KN এ যে পরিমাণ deflection হবে সেটা temporarily

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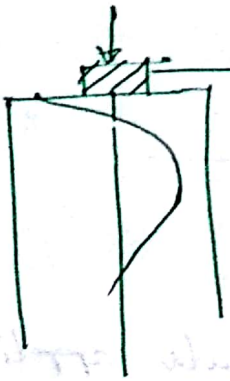
Imp for Exam.

- friction (Math)
- Prestressing loss (Theory — sources of prestressing loss)
- Composite section (Theory + full problem), full design.
- Preliminary design & final design.
- Determine cracking moment (or load)
- for different position of C how the stress distribution changes (Diff. stress condition — theory)
- T section or I section এর math ($M_n = \phi M_n = ?$)
- 

⇒ Brief description.
- Deflection এর problem
- Moment বের করে, stress determination or comp. section full design

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** Imp — shear (Bearing, Anchorage, transfer bond, bond)

- AASHTO PCI prestress conc. section
- shapes of conc. section
- Design with std precast section

- Elastic Design (conc. section) considering tension or without Tension.

- theory - elastic design concepts (general) (chapter-6)

- large ratio $\frac{M_G}{M_T}$, small ratio $\frac{M_G}{M_T}$.

** — Chapter 5 | Art 5-9 | प्रीस्ट्रेस - (math + theory)

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