Prestressed Concrete

Notes by-

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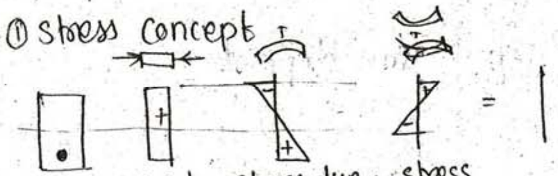
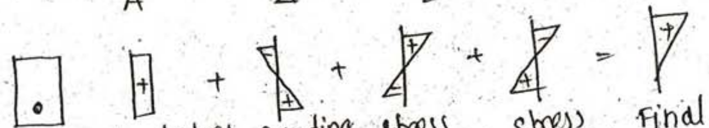
16M

Losses ~~in~~ PSC ECC	Formula. ....(m.x.l.	at transfer (Wd)	at working (WL)	Pre Ten.	Post Ten.	Time dependent
① Frictional loss	$\boxed{f_L = \cancel{f_{ei}}(\mu\alpha - k.l)P_i}$ ~~fei~~ = Pi = Initial prestressing force $\alpha = \frac{4e}{l}$ ... single $= \frac{8e}{l}$ ... Double	✓	✗	✗	✓	✗
② Slip of anchorage	$f = \frac{\Delta E_s}{l}$ $\Delta = \frac{Pl}{AE}$	✓	✗	✗	✓	✗
③ Shrinkage of concrete	$f = \varepsilon . E_s$ $\varepsilon = 300 \times 10^{-6}$ Pre $\varepsilon = \frac{200 \times 10^{-6}}{\log_{10}(t+2)}$	✓	✓	✓	✓	✓
④ Elastic shortening of concrete.	$f = m . f_c$ $f_c = f_1 + \frac{2}{3}(f_2 - f_1)$ $f_1 = \frac{P}{A}$, $f_2 = \frac{M}{Z}$	✓	✗	✓	✓	✗
⑤ Creep in concrete	$f = \cancel{f_c \times F_s \times \phi}$ $\boxed{\phi f_c \times m}$ $\phi = \frac{\text{creep strain}}{\text{Elastic strain}}$	✗	✓	✓	✓	✓
⑥ Creep in steel (Relaxation)	2% of Pi	✗	✓	✓	✓	✓

① Stress concept



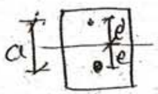
$\frac{P_i}{A}$ $\quad \frac{P_i \cdot e}{Z}$ $\quad \frac{M_d}{Z}$



$\frac{P_o}{A}$ $\quad \frac{P_i e}{Z}$ $\quad \frac{M_d}{Z}$ $\quad \frac{M_L}{Z}$

② P-line, C-line, thrust line, internal couple, strength concept

$a_1 = \frac{M_d}{P_i}$, $a_2 = \frac{M_L}{P_o}$

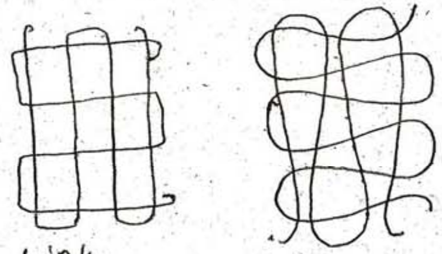


$e' + e = a$

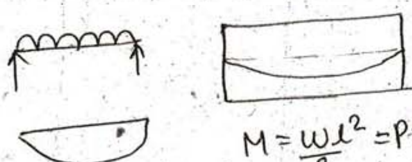
$\therefore e' = a - e$

stress due to DL $= \frac{P_i}{A} \pm \frac{P_i e'}{Z}$

stress due to LL $= \frac{P_o}{A} \pm \frac{P_o \cdot e'}{Z}$

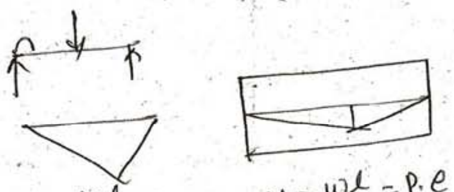


③ Load Balancing concept



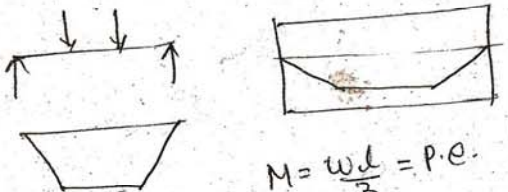
$\frac{wl^2}{8}$

$M = \frac{wl^2}{8} = P \times e$



$\frac{wl}{4}$

$M = \frac{wl}{4} = P \cdot e$



$\frac{wl}{3}$

$M = \frac{wl}{3} = P \cdot e$

① stress in concrete $= \frac{F}{\text{Area of concrete}}$

② stress in anchorage $= \frac{F}{\text{Area of anchorage}}$

$\ngtr 0.8 \times 0.8\, f_{ck}$

③ spacing $= \frac{0.8\, f_{ck} \times \text{Depth of beam} \times a_{st}}{0.3 \times F \left(1 - \frac{a_1}{2}\right)}$

o 8 @ 150 c/c.

* Design of end block.

Area of anchorage $= \frac{\pi}{4} (\text{Dia. of cone})^2$

① Bearing stress $= \frac{F}{\text{Area of anchorage}}$

$F =$ ~~stress~~ Force in each cable $= \frac{P}{n}$

② stress in concrete $= \frac{F}{\text{Area of concrete for each anchorage}}$

$\ngtr 0.8\, f_{ci}$

$\ngtr 0.8 \times 0.8\, f_{ck}$.

③ $\boxed{\text{Bursting Force} = 0.3 \times F \left[1 - \frac{a_1}{a_2}\right]}$

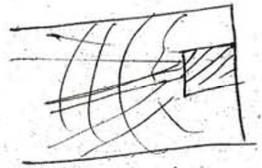
a_1 = side of anchorage

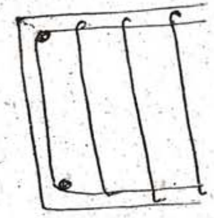
a_2 = side of concrete block.

④ Providing 8 mm dia. bar,

$\boxed{\text{spacing} = \frac{a_{st} \times 0.87 f_y \times \text{Depth of beam}}{\text{Bursting force}}}$

· Provide 8 @ 150 c/c vertical as well as horizontal to all faces of end block.





Find loss due to elastic deformation:-

a] simultaneous tensioning : No loss

b] Successive tensioning.

Cable 1 stretched - No loss

cable 2 ⇒ loss in 1 = m×fc

Cable 3 ⇒ Loss in 1 = m×fc

+ Loss in 2 = m×fc

Total loss = $\frac{3 \times m \times fc}{3}$

$fc = \frac{Pi}{A} + \frac{2}{3}\left(\frac{Pi \cdot e}{Z}\right)$

$A = 3\times10^4$ mm^2

$Pi = \cancel{1200 \times 5 \times \frac{\pi}{4}(50)^2}$ 1200×50

$= \cancel{7069\ kN}$ 60kN

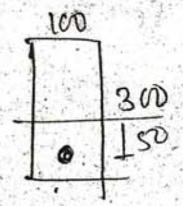
$I = 225\times10^6$ mm^4

$\therefore Pc = \frac{\overset{60}{\cancel{7069}}\times10^3}{3\times10^4} + \frac{2}{3}\left(\frac{\overset{60}{\cancel{7069}}\times10^3\times50\times50}{225\times10^6}\right)$

$= 2.67$ N/mm^2

Total loss $= \frac{3\times5\times2.67}{3} = 16$ N/mm^2

$\frac{145}{5.7}$)



5 No. × 7 dia

e = 50mm

fPi = 1200 N/mm^2

Es = 210

Ec = 35, ∅ = 1.6

Find loss due to creep in concrete.

$fL = \phi \times fc \times m$

$fc = \frac{Pi}{A} + \frac{Pi \cdot e}{I} \times y'$

$Pi = 1200\times5\times\frac{\pi}{4}\times7^2 = 231$ kN

$A = 3\times10^4$ mm^2

e = 50

$I = 225\times10^6$ mm^4

$\therefore fc = 10.23$

$\therefore fL = \phi \cdot fc \times m$

$= 10.23\times1.6\times\frac{210}{35}$

$= 98.24$ N/mm^2

cable 1 $fp = 720\left(0.35\times\frac{4\times100}{10\times10^3} - 0.0015\times10\times\right)$ (0.04)

$\frac{151}{5.9}$) $l = 10$m

$A = 30\times10^3$ mm^2

$Ast = 3\times200 = 600$ mm^2

$Pi = 1200$ N/mm^2

cable 1 : Parabolic e = 50mm at support & 50 mm at centroid.

cable 2 - Parabolic e = 0 at support, e = 50 at midspan

cable 3 - straight . e = 50mm.

one end Tensioned.

Find loss due to friction.

$\mu = 0.35$

$k = 0.0015$/m

$f_F = Pi(\mu\alpha - kl)$

$\alpha = \frac{8e}{l}$ → one side

$= \frac{4e}{l}$ → both end.

① Cable 1 :- ecc = 100 mm.

$\therefore f_{10} =$ Pi = 1200×600 = 720 kN.

$\mu = 0.35$

$\alpha = \frac{4e}{l}$

k = 0.0015/m

l = 10m

144 / 5.6

$P_i = 300\,kN$

$A_{st} = 300\,mm^2$

$E_s = 210\,kN/mm^2$

$t = 8$ days

$f_{shrinkage} = 8$

① $f_s = \varepsilon \cdot E_s$

$\varepsilon = 300 \times 10^{-6}$ Pre

$= \dfrac{200 \times 10^{-6}}{\log(t+2)}$ Post

$= 2 \times 10^{-4}$

7mm-13

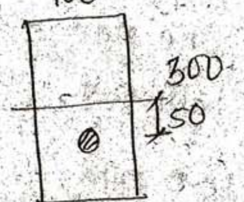
$f_{spre} = 300 \times 10^{-6} \times 210 \times 10^3$

$= 63\ N/mm^2$

$f_{post} = 2 \times 10^{-4} \times 210 \times 10^3$

$= 42\ N/mm^2$

137 / 5.1



$P_i = 150\,kN$

$e = 50\,mm$

$E_s = 210$

$E_c = 35$

$A_{st} = 188\,mm^2$

$m = \dfrac{E_s}{E_c}$

$= \dfrac{280}{3\sigma_{cbc}}$

Find loss due to Elastic deformat? of concrete.

$f_E = m \times f_c$

$f_c = f_1 + \frac{2}{3}[f_2 - f_1]$

$f_1 = \dfrac{P_i}{A}$ & $f_2 - f_1 = \dfrac{P_i \cdot e}{Z}$

$f_c = \dfrac{P_i}{A} + \dfrac{P_i \cdot e}{Z}$, $Z = \dfrac{I}{y}$

$A = 3 \times 10^4\,mm^2$

$I = 225 \times 10^6\,mm^4$

$y = 50\,mm = ecc.$

$Z = \dfrac{I}{y} = 4.5 \times 10^6\,mm^4$

$f_c = \dfrac{150 \times 10^3}{3 \times 10^4} + \frac{2}{3}\left[\dfrac{150 \times 10^3 \times 50}{4.5 \times 10^6}\right]$

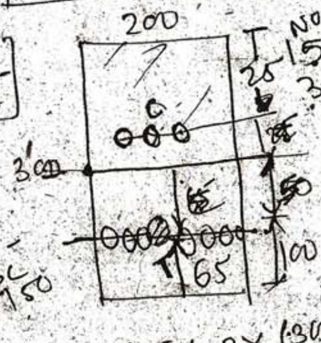
$= 6.67$

$f_E = \dfrac{210}{35} \times 6.67$

$\boxed{f_E = 40\ N/mm^2}$

$f_c = \dfrac{P}{A} + \dfrac{P_i \cdot e \cdot y}{I}$

138 / 5.2



No mm ecc

15 × 5 × 65 – bottom

3 × 5 × 25 – Top

$f_{pi} = 840\ N/mm^2$

$E_s = 210$

$E_c = 31.5$

$18 \times \frac{\pi}{4} \times 5^2 \times 840$

$\bar{y} = \dfrac{15 \times 65 + 3 \times (300 - 25)}{15 + 3} = 100\,mm$

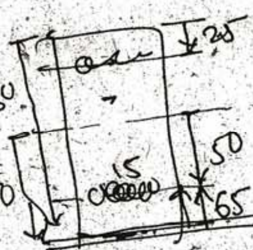
$f_E = m \times f_c$

$f_c = f_1 + \left(\dfrac{P_i \cdot e}{Z}\right)$

$P_i = 840 \times 18 \times \frac{\pi}{4}(5)^2$

$= 297\ kN$

$A = 6 \times 10^4\,mm^2$



$M =$

$I = 450 \times 10^6\,mm^4$

~~$y = 50\,mm$~~ $y = 85\,mm$ & $125\,mm$

At top level $= \dfrac{P_i}{A} - \dfrac{P_i \cdot e}{Z}$

$= \dfrac{297}{60} - \dfrac{297 \times 50 \times 125 \times 10^3}{450 \times 10^6}$

$f_{c1} = 0.825\ N/mm^2$

At bottom $= \dfrac{P_i}{A} + \dfrac{P_i \cdot e}{Z}$

$= \dfrac{297}{60} + \dfrac{297 \times 50 \times 85 \times 10^3}{450 \times 10^6}$

$f_{c2} = 7.755\ N/mm^2$

Loss at top $= m f_{c1}$

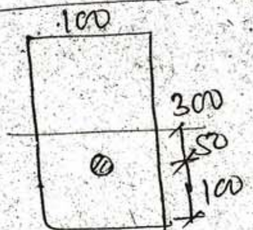
$= \dfrac{210}{31.5} \times 0.825$

$= 5.5\ N/mm^2$

Loss at bottom $= \dfrac{210}{31.5} \times 7.755$

$= 51.7\ N/mm^2$

139 / 5.3



3 × 50

$f_{pi} = 1200\ N/mm^2$

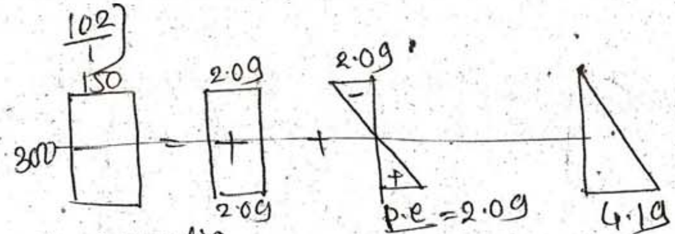
$e = 50\,mm$

$m = 6$

$\boxed{\text{Loss}}$

Name	Formula	at transfer	at working	Pre Ten.	Post Ten.	Time dep.
① Frictional loss	$f = (\mu\alpha - kl)\cdot P_i$ μ = coeff. of friction $\alpha = \frac{8e}{l}$ ⇒ Single side prestressed $= \frac{4e}{l}$ ⇒ Two end. K = wave effect l = length (m) ~ Note. P_i = Initial prestressing force	✓	✗	✗	✓	✗
② Loss due to slip of anchorage FSSECC	$f = \frac{\Delta E_s}{l}$ $\Delta = \frac{PL}{AE}$ $E_s = 210\ kN/mm^2$	✓	✗	✗	✓	✗
③ Elastic shortening of concrete.	$f = m \times f_c$ $\qquad f_c = \frac{P_i}{A} + \frac{P_i \cdot e \times y'}{I}$	~~✗~~ ✓	✗	~~✗~~ ✓	✓	✗
⑤ Shrink Creep in concrete	$f = m \cdot f_c \cdot \phi$ $\qquad m = \frac{E_s}{E_c} = \frac{280}{3\sigma_{cbc}}$ $\phi = \frac{\text{creep strain}}{\text{Elastic strain}}$	✗	✓	✓	✓	✓
⑥ Shrinkage in concrete	$f = \varepsilon \cdot E_s$ $\varepsilon = 300 \times 10^{-6}$ → Pre $\varepsilon = \frac{200 \times 10^{-6}}{\log(t+2)}$ $\quad t$ = No. of days.	✓	✓	✓	✓	✓
⑥ Relaxation in steel	1% of initial prestress.	✗	✓	✓	✓	✓

$\frac{102}{1}$



$\frac{P.e}{Z} = 2.09$

4 wire x5 dia

$f_{Pi} = 1200\ N/mm^2$

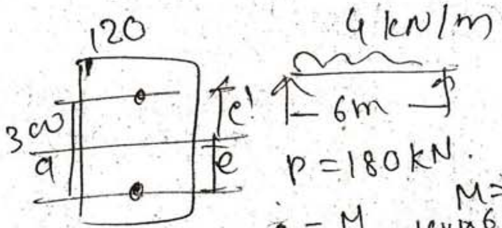
$e = 50\ mm$,

$P = 94.25\ kN$.

$A = 45 \times 10^3\ mm^2$

$I = 337.5 \times 10^6\ mm^4$

4.6



$P = 180\ kN$.

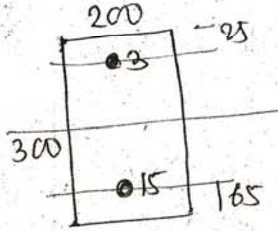
$M = \frac{wl^2}{8} = 18$

$a = \frac{M}{P} = \frac{18 \times 10^6}{180}$

$a = 100\ mm$ at centre

at support $= 0$

$\frac{103}{2}$



$f_{pi} = 840$

6 m.

$W_L = 6\ kN/m$.

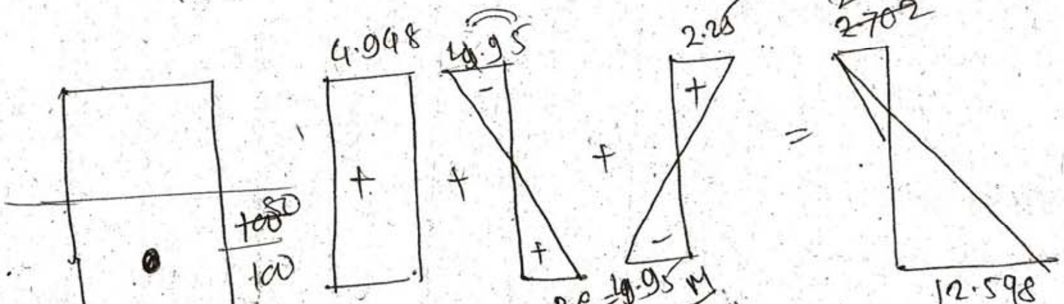
$\gamma = 24\ kN/m^3$

$\bar{y} = \frac{15 \times 65 + 3 \times 275}{18} = 100\ mm$

$w_d = 25 \times 0.06$

$= \cancel{0.15}\ 1.5$

$M_d = \frac{1.5 \times 6^2}{8} = 6.75$



$\frac{P.e}{Z} = 19.95$ $\frac{M}{Z}$

$P_i = 840 \times 18 \times \frac{\pi}{4}(5)^2$

$= 297\ kN$

$A = 60 \times 10^3$

$I = 450 \times 10^6$ $Z = 3 \times 10^6$