CMR
INSTITUTE OF
TECHNOLOGY

USN | | | | | | | | | |

Internal Assessment Test 1 – September 2016

Sub:	Design of Pre-stressed concrete structure					Code:	10CV74
Date:	08/09/16	Duration:	90 mins	Max Marks:	50	Sem: 7	Branch: CV

Note: **Answer any FIVE Full questions. Use of IS 1343 -1980 is Permitted**

1 a	Define Pre-stressed Concrete? State its advantage over RCC?	05
b	Distinguish between pre-tensioning and post tensioning	05
2 a	Explain Load balancing concept in pre-stressed concrete members	05
b	What is Pressure Line? Explain its Significance?	05
3 a	List out Various Types of Losses under Pre tensioned and Post tensioned members? Identify which are immediate Losses and which are Time dependent losses?	04
b	Give computational Formula either based on IS Code 1343 -1980 or from first principle for pre-stress Losses under (a) Elastic Shortening (b) Creep (c) Shrinkage in Concrete	06
4	A rectangular concrete beam 150mm x 450mm deep spanning over 12 m is pre-stressed by a straight cable carrying effective pre-stressing force of 400 KN. The wire is located at an eccentricity of 100 mm below CGC (neutral axis). Beam carries a live load of 2.4 kN/m. (A) Calculate the resultant Stress distribution for center of span cross section, concrete density is 24kN/Cum.	07
	(B) Find the magnitude of the pre-stressing force, under same loading condition if bottom fiber stress (soffit) is ZERO at mid span	03
5 (3kN/m)	A PSC beam with rectangular section 120mm x 300mm deep supports a uniformly distributed load of 5 kN/m, which includes self weight of the beam. The effective span of the beam is 8 m. The beam is CONCENTRICALLY pre-stressed by a cable carrying a force of 200KN. Locate the position of the pressure line in the beam at support, quarter span and mid span. Plot the pressure or thrust line	10
6 (250 sq mm)	A pre-tensioned concrete beam 200mm x 300mm and span 6m is initially pre-stressed by a force of 400 kN applied at a constant eccentricity of 70mm by tendons of area 700 sq.mm If Es = 2x10^5 N/ mm^2 and Ec = 0.333 x 10^5 N/mm^2, Creep coefficient in concrete = 2.0, Shrinkage strain in concrete is 0.0003, Determine Loss of Pre-stress due to Elastic shortening of Concrete, Shrinkage and Creep. Assume any data missing suitably. What is the Total % Loss of Pre0stress	10
7	A post tensioned PSC beam 100mm x 300mm deep, spanning 10m, simply supported is stressed by successive tensioning and anchoring of three cables. The cross sectional areas of each cable are 250 sq mm. The initial stress in the cable is 1350 N/sq mm, modular ratio is 6. The first cable is parabolic having eccentricity 50mm below CGC at mid span and 50mm above CGC at support. The second cable is parabolic having zero eccentricity at support and 50mm below CGC at mid span. The last cable is straight having constant eccentricity of 50mm below CGC. Estimate the percentage loss of pre-stress in each of the cables.	10

CI Approved CCI

CMR Institute of Technology

Page I

CIVIL

TEST no 1

8/9/16.

10CV74

1 a Define prestressed concrete? State its advantage over RCC. — (5)

— Prestressed concrete is a concrete structure where Internal stresses of suitable magnitude & distribution are introduced so that the stresses resulting from External Loads are counteracted to a desired degree. In RCC members, the prestress is commonly Introduced by tensioning the steel reinforcement. — 2 —

Advantages of PSC vs RCC

(1) In case of fully prestressed members, which are free from tensile stress, the CS is more efficiently utilized.

(2) It is more resistant to shear, in case of curved Cable — For long span members.

(3) It is more stiffer under working loads

(4) The use of HTS & Highest concrete results in lighter & slender sections.

(5) Good resistance to Impact load

(6) Cost of foundation reduces, due to less Dead load.

(7) More economical for long span Bridges.

6 x 1/2 = (3)

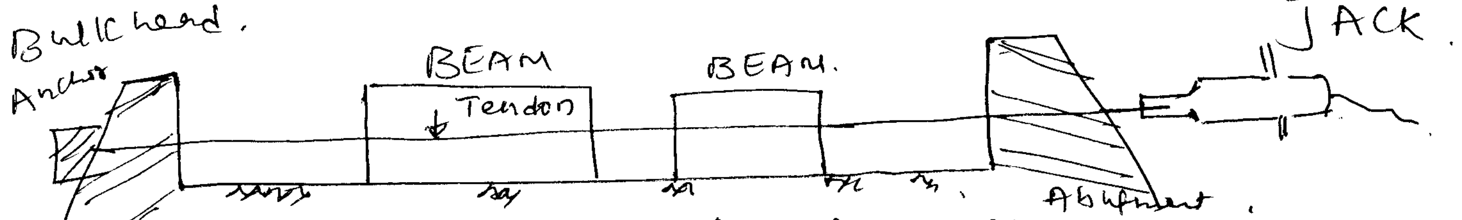
I B

Distinguish between pre tensioning & post Tensioning. (5)

→ 2 Page.

2 Pgs

Pretensioning System



Hoyer's Long line System.

Here The Tendon's are first tensioned between Rigid anchor Blocks, cast on the ground, prior to The Casting of concrete in the mould. When the Concrete attains sufficient strength, the jacking pressure is released. The tendons tend to shorten but are checked by the bond between Concrete & Steel. In this way pre-stress is transferred to The Concrete by bond.

(2½) The loss of prestress is due to elastic shortening of Concrete, ~~[illegible]~~, Shrinkage & creep.

For mass production, Hoyer method is adopted in the manufacture of electric poles, Railway Sleeper, prefab elements of Bridge - VUP, PUP, Box Culvert etc.

POST TENSIONING

In post tensioning the Concrete units are first cast by incorporating ducts or grooves to house the tendons. When the concrete attains sufficient strength the HTS wires are tensioned by means of Jack & anchored. The forces are transmitted to the concrete by means of end anchorage and when the cable is curved, Through the radial pressure between the cable & the duct. The space between the cable & the duct is generally grouted After Tensioning operation.

(2½)

- Prestress loss due to creep, shrinkage, relaxation of stress in steel, Friction, Anchorage slippage + elastic shortening if cables are tensioned one after the other.
- Suitable for Medium to long span In situ works - Bridges.

Page III   3 page.

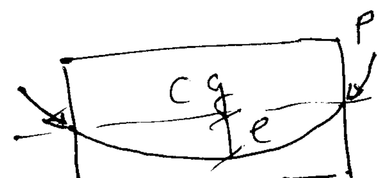
2a Explain Load Balancing Concept in PSC member – (05)

— Useful in selection of cable profile, which can supply the most desirable system of forces in concrete.

— It is possible to select suitable cable profile in PSC members such that the transverse component of the cable forces balances the given type of external loads.

(2)

→ This is illustrated by considering the free body of concrete, with the tendon replaced by forces acting on the concrete beam as below.



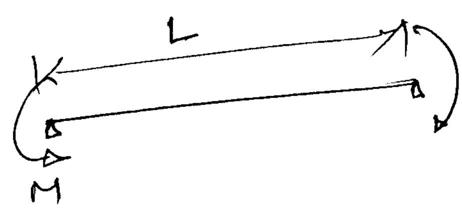
Tendon profile.

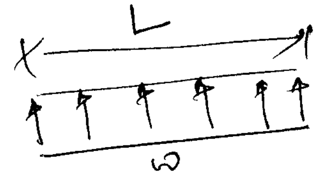
$W = \frac{8Pe}{L^2}$

Equivalent moment load.

$M = Pe.$

Equivalent loading

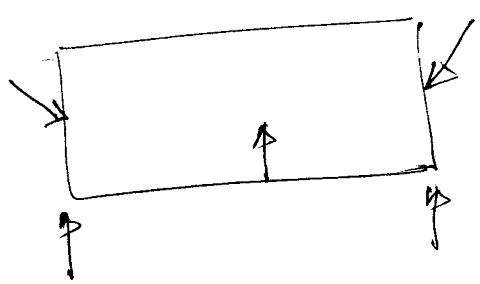


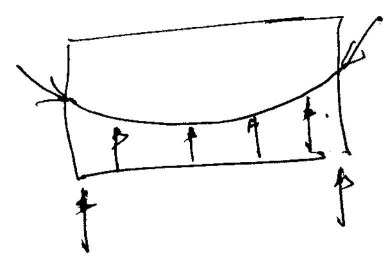


(3)

Camber $\frac{ML^2}{8EI}$. $\frac{5WL^4}{384EI}$.

Reaction of cable on beam.





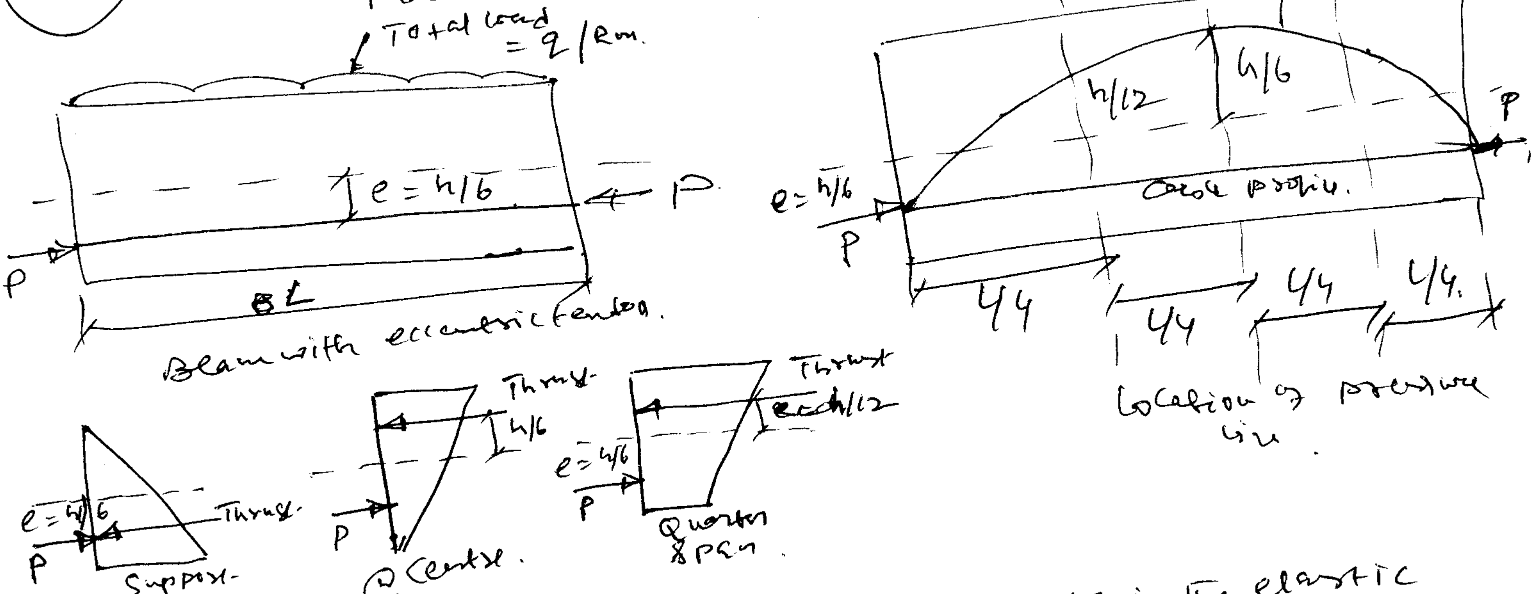
Q b. What is pressure line ? Explain its significance?

— At any given section of a prestressed concrete beam, the combined effect of the prestressing force and the externally applied load will result in a distribution of concrete stresses which can be resolved into a single force. The locus of application of this resultant force in any structure is termed as the "pressure line or thrust line"

Significance

- Useful in understanding the load carrying mechanisms of a PSC section.
- The location of pressure line depends upon the magnitude and direction of the moments applied @ the c/s and the magnitude and distribution of stress due to prestressing force.

(2)



- A change in the external moments in the elastic range of PSC beam results in the shift of the pressure line rather than in an increase in the resultant force in the beam.

(2)

→ In RCC st → constant lever arm, with increase of ~~load for~~ thrust for any external increase in load.

In PSC → Constant internal thrust for changing or shift in lever arm (a)

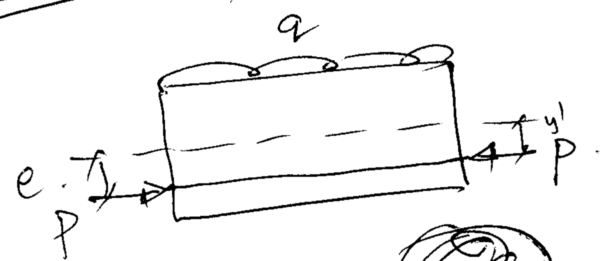
Q 3a List out various types of losses under pre tensioned & post- tensioned members & Identify which are immediate losses & which are time dependent losses — 04

(4) marks

#	PRETENSION	POST TENSION.
A	IMMEDIATE	Immediate.
1	Loss due to elastic deformation of concrete.	(1) — No loss due to elastic deformation if wires are pulled simultaneously. If the loss will be there if wires are pulled successively.
2		(2) Friction loss.
		(3) Anchorage slip.
(B)	TIME DEPENDENT	Time dependent
		(4) Shrinkage of concrete.
(2)	Shrinkage of concrete	(5) Creep of concrete.
(3)	Creep of concrete.	(6) Creep in steel or loss due relaxation of stress in steel.
(4)	Creep in steel or loss due relaxation of stress in steel.	

3B a) Elastic Shortening.

pretensioned.



$Loss = m f_c$.

m = modular ratio = $\frac{E_{st}}{E_{concrete}}$.

f_c = Stress in concrete @ the level of steel.

(2)

Post tensioned.

= 0 If cables are pulled simultaneously.

Computation should be carried for each cable if they are stressed successively & added losses.

$$f_c = \frac{P}{A} \pm \left(\frac{Pe}{I}\right)e \pm \left(\frac{M_q}{I}\right)y'$$

(3)

Creep

Loss due to creep $= \phi m f_c$ — IS code method.

ϕ = creep coefficient, $\phi = \frac{\epsilon_{cc}}{\epsilon_{Es}} = \frac{\text{ultimate creep strain}}{\text{Elastic limit str}}$

(2) depends on age of transfer.

for 28 days — $\phi = 1.6$.

Shrinkage

Pre tensioned $= (0.0003) \times E_{st}$ — (1).

Post tensioned $= \left\{ \frac{0.0002}{\log_{10}(t+2)} \right\} \times E_{st}$ — (1).

t = age of concrete of transfer.

PSC

TEST NO 1 — Page VIII 7

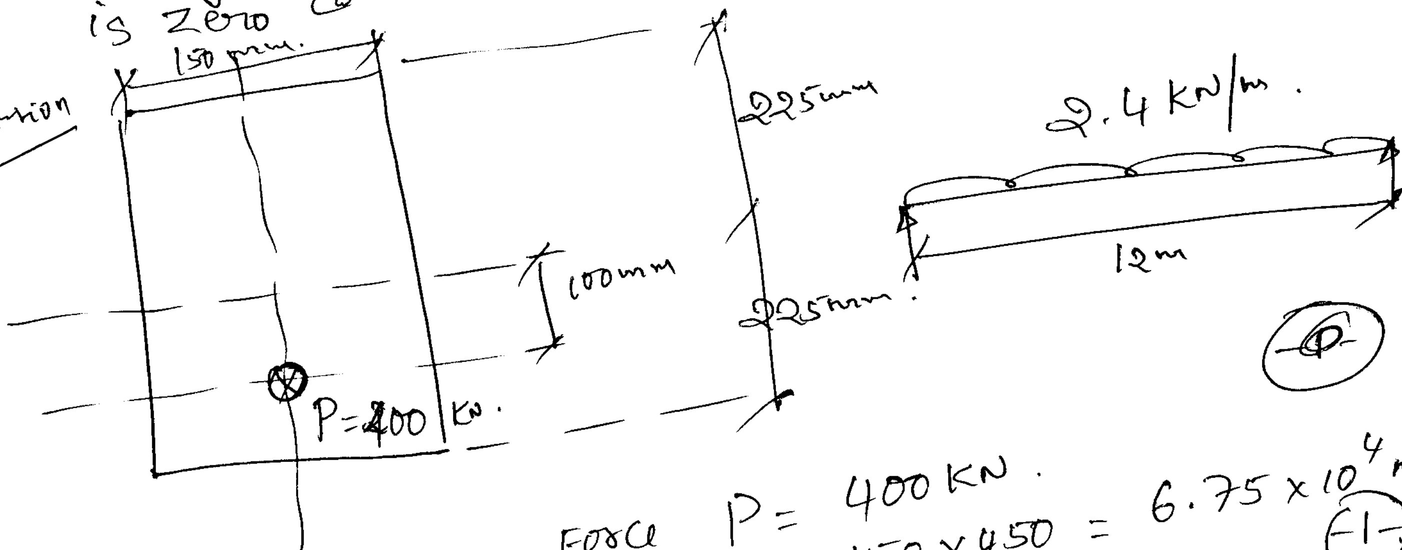
Solution

Q4 A rectangular concrete beam 150 x 450 mm deep, spanning over 12 m is prestressed by a single st cable carrying effective prestressing force of 400 KN. The wire is located @ an eccentricity of 100 mm below CGC, LL = 2.4 KN/m.

a) Calculate the resultant stress distribution for centre of span cross section, density of concrete = 24 KN/cum. — (7)

b) Find the magnitude of the prestressing force under same loading conditions of the bottom fibre stress (Soffit) is zero @ mid span — (3)

Solution



(2)

Data

prestressing force $P = 400\,KN$.

Cross sectional Area $= 150 \times 450 = 6.75 \times 10^4\,mm^2$ (1)

eccentricity $e = 100\,mm$.

(1) Self wt of the beam $= 0.15 \times 0.45 \times 1 \times 24 = 1.62\,KN/m$. (1)

(2) Live load on the beam $= 2.4\,KN/m$.

Total load $= DL + LL = 1.62 + 2.4 = 4.02\,KN/m$.

(3) Section modulus $= Z_{xx} = \frac{bd^2}{6} = \frac{150 \times 450^2}{6}$

$= 5.0625 \times 10^6\,mm^3$. (1)

(4) Bending moment @ centre span $= \frac{wl^2}{8} = \frac{4.02 \times 12^2}{8} = 72.36\,KN\text{-}m$ (1)

Bending Stress $= \pm \frac{M}{Z}$

$= \frac{72.36 \times 10^6}{5.0625 \times 10^6}$ N/mm²

$= \pm$ 14.29 N/mm²

Stresses due to prestress

$= \frac{P}{A} \pm \frac{Pe}{Z}$

$= \frac{400 \times 10^3}{6.75 \times 10^4} \pm \frac{400 \times 10^3 \times 100}{5.0625 \times 10^6}$ N/mm²

$= 5.9259 \pm 7.90123$

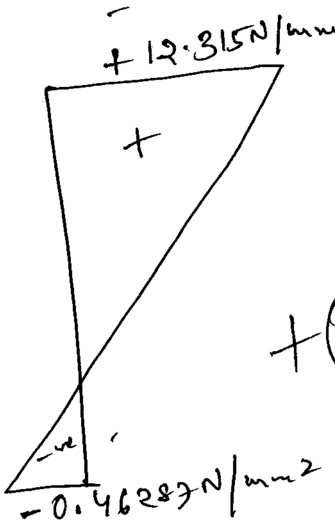
Resultant Stress @ mid span.

Top Fibre = 5.9259 − 7.90123 + 14.29

= 12.315 N/mm².

Bottom Fibre = 5.9259 + 7.90123 − 14.29

= −0.46287 N/mm²



(2) + (1) = (7)

Part B

If P_x = prestressing force required to balance the stresses @ soffit then

$$\frac{P}{A} + \frac{Pe}{Z} - \frac{M}{Z} = 0.$$

$$\frac{P}{A} + \frac{Pe}{Z} = \frac{M}{Z}.$$

$$P_x\left[\frac{1}{A} + \frac{e}{Z}\right] = \frac{M}{Z}.$$

$$P\left[\frac{Z + Ae}{AZ}\right] = \frac{M}{Z}$$

$$P = \frac{M \times A}{(Z + Ae)}$$

$$= \frac{(72.36 \times 10^6) \times (6.75 \times 10^4)}{(5.0625 \times 10^6 + 6.75 \times 10^4 \times 100)}$$

$$= \frac{4.8843 \times 10^{12}}{413485.7143}$$

(3)

$$P_x\left[\frac{1}{6.75 \times 10^4} + \frac{100}{5.0625 \times 10^6}\right] = \frac{72.36 \times 10^6}{5.0625 \times 10^6}$$

$$P_x\left[3.456 \times 10^{-5}\right] =$$

$$P_x\left[1.481481 \times 10^{-5} + 1.975308642 \times 10^{-5}\right] = 14.29$$

$$3.45 \times 10^{-5} P = 14.29$$

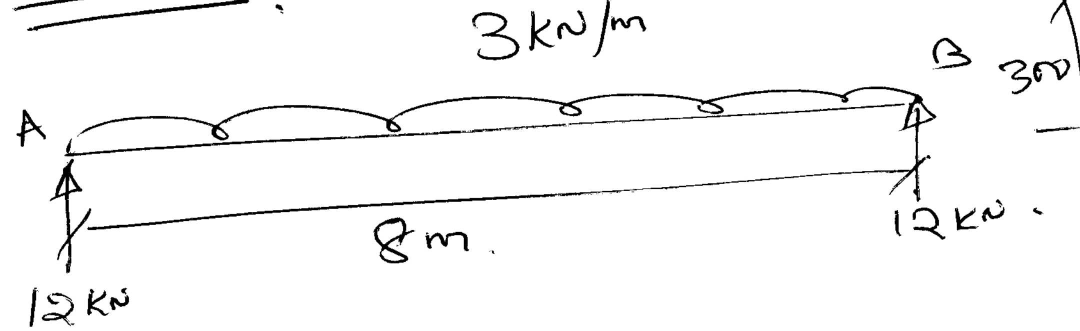
$$P = \frac{14.29}{3.45 \times 10^{-5}} = \frac{14.29 \times 10^5}{3.45}$$

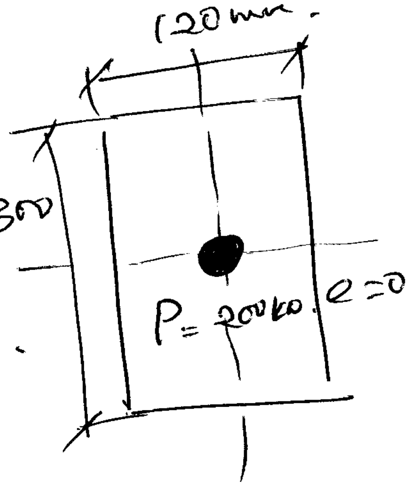
4.142×10^5 N

4.142×100

= 414.2 kN

Q NO5





Assume Beam is simply supported.

Prestressing force = 200 KN.

eccentricity e = 0.

Area of c/s = $120 \times 300 = 36 \times 10^3 \, mm^2$

$Z_t = Z_b = \frac{120 \times 300^2}{6} = 18 \times 10^5 \, mm^3$.

To calculate BM due to LL + DL.

At support M = 0.

At mid span = $\frac{wl^2}{8} = \frac{3 \times 64}{8} = 24 \, kN\text{-}m$.

At Quarter span, $M = 12 \times 2 - 3 \times 2 \times 2/2$

$= 24 - 6 = 18 \, kN\text{-}m$.

Stress calculations.

Direct stress due to prestress $= \frac{P}{A} \mp \frac{Pe}{Z}$

as $e = 0$, $\sigma_D = P/A$.

Constant Stress $= \frac{200 \times 10^3}{36 \times 10^3} = 5.55 \, N/mm^2$

Bending Stress — LL + DL

At Support, $M = 0$, Stress $= 0$.

At Quarter Span, $\sigma_b = \pm M/Z = \dfrac{18 \times 10^{6}}{18 \times 10^{5}} = 10\ N/mm^2$

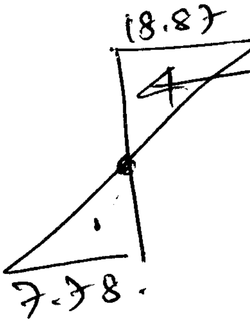
At Mid Span $\sigma = \pm M/Z = \dfrac{24 \times 10^{6}}{18 \times 10^{5}}$

$= \dfrac{240}{18} = 13.33\ N/mm^2$

Hence.

At mid span.

Resultant stress is.



$C = T = P$ Top fibre $= 5.55 + 13.33$

$= 18.87\ N/mm^2$

Bottom fibre $= 5.55 - 13.33$

$= -7.78\ N/mm^2$

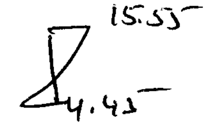
If e' is the shift in pressure line from CGC.

then $\dfrac{N}{A} + \dfrac{Ne'}{Z} = \dfrac{P}{A} + \dfrac{Pe'}{Z} = 18.87\ N/mm^2$

$5.55 + \left(\dfrac{200 \times 10^3}{18 \times 10^5}\right) e' = 18.87$

$e' = \left(\dfrac{18 \times 10^{5}}{200 \times 10^{3}}\right) \times 13.32$

$\dfrac{18 \times 100}{200} \times 13.32 = 119.88\ mm$



At Quarter Span.

Top fibre Stress = $5.55 + 10 = 15.55\ N/mm^2$

Bottom fibre Stress = $5.55 - 10 = -4.45\ N/mm^2$

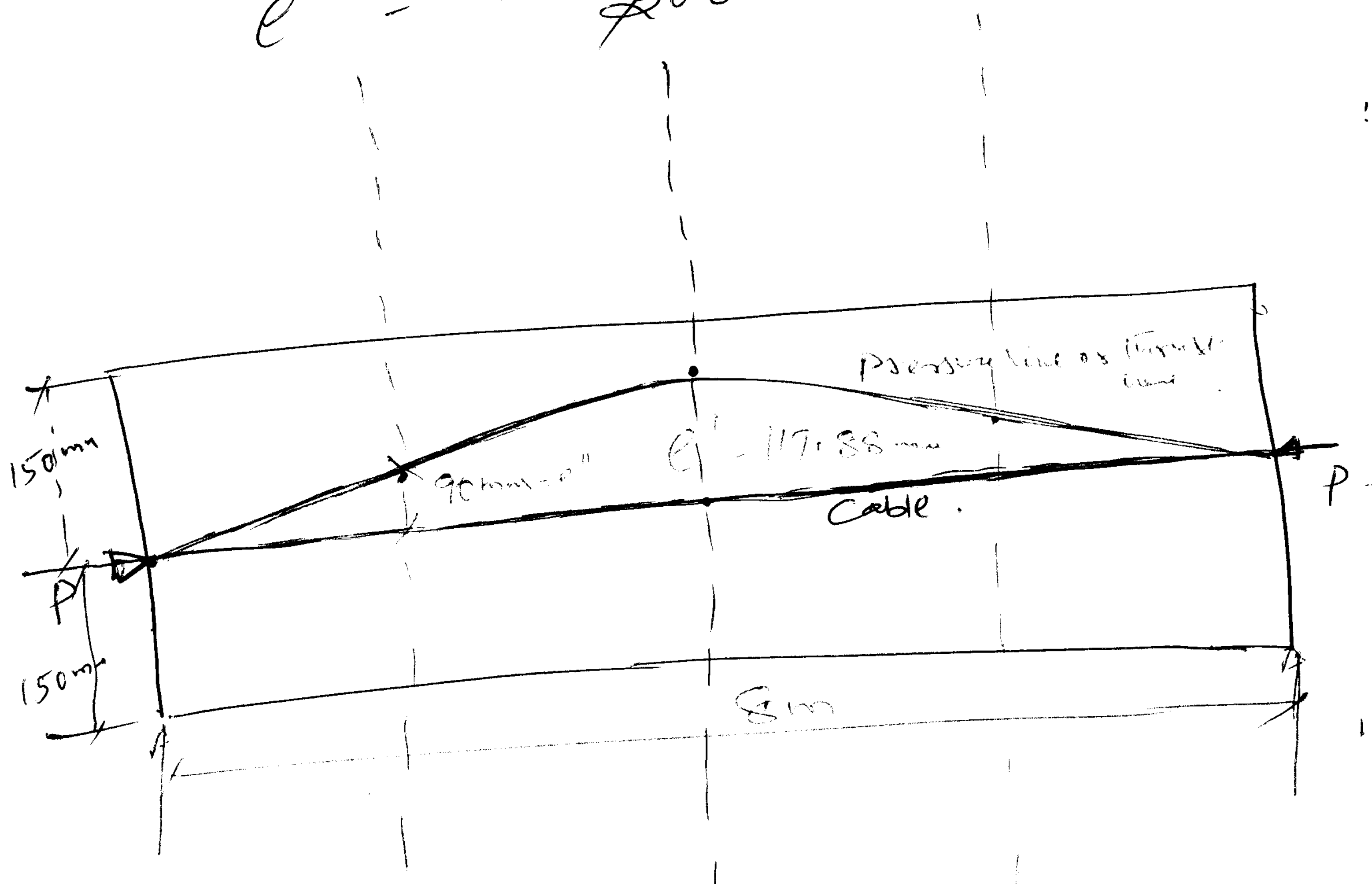
If e'' is the shift in pressure line from CG.

Then $\left(\frac{N}{A} + \frac{Ne''}{Z_t}\right) = 15.55\ N/mm^2$

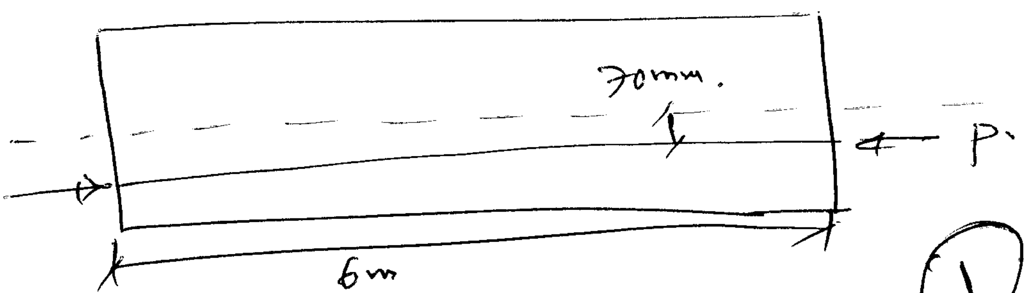
$$\frac{P}{A} + \frac{Pe''}{Z_t} = 15.55$$

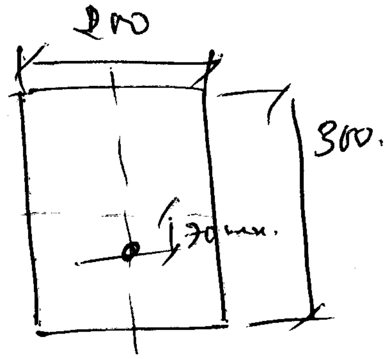
$$\Rightarrow 5.55 + \left(\frac{200\times10^3}{18\times10^4}\right)e'' = 15.55$$

$$\Rightarrow e'' = \frac{10\times18\times100}{200} = 90\,mm.$$



Q6





Neglecting DL effect.

Cable area = ~~200 sqmm~~ 250 sqmm ✓

Total prestressing force = 400 kN = 400×10^3 N.

$E_s = 2 \times 10^5 \ N/mm^2$

$E_c = 0.333 \times 10^5 \ N/mm^2$

$\phi = 2$

$\varepsilon = 0.0003.$

% loss $= \frac{258.4198}{1600} = 16.15\%$.

The concrete fibre stress due to prestress @ the level of steel wire = $f_c = \frac{P}{A_c} + \left(\frac{Pe}{I}\right)e$

$$f_c = \frac{400 \times 10^3}{200 \times 300} + \frac{(400 \times 10^3)}{\frac{200 \times 300^3}{12}} \times 70 \times 70$$

$= 6.67 + 4.355 = 11.02 \ N/mm^2$

Loss due to elastic shortening of concrete = $m f_c = 6 \times 11.02 = 66.14 \ N/mm^2$

Loss due to creep = $\phi f_c \times m = 2 \times 66.14 = 132.2799 \ N/mm^2$

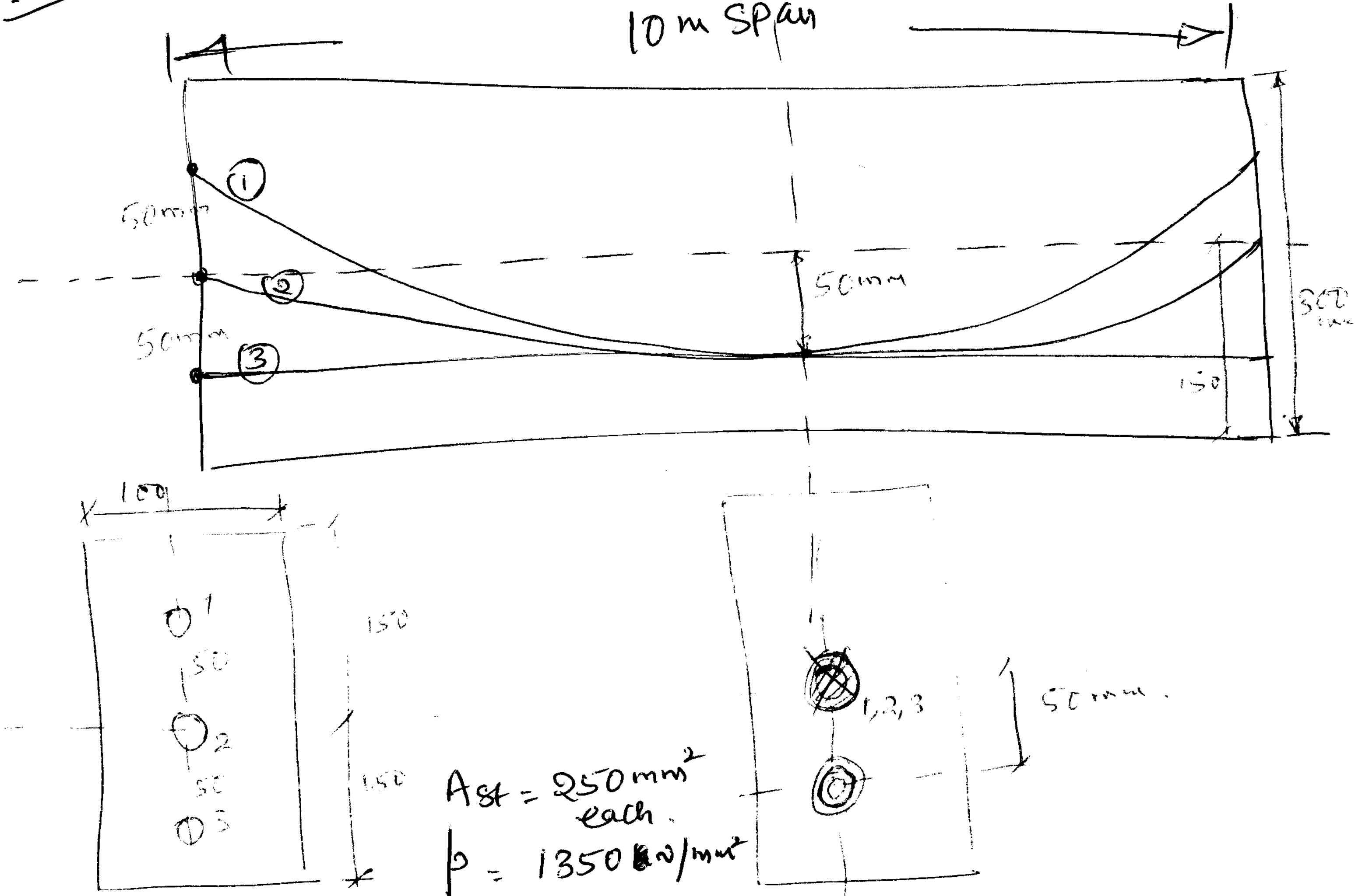
Loss due to shrinkage = $\varepsilon \times E_s = 0.0003 \times 2 \times 10^5 = 60 \ N/mm^2$

Total $258.4198 \ N/mm^2$

Applied stress = $P/A_{st} = \frac{400 \times 10^3}{250} = 1600 \ N/mm^2$

% loss = ~~...~~ %.

7



$A_{st} = 250 \, mm^2$ each.

$p = 1350 \, N/mm^2$

$m = 6$

Solution

Force in each cable = $\frac{1350 \times 250 \times 1}{1000} = 337.5 \, KN$ — Neglecting DL effect — (1)

(1)

$A_c = 100 \times 300 = 3 \times 10^4 \, mm^2$

$\alpha_e = m = 6$

$I = \frac{100 \times 300^3}{12} = 225 \times 10^6 \, mm^4.$

When Cable I is stressed and anchored
No loss in I, II & III ~ (1)

When Cable II is stressed.
No loss in Cable-2
Loss of prestress in Cable-I

Results - 2 marks

For Cable 1

Stress @ the Level of Cable I, when Cable 2 is stressed.

$(f_{e_2})_{1\,stressed}$ = Average between support & centre span

@ support $= \frac{P}{A_c} - \left(\frac{Pe_2}{I}\right)e_1$

$= \frac{337.5\times10^3}{3\times10^4} = 11.25\ N/mm^2$

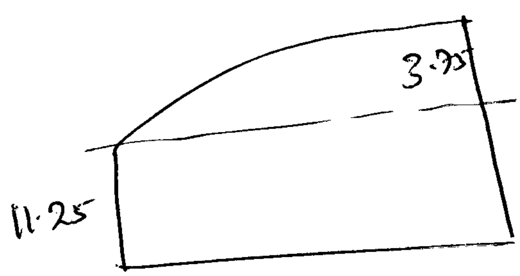
$e_2 = 0$, $e_1 = 50mm$

@ centre span $= \left[\frac{P}{A_c} + \left(\frac{Pe_2}{I}\right)e_1\right]$ at centre.

$= 11.25 + \left(\frac{337.5\times10^3\times 50}{225\times10^{6}3}\right)\times 50$

$= 3.75\ kN/mm^2 + 11.25$

$= 15\ kN/mm^2$



∴ Average Stress in concrete.

$= 11.25 + \frac{2}{3}\times 3.75$

$= 13.75\ N/mm^2$

When Cable 3 is stressed.

Cable 3 = loss = 0

loss occur in Cable 1 & 2.

Results

3 marks

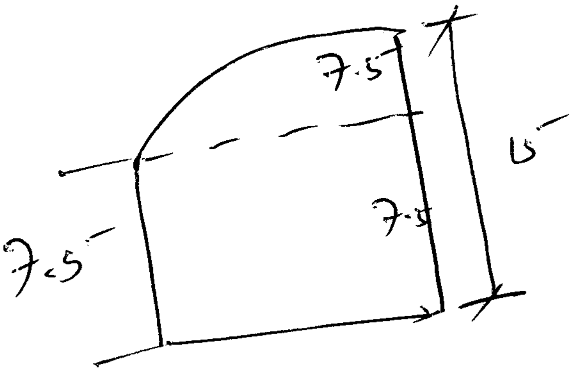
[Cable-1] 3 stressed. $e_3 = e_1 = 50$ mm

Stress @ Support. $\frac{P}{A_c} - \left(\frac{Pe_3}{I}\right)e_1$

$= 11.25 - 3.75 = 7.5$ N/mm²

Stress @ Centre. $= \frac{P}{A_c} + \left(\frac{Pe_3}{I}\right)e_1$

$= 11.25 + 3.75 = 15$ N/mm²



Average Stress $= 7.5 + \frac{2}{3} \times 7.5$

$= \underline{12.5}$ N/mm²

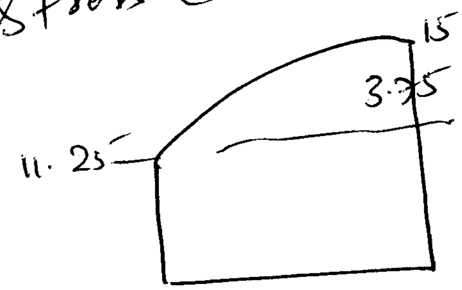
[Cable-2] 3 stressed. $e_2 = 0$.

Stress @ Support $= \frac{P}{A} - \left(\frac{Pe_3}{I}\right)e_2$

$= 11.25$ N/mm²

Stress @ Centre $= \frac{P}{A} + \left(\frac{Pe_3}{I}\right)e_2$, $e_3 = e_2 = 50$

$= 11.25 + 3.75 = 15$ N/mm²



Average Stress $= 11.25 + \frac{2}{3} \times 3.75$

$= 13.75$ N/mm²

Losses in each Cable.

Cable I $= (0 + 13.75 + 12.5) \times 6 = 157.5$ N/mm²

% loss $= \frac{157.5}{1350} = 11.67$ %.

Results

Cable 2

$$Loss = (0 + 0 + 13.75) \times 6$$
$$= 82.5\ N/mm^2$$

$$\%\ loss = \frac{82.5}{1350} = 6.11\%$$

Cable III = 0 = 0%

~ 0 ~