CBCS SCHEME

USN | | | | | | | | | | | 18CV81

Eighth Semester B.E. Degree Examination, June/July 2023
Design of Pre-Stressed Concrete

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of IS 1343 is permitted.

Module-1

1 a. With a neat sketch explain Pretensioning and Post-tensioning system. List out the difference between them [any three]. **(08 Marks)**

b. Define Anchorage. Explain with sketch Freyssinet system of Post-tensioning. **(06 Marks)**

c. Explain the need for High Strength Concrete and High Strength Steel for Prestressed concrete member. **(06 Marks)**

OR

2 a. Define Pressure line. Plot the pressure line for a simply supported rectangular beam of size b × h subjected load and prestressed by force "P" at a constant eccentricity of "h/6" such that bottom fibre stress at mid-span due to all load and "P" equal to "Zero". **(06 Marks)**

b. An unsymmetrical I-section beam is used to support an imposed load of 2 kN/m over a span of 8m. The sectional details are top flange, 300mm wide and 60mm thick; bottom flange, 100mm wide and 60mm thick; thickness of web = 80 mm; overall depth of beam = 400mm. At the centre of the span, the effective prestressing force of 100 kN is located at 50mm from the soffit of the beam. Estimate the stresses at the centre of span section of the beam for the following load condition.
i) Prestress + Self weight
ii) Prestress + Self weight + Live load. **(14 Marks)**

Module-2

3 a. Define losses of Prestress. Explain the different losses of Prestress encountered in the Pretensioning and Post-tensioning system. **(08 Marks)**

b. A pretensioned beam, 200 × 300mm is prestressed by 10 wires of 7mm diameter initially stressed to 1200N/mm² with their centroids located 100mm from the soffit. Find the maximum stress in concrete immediately after transfer, allowing only for elastic shortening of concrete. If the concrete undergoes a further shortening due to creep and shrinkage while there is a relaxation of five percent of steel stress. Estimate the final percentage loss of stress in the wires using IS 1343 regulations and following data:
$E_s = 210 kN/mm^2$; $E_c = 5700 (f_{cu})^{1/2}$;
$f_{cu} = 42 N/mm^2$; Creep co-efficient $\phi = 1.6$
Total residual shrinkage strain = 3×10^{4}. **(12 Marks)**

OR

4 a. Derive the quantification of deflection due to the effect of parabolic tendon profile having eccentricity "e" at the centre and zero at support. **(06 Marks)**

b. What are the factors affecting deflection of PSC beam. **(04 Marks)**

c. A concrete beam with a symmetrical I-section has flange width and depth 200 × 60 mm. Thickness of web is 80mm and overall depth is 400mm. The beam is prestressed by a cable carrying a force of 1000 kN. The span of the beam is 8m. The centre line of the cable is 150mm from the soffit of the beam at the centre of span, linearly varying to 250mm at the supports. Compute the initial deflection at mid-span due to prestress and the self-weight of the beam, assuming E_c = 38 kN/mm^2. Compare the deflection with the limiting deflection permitted in IS:1343 [γ_c = 24 kN/m^3]. (10 Marks)

Module-3

5 a. A post-tensioned bridge girder with unbounded tendons is of box section of overall dimensions 1200mm wide by 1800mm deep with wall thickness of 150mm. The high-tensile steel has an area of 4000mm^2 and is located at an effective depth of 1600mm. The effective prestress in steel after all losses is 1000 N/mm^2 and the effective span of the girder is 24m. If f_{ck} = 40 N/mm^2 and f_p = 1600 N/mm^2. Estimate the ultimate flexural strength of the section. (10 Marks)

b. A pretensioned prestressed beam having a rectangular section, 150 mm wide and 300mm deep has an effective cover of 50mm. If f_{ck} = 40 N/mm^2, f_p = 1600 N/mm^2, and the area of prestressing steel A_p = 461 mm^2. Calculate the ultimate flexural strength of the section using IS:1343 code provision. (10 Marks)

OR

6 a. Explain the different types of flexural failure observed in PSC members. (06 Marks)

b. Determine the effective prestress area of prestressing steel and the area of the section from preliminary design for a simply supported Type1 prestressed beam with M_T = 435 kNm (Including an estimated M_{sw} = 55 kNm). The height of the beam is restricted to 920 mm. The prestress at service f_{pe} = 860 N/mm^2. The allowable compressive stress of concrete at service is 11 N/mm^2.

Type of prestressing tendon = 7 wires strand
Nominal diameter = 12.8 mm
Nominal area = 99.3 mm^2

(14 Marks)

Module-4

7 a. Explain the types of shear cracks in PSC. List the different ways of improving the shear resistances by prestressing technique. (08 Marks)

b. A concrete beam having a rectangular section 150 × 300mm is prestressed by a parabolic cable having an eccentricity of 100mm at the centre of span, reducing to zero at the supports. Span of beam is 8m. The beam supports a live load of 2 kN/m. Determine the effective force in the cable to balance the dead and live loads on the beam. Estimate the principle stresses at the support section. (12 Marks)

OR

8 A PSC beam of symmetrical I-section has overall depth of 2m. Thickness of web is 200mm. Effective span is 40m. The beam is prestressed by cables which are concentric at supports and have eccentricity of 750mm at centre span. Force in the cable is 1200 kN at the transfer stage, f_{ck} = 60 N/mm^2. Estimate the ultimate shear resistance at support due to loads is 2834 kN and loss ratio is 0.8, design the suitable shear reinforcement using Fe415 steel. Area of section is 0.88× 10^6 mm^2. (20 Marks)

Module-5

9 a. Explain the terms i) End Block stress distribution ii) Bursting tension with reference to post-tensioned prestressed members. (06 Marks)

b. The end blocks of a prestressed concrete girder is 200mm wide by 300mm deep. The beam is post-tensioned by two Freyssinet anchorages each of 100mm diameter with their centres located at 75mm from the top and bottom of beam. The force transmitted by each anchorage being 2000 kN. Compute the bursting force and design suitable reinforcement according to the IS:1343 code. (14 Marks)

OR

10 The end block of a post-tensioned prestressed member is 550 mm wide and 550mm deep four cables, each made up of seven wires of 12mm diameter strands and carrying a force of 1000 kN, are anchored by plate anchorages, 150×150mm, located with their centres at 125mm from the edges of the end block. The cable duct is of 50mm diameter. The 28 days cube strength of concrete f_{cu} = 45 N/mm^2, The cube strength at transfer f_{ci} = 25 N/mm^2. Permissible bearing stresses behind anchorage should conform with IS:1343. The characteristic yield stress in mild steel anchorage reinforcement is 260 N/mm^2. Design suitable anchorage for the end block. (20 Marks)

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DEPARTMENT OF CIVIL ENGINEERING.

VIII SEM B.E. DEGREE EXAMINATION JUNE/JULY 2023.

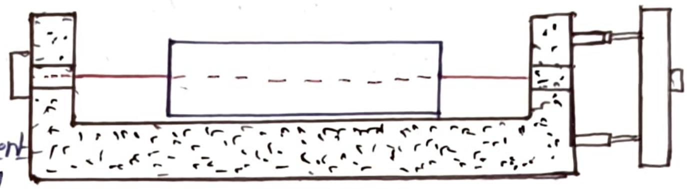
DESIGN OF PRE-STRESSED CONCRETE.

(18CV81).

QUESTION PAPER SOLUTION.

Q1.a. PRETENSIONING: In pre-tensioning systems the tendons are tensioned, before placing the concrete. In this method the pre-stress is imparted to concrete by bond b/w steel and concrete.

Pretensioning method is used for the mass production of small pre-cast concrete element like railway sleepers, electric poles etc.



POST TENSIONING: In this system concrete element is cast with ducts to house pre-stressing wires.

After concrete gets sufficient strength PS wires are passed through the duct, fixed at 1 end & stretched with use of jacks which bear against the member itself.

The differences b/w pretensioning & postensioning

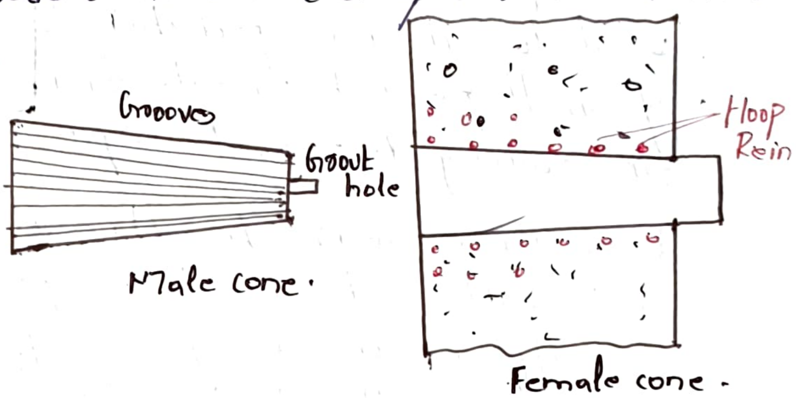
PRETENSIONING	POST TENSIONING
1) Tendons are tensioned before placing the concrete	1) Tendons are tensioned after placing the concrete
2) Suitable for small span	2) Suitable for long span.
3) No Loss due to Friction & Anchorage slip	3) There is loss due to anchorage slip.

Q1.b. Anchorage is a device to anchor the tendon, to the concrete member in post-tensioning or the device to anchorage tendon during the hardening of concrete in pretensioning.

FREYSSINET SYSTEM: is based on wedge action. It consist of a hollow cylinder called a female cone & conical plug also called as male cone.

To get better bond the outer surface of female cone is corrugated & is heavily reinforced with closely spaced spiral reinforcement.

This cone is embedded at the end of concrete element.



Q1.c. HIGH STRENGTH CONCRETE. is used for following reasons

1) Elastic strain, shrinkage & plastic flow is less in high strength concrete reducing loss of PS considerably

2) With increase in strength of concrete, the required c/s of member reduces. This reduces self-weight while building large span structure.

3) In order to take full advantage of high strength steel, high strength concrete is necessary.

HIGH STRENGTH STEEL.

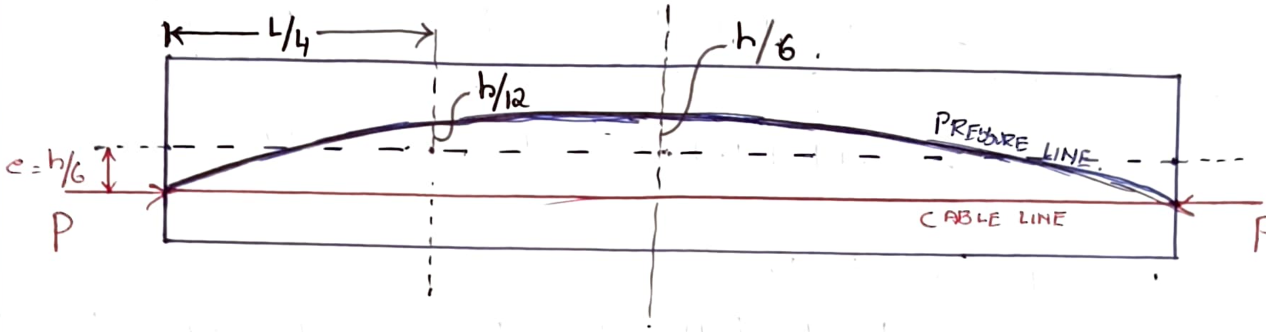
The loss in PSC members due to various reasons are generally in the range of 250 N/mm² to 400 N/mm².

If mild steel or deformed steel is used the residual stresses after losses is either zero or negligible.

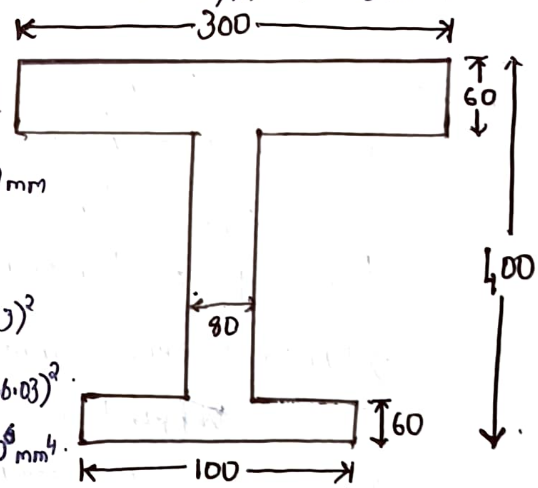
Hence high tensile steel wires are used which varies from 1600 to 2000 N/mm².

1.a. The pressure line in a beam is the locus of the resultant compression (C) along the length. It is also called as thrust line or C-line.

It is used to check whether C at transfer & under service loads is falling within kern zone of the section.



b. GIVEN, $P = 100 kN$ $e_b = 50 mm$ $LL = 2 kN/m$ $L = 8m$.



$A = 46400 mm^2$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3} = \frac{(300\times60)(30) + (280\times80)(60+140) + (100\times60)(370)}{300\times60 + 280\times80 + 100\times60}$$

$\bar{y} = 156.03 mm = y_t$ $y_b = 400 - 156.03 = 243.97 mm$

$\therefore e = 243.97 - 50 = 193.97 mm$.

$I = I_1 + I_2 + I_3$.

$$= \frac{300\times60^3}{12} + (300\times60)(156.03-30)^2 + \frac{80\times280^3}{12} + (80\times280)(200-156.03)^2 + \frac{100\times60^3}{12} + (100\times60)(370-156.03)^2.$$

$= 291.3\times10^6 + 189.65\times10^6 + 276.5\times10^6 = 757.45\times10^6 mm^4$.

$DL = (0.3\times0.06 + 0.08\times0.28 + 0.1\times0.06)\times25 = 1.16 kN/m^2$.

BM at Centre span due to $DL = \frac{1.16\times8^2}{8} = 9.28 kNm = M_g$

BM at Centre span due to $LL = \frac{2\times8^2}{8} = 16 kNm = M_q$.

Due to PS+SW, $f_b = \frac{P}{A} + \frac{Pe}{I} y_b - \frac{M_g}{I} \times y_b$.

$$= \frac{100\times10^3}{46400} + \frac{100\times10^3\times243.97 \times 193.97}{757.45\times10^6} - \frac{9.28\times10^6\times243.97}{757.45\times10^6} = 5.429 N/mm^2$$

2.155 + 6.25 2.98

f_t = [illegible]

Due to PS+SW+LL, $f_b = \frac{P}{A} + \frac{Pe}{I} y_b - \frac{M_g}{I} y_b - \frac{M_q y_b}{I}$.

$= \frac{100\times10^3}{46400} + \frac{100\times10^3 \times 193.97 \times 243.97}{757.45\times10^6} - \frac{9.28\times10^6 \times 243.97}{757.45\times10^6} - \frac{16\times10^6 \times 243.97}{757.45\times10^6}$

$= 2.15 + 6.25 - 2.98 - 5.15 = 0.27\ N/mm^2$.

$f_t = \frac{P}{A} - \frac{Pe}{I} y_t + \frac{M_g y_t}{I} + \frac{M_q y_t}{I}$.

$= \frac{100\times10^3}{46400} - \frac{100\times10^3 \times 193.97 \times 156.03}{757.45\times10^6} + \frac{9.28\times10^6 \times 156.03}{757.45\times10^6} + \frac{16\times10^6 \times 156.03}{757.45\times10^6}$

$= 2.15 - 3.99 + 1.91 + 3.29 = 3.36\ N/mm^2$.

Due to PS+SW

$f_t = \frac{P}{A} - \frac{Pe\, y_t}{I} + \frac{M_g\, y_t}{I} = 2.15 - 3.99 + 1.891 = 0.07\ N/mm^2$.

Q3.a. The various reductions of the prestressing force are termed as the losses in pre-stress.

The different losses of prestress encountered during pretensioning & post-tensioning are.

1) ELASTIC SHORTENING

~~When~~ PRE-TENSIONED members, when tendons are cut & PS force is transferred to member, concrete undergoes immediate shortening due to pre-stress.

The tendon also shortens by the same amount which leads to loss of pre-stress.

In POST TENSIONED, if there is only 1 tendon, there is no loss. For more than 1 tendon, if tendons are stretched sequentially then there will be loss

2) LOSS DUE TO CREEP.

Creep of concrete is defined as the increase in deformation with time under constant load.

Due to creep of concrete, the pre-stress in the tendon is reduced with time.

The loss of PS due to creep is given by.

$Loss = E_p \epsilon_{cr}$

3) LOSS DUE TO SHRINKAGE.

Shrinkage of concrete is defined as the contraction due to loss of moisture.

Due to the shrinkage of concrete the pre-stress in the tendon is reduced with time.

The loss of PS due to shrinkage is given by

$Loss = E_p \epsilon_{sh}$.

4) RELAXATION OF STEEL.

Relaxation of steel is defined as the decrease in stress with time under constant strain.

Due to relaxation of steel, the PS in the tendon is reduced with time.

5) LOSS DUE TO FRICTION.

The friction generated at the interface of concrete & steel during the stretching of a curved tendon in a post-tensioned member leads to a drop in the pre-stress along the member from the stretching end.

6) LOSS DUE TO ANCHORAGE SLIP.

In a post-tensioned member, when the pre-stress is transferred to the concrete, the wedges slip through a little distance before they get properly seated in the conical space. There is loss due to consequent reduction in length of tendon.

Q3.b

Given $b = 200$ $D = 300mm$ $f_p = 1200\ N/mm^2$. $f_{ck} = 42$ [illegible]

Area, $A = 200 \times 300 = 60000\ mm^2$.

$E_c = 5700\sqrt{f_{ck}} = 5700\sqrt{42} = 36900\ N/mm^2$.

$$I = \frac{bD^3}{12} = \frac{200 \times 300^3}{12} = 45 \times 10^7\ mm^4$$

$$\alpha_e = \frac{E_s}{E_c} = 5.7.$$

$e = 150 - 100 = 50\ mm$

$$P = f_p(A_p) = 1200 \times \left(10 \times \frac{\pi}{4} \times 7^2\right) = 462 \times 10^3\ N.$$

$$f_c = \frac{P}{A} + \frac{Pey}{I} = \frac{462 \times 10^3}{60000} + \frac{462 \times 10^3 \times 50 \times 50}{45 \times 10^7} = 10.3\ N/mm^2.$$

Loss due to ELASTIC DEFORMATION $= \alpha f_c = 5.7 \times 10.3 = 58.8\ N/mm^2$

FORCE IN WIRES IMMEDIATELY AFTER TRANSFER

$$= (1200 - 58.8)\left(10 \times \frac{\pi}{4} \times 7^2\right) = 440 \times 10^3\ N.$$

Stress in Concrete at level of steel.

$$f_c = \frac{440 \times 10^3}{60000} + \frac{440 \times 10^3 \times 50 \times 50}{45 \times 10^7} = 9.78\ N/mm^2.$$

TYPES OF LOSSES

1) ELASTIC DEFORMATION $= 58.8\ N/mm^2$.

2) CREEP OF CONCRETE $= \phi \times f_c \times \alpha = 1.6 \times 9.78 \times 5.7 = 89.2\ N/mm^2$.

3) SHRINKAGE " " $= \varepsilon_s \times E_s = (3 \times 10^{-4})(210 \times 10^3) = 63.0\ N/mm^2$.

4) RELAXATION OF STEEL $= (5/100) \times 1200 = 60\ N/mm^2$.

TOTAL $= 271\ N/mm^2$.

Final Stress in wires $= 1200 - 271 = 929\ N/mm^2$.

$$\%\ \text{Loss} = \frac{271}{1200} \times 100 = 22.58\%$$

2) LOSS DUE TO CREEP.

Creep of concrete is defined as the increase in deformation with time under constant load.

Due to creep of concrete, the pre-stress in the tendon is reduced with time.

The loss of PS due to creep is given by.

Loss = $E_p \epsilon_{cr}$

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Shrinkage of concrete is defined as the contraction due to loss of moisture.

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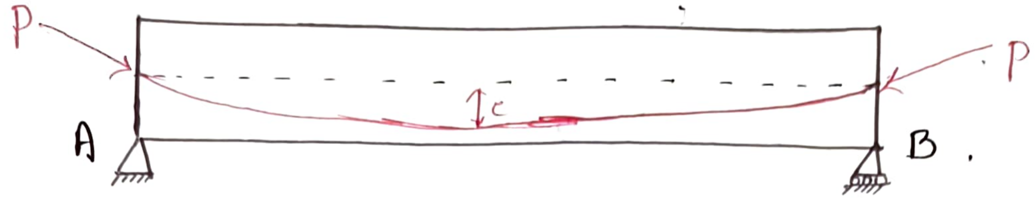
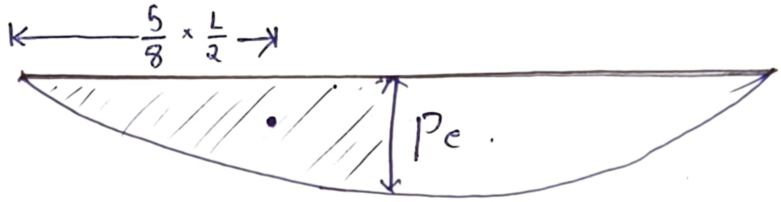
Q4.a.





Since tendon profile is parabolic BM varies parabolically.

At a section X, x distance from end A.

$$M_x = Pe_x$$

At mid span, $M = Pe$.

Centroid of area of BMD from support $A = \frac{5}{8} \times \frac{L}{2}$.

Area of BMB from A to $C = \frac{1}{2} \times \frac{2}{3} L \times Pe = \frac{1}{3} PeL$.

$\therefore$ Deflection, Δ = Area x Centroid $\times \frac{1}{EI}$

$$= \left(\frac{1}{3} \times PeL\right)\left(\frac{5}{8} \times \frac{L}{2}\right) \times \frac{1}{EI}.$$

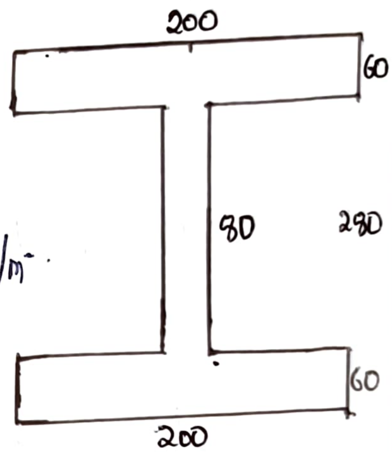
$$\therefore \Delta = \frac{5}{48} \frac{PeL^2}{EI}$$

b. The factors affecting deflection of PSC are

1) Magnitude of PS force.
2) Profile of PS cables.
3) Self weight.

4) Imposed Load
5) Modulus of Elasticity of concrete
6) Moment of Inertia of section
7) Span of member.
8) Loss factor of PS.
9) Shrinkage, Creep & Relaxation Steel.

Q4.c. Given, $P = 1000\,kN$ $L = 8m$ $e_b = 150mm$ near mid-span
$e_b = 250mm$ at support $E_c = 38\,kN/mm^2$. $\gamma_c = 24\,kN/m^3$.



Area $= (200\times60)\times2 + 80\times280 = 46400\,mm^2$

$$I = \frac{200\times400^3}{12} - \frac{120\times280^3}{12} = 847.14\times10^6\,mm^4.$$

Self wt., $g = 0.0464\times24 = 1.114\,kN/m$.

Deflection due to PS force

$$a_p = \frac{PL^2}{24EI}(-2e_1+e_2).$$

$e_1 = 200-150 = 50$

$e_2 = 200-250 = -50$.

$$= \frac{1000\times10^3\times8000^2\,(-2\times50+50)}{24\times38\times10^3\times847.14\times10^6} = -4.14\,mm$$

Deflection due to S.W, $a_g = \dfrac{5gL^4}{384EI} = \dfrac{5\times1.114\times8000^4}{384\times38\times10^3\times847.14\times10^6}$

$= 1.84\,mm$.

Deflection due to PS + SW $= -4.14 + 1.84 = -2.3\,mm$
(upwards)

Max Deflection $= \dfrac{Span}{250} = \dfrac{8000}{250} = 32\,mm$

Q5.a.

Given: $A_{ps} = 4000 mm^2$ $f_{ck} = 40 N/mm^2$

$b_w = 300mm$ $f_{pu} = 1600 N/mm^2$ $d = 1600 mm$ $D_f = 150mm$

$b = 1200mm$.

$A_{pf} = 0.45 f_{ck} (b - b_w) \times (D_f/f_{pu}) = 0.45 \times 40 (1200 - 300)(150/1600)$

$= 1518 mm^2$.

$A_{pw} = 4000 - 1518 = 2482 mm^2$.

$L = 24000mm$.
$\frac{L}{d} = \frac{24000}{1600}$
$= 15$.

Ratio $\frac{A_{pw} f_{pu}}{b_w d f_{ck}} = \frac{2482 \times 1600}{300 \times 1600 \times 40} = 0.206$.

From IS 1343 Table 12.

$\frac{f_{pb}}{~~0.87~~ f_{pu}} = ~~[\text{scribbled}]~~ 1.215$ and $\frac{x_u}{d} = 0.61$.

$f_{pb} = ~~0.95~~ 1.215 \times ~~[\text{scribbled}]~~ \times 1600 = ~~[\text{scribbled}]~~ N/mm^2$ $1944 N/mm^2$

$x_u = ~~0.414~~ 0.61 d = 0.414 \times 1600 = ~~[\text{scribbled}]~~ = 976 mm$.

$M_u = f_{pb} A_{pw} (d - 0.42 x_u) + 0.45 f_{ck} (b - b_w) D_f (d - 0.5 D_f)$

$= ~~1322~~ 1944 \times 2482 \times (1600 - 0.42 \times ~~662.4~~ 976)$

$+ 0.45 \times 40 (1200 - 300) \times 150 (1600 - 0.5 \times 150)$

$= ~~8043 kNm~~ = 5.74 \times 10^9 + 3.7 \times 10^9$.

$= 9.44 \times 10^9 Nmm = ~~8695~~ 9447 kNm$

Q5.b. Given $b = 150mm$ $D = 300mm$ $d' = 50mm$

$f_{ck} = 40 N/mm^2$ $f_p = 1600 N/mm^2$ $A_p = 461 mm^2$.

Effective depth, $d = D - d' = 300 - 50 = 250mm$.

Ratio, $\frac{A_p f_p}{b d f_{ck}} = \frac{461 \times 1600}{150 \times 250 \times 40} = 0.5$.

From IS 1343, Table 11

$\frac{f_{pu}}{0.87 f_p} = 0.9$. and $\frac{x_u}{d} = 0.783$.

$f_{pu} = 0.9 \times 0.87 \times 1600 = 1252.8 N/mm^2$

$x_u = 0.783 \times 250 = 195.75mm$

$M_u = f_{pb} \times A_{ps}(d - 0.42 x_u)$.

$= 1252.8 \times 461 (250 - 0.42 \times 195.75)$

$= 96.9 \times 10^6 Nmm$

$= 96.9 kNm$.

Q6.a. The different types of flexural failure observed in PSC members are.

1) ~~UNDER-REINFORCED~~ BALANCED FAILURE.

The situation at which the strain in concrete reaches its limiting value & stress in steel also reaches its limiting value is known as balanced condition. failure where both steel & concrete fail at same time.

2) UNDER REINFORCED FAILURE.

If quantity of steel is less than that required for balanced section it is called under reinforced s/c.

Here the failure is associated with visible cracks & large deflections which serves as warning. as the steel fails first.

3) OVER REINFORCED FAILURE.

If quantity of steel is more than that required for balanced section it is called as over reinforced s/c.

Here as the concrete fails first, the failure is associated with sudden bursting of concrete without any warning.

Q6.b GIVEN, $M_T = 435$ kNm $M_{SW} = 55$ kNm $f_{po} = 1035\ N/mm^2$ $f_{pe} = 860\ N/mm^2$.

(A) PRELIMINARY DESIGN.

1) Estimate LEVER ARM, Z.

$$\frac{M_{SW}}{M_T} = \frac{55}{435} = 12.5\%$$

Since $M_{SW} < 0.3 M_T$ use $Z = 0.5h = 0.5 \times 920 = 460$ mm

2) Estimate EFFECTIVE PRE-STRESS.

Moment due to IL = $M_{IL} = M_T - M_{SW} = 435 - 55 = 380$ kNm

Effective PS, $P_e = \frac{380 \times 10^6}{460 \times 10^3} = 826 \times 10^3 N = 826$ kN.

3) Estimate Area of PS steel.

$$A_p = \frac{P_e}{f_{pe}} = \frac{826 \times 10^3}{860} = 960\ mm^2.$$

4) Estimate area of the 5% to have average stress in concrete.

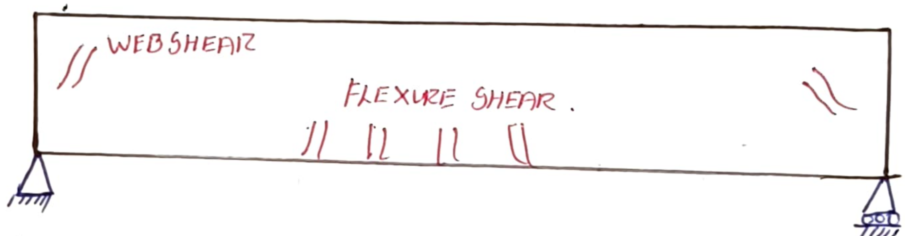
$$A = \frac{P_e}{0.5 f_{ci}} = \frac{826 \times 10^3}{0.5 \times 11} = 150 \times 10^3 \ mm^3.$$

Q7.a. The different types of shear cracks are.

1) FLEXURE SHEAR CRACKS.

are initiated due to flexure tensile stress exceeding pre-compression in extreme fibres of concrete.

- Then minor principal stress due to flexure & shear which exceed the tensile strength of concrete spreads the cracks near mid span region.



2) WEB SHEAR CRACKS.

The shear cracks near the support are known as web shear cracks. which are mainly due to high shear stress..

They generally start from interior point, since shear stress is high at centroidal section. They spread at about 45°.

The methods of improving the shear resistances are

1) Vertical or Transverse Pre-stressing.
2) Horizontal or Axial "
3) Prestressing by sloping cables at Ends.

Q7.b. Given, $b = 150mm$ $h = 300mm$ $e = 100mm$ $L = 8m$

$LL = 2 kN/m$

Self wt. of beam $= 0.15 \times 0.3 \times 24 = 1.08 kN/m$.

TOTAL LOAD $= 2 + 1.08 = 3.08 kN/m = w$

By load Balancing concept.

$P_e = M \Rightarrow P_e = \frac{wL^2}{8} \Rightarrow P \times 100 = \frac{3.08 \times 8000^2}{8}$

$\Rightarrow P = 246.4 \times 10^3 N$.

slope of cable at support, $\theta = \frac{4e}{L} = \frac{4 \times 100}{8000} = \frac{1}{20}$.

Vertical component of PS force $= P\theta = 246.4 \times \frac{1}{20}$

$= 12.32 kN$.

Reaction at support due to DL & LL $= \frac{wL}{2} = \frac{3.08 \times 8}{2}$

$= 12.32 kN$

$\therefore$ Net shear force at support $= 0$

Horizontal PS at support $= \frac{P}{A} = \frac{246.4 \times 10^3}{150 \times 300}$.

$= 5.5 N/mm^2$.

$\therefore$ Principal stress at support $= 5.5 N/mm^2$.

Q8. Given $D = 2000mm$ $b_w = 200mm$ $L = 40m$
$e = 750mm$ $P = 1200kN$ $f_{ck} = 60 N/mm^2$ $V = 2834 kN$ $\eta = 0.8$
$f_y = 415 N/mm^2$ $A = 0.88 \times 10^6 mm^2$.

$$f_{cp} = \frac{P}{A} = \frac{1200 \times 10^3}{0.88 \times 10^6} = 1.36 N/mm^2.$$

$$\theta = \frac{4e}{L} = \frac{4 \times 750}{40000} = 0.075$$

$$f_t = 0.24\sqrt{f_{ck}} = 0.24\sqrt{60} = 1.86 N/mm^2.$$

$$V_c = 0.67 bD \sqrt{f_t^2 + 0.8 f_{cp} f_t} + P \sin\theta$$

$$= 0.67 \times 200 \times 2000 \sqrt{1.86^2 + 0.8 \times 1.36 \times 1.86} + 1200 \times 10^3 \times 0.075$$

$$= 627.55 \times 10^3 N + 90 \times 10^3 N = 717.55 \times 10^3 N.$$

when $V > V_c$.

$$S_v = \frac{0.87 \times f_y \times d_t \, A_{sv}}{V - V_c}$$

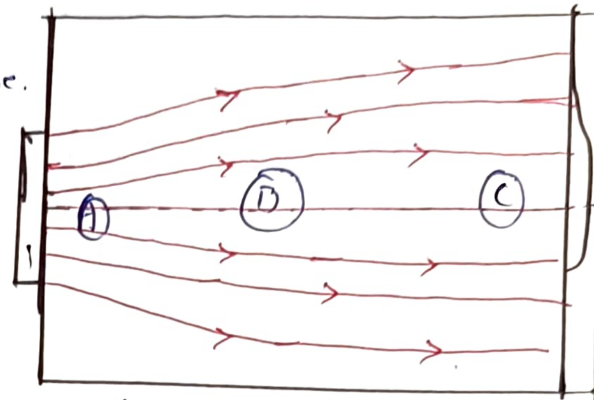
$$A_{sv} = 2 \times \frac{\pi}{4} \times 10^2 = 159.53 mm^2.$$

$$S_v = \frac{0.87 \times 415 \times 2000 \times 159.53}{(2834 - 717.55) \times 10^3}$$

$$= 54.29 mm.$$

Provide 2LVS of 8mm dia @ 50 mm c/c.

Q9.a. END BLOCK STRESS DISTRIBUTION.

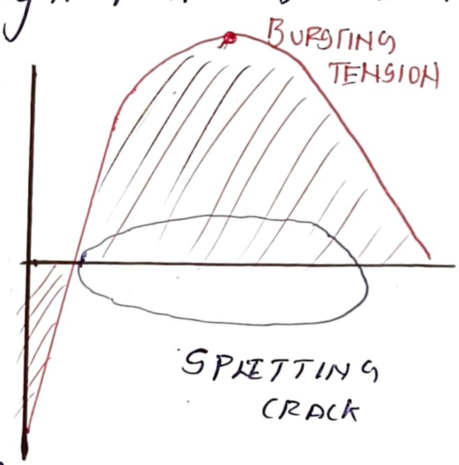


The stress distribution in end block is as shown in figure. The curvature of struts being convex towards centre line of the block induces compressive stress in zone A.

In zone B, the curvature is reversed in direction & struts tend to deflect outwards separating from each other & consequently developing transverse tensile stresses.

In zone C, the struts are straight & ||ed so that transverse stresses are induced.

BURSTING TENSION



The effect of transverse tensile stress is to develop a zone of bursting tension in a direction ⊥r to anchorage force, resulting in horizontal cracking as shown in figure.

Q9.b. Given $b = 200mm$ $h = 300mm$ $P = 200kN$

Equivalent side of square, $2y_{po} = \sqrt{\frac{\pi}{4} \times 100^2} = 89mm$

Side of surrounding prism $2y_o = 150mm$.

$$\frac{y_{po}}{y_o} = \frac{89}{150} = 0.593.$$

Average compressive stress, $f_c = \frac{P}{A_{bo}} = \frac{2000\times10^3}{150\times150}$.

$= 88.9 \, N/mm^2$

Tensile stress, $f_{v(max)} = 88.9[0.98 - 0.825(0.593)]$

$= 44.45 \, N/mm^2$.

Transverse Tension, $F_{bst} = 2000\times10^3[0.48 - 0.4(0.593)]$

$= 500000N = 500kN$.

Using 10mm dia mild steel links with $f_y = 250N/mm^2$

No. of bars required $= \frac{500\times10^3}{0.87\times250\times(\frac{\pi}{4}\times10^2)} = 32$

Q.10.

Given $P_k = 1000\,kN$ $2y_{po} = 150\,mm$

$2y_o = 250\,mm$

$\therefore \frac{y_{po}}{y_o} = \frac{150}{250} = 0.6$

Area of cable duct $= \frac{\pi}{4} \times 50^2 = 2000\,mm^2$.

Net Area of surrounding prism $= [250^2 - 2000]$

$= 60500\,mm^2$.

Average compressive stress, $f_c = \frac{P}{A} = \frac{1000 \times 10^3}{60500}$

$= 16.5\,N/mm^2$.

$A_{pun} = 22500\,mm^2$

$A_{br} = 60500\,mm^2$

$\frac{A_{br}}{A_{pun}} = \frac{60500}{22500} = 2.7$

Bearing stress$_{lim}$ $= 0.48 \times f_{ci} \times \sqrt{\frac{A_{br}}{A_{pun}}}$ or $0.8 f_{ci}$

$= 0.48 \times 25 \times \sqrt{2.7}$ or 0.8×25

$= 19.7\,N/mm^2$ or $20\,N/mm^2$ (whichever is small)

Actual bearing stress $= 16.5\,N/mm^2$.

Bursting Tension, $F_{bst} = P_k\left[0.32 - 0.3\left(\frac{y_{po}}{y_o}\right)\right]$

$= 1000[0.32 - 0.3 \times 0.6]$

$= 140\,kN$

Using 10mm dia HYSD links.

$$\text{No of bars} = \frac{F_{bst}}{0.87 f_y A_s}$$

$$= \frac{140 \times 10^3}{0.87 \times 250 \times \left(\frac{\pi}{4} \times 10^2\right)}$$

$$= 8.$$

∴ Provide 8 bars of 10mm dia.

(HARSHAVARDHAN).