PRESTRESSED CONCRETE STRUCTURES
(CIVL 4141)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Resultant stress in the cross-section of a prestressed beam comprises of:
(a) Prestress + Dead load stress + Live load stress
(b) Prestress + Dead load stress
(c) Prestress + Live load stress
(d) Only direct stress + Bending stress.

(ii) Loss of stress due to friction depends on
(a) modulus of elasticity of concrete (b) coefficient of friction
(c) relaxation of stress in steel (d) elastic shortening.

(iii) The grade of concrete for prestressed members should be in the range of
(a) M-20 to M-30 (b) M30 to M-60 (c) M-60 to M-80 (d) M-80 to M-100.

(iv) The loss of stress which is absent in pre-tensioned members is
(a) Shrinkage of concrete (b) Friction and anchorage slip
(c) Creep of concrete (d) Elastic deformation of concrete.

(v) The spacing of stirrups in a prestressed beam should
(a) not exceed the overall depth (b) not greater than effective depth
(c) not exceed 0.75 times the effective depth (d) equivalent to effective depth.

(vi) A parabolic cable profile with maximum eccentricity at mid-span and concentric at supports when stressed results in
(a) Zero deflection (b) Downward deflection
(c) Upward deflection (d) Minimum deflection.

(vii) In post-tensioning system
(a) wires are first tensioned followed by concreting
(b) Tensioning of wires and concreting is simultaneously done
(c) The wires are tensioned against hardened concrete
(d) The wires are tensioned in workshop and transfer it to the site.

(viii) Maximum permissible final deflection of a beam should not exceed
(a) span/350 (b) span/250 (c) span/300 (d) span/450.

(ix) In pre-stressed concrete beam, the applied loads are resisted by
(a) an increase in stress in tendons
(b) a shift in pressure line from cable line depending upon the moment
(c) an increase in tensile stress in concrete
(d) pressure line coinciding with cable line.

(x) The anchorage zone in a post-tensioned PSC beam extends over a length of
(a) ½ the depth of beam (b) twice the depth of beam
(c) depth of beam (d) width of the beam.

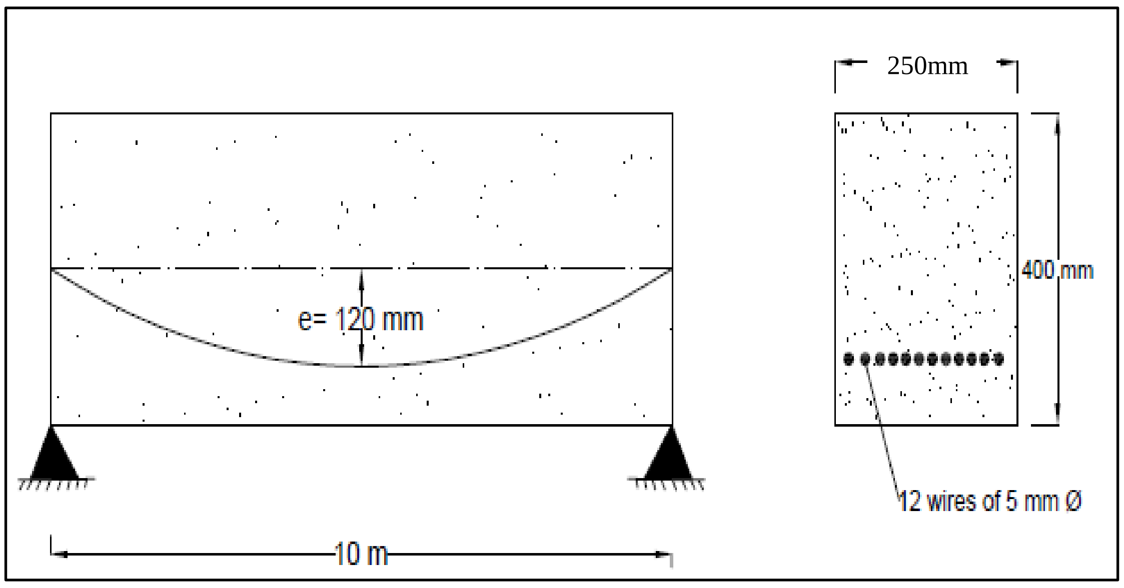
Group – B

2. (a) A prestressed concrete beam spanning over 8m is of rectangular section,150mm wide and 300mm deep. The beam is prestressed by a parabolic cable having an eccentricity of 75mm below the centroidal axis at centre of span and an eccentricity of 25mm above the centroidal axis at support section. The initial force in the cable is 350kN. The beam supports an udl of 8kN/m in addition to its self-weight. E_c=35kN/mm^2.Neglecting loss of prestress, estimate the short-term deflection due to prestress and self-weight.

[CO1, Evaluate/HOCQ]

(b) A post-tensioned beam of 250 mm × 400 mm deep is prestressed by 12 wires of 5 mm diameter initially stressed with 100 N/mm^2 shown in fig. below. The cable profile is parabolic with zero eccentricity at supports and 120 mm at the centre. The span of the beam is 10 m. Estimate the loss of prestress due to various factors and percentage loss for the following data.

Grade of concrete = M40
E_s = 210 kN/mm^2
Residual shrinkage strain = 3 × 10^{-4}
Relaxation of stress in steel = 4 %
Creep coefficient= Ø= 1.6
Co-efficient of friction between the cable and duct= 0.55
Wave effect= 0.0015/m
Anchorage slip= 3 mm
Consider, E_c= 5000√f_{ck}.

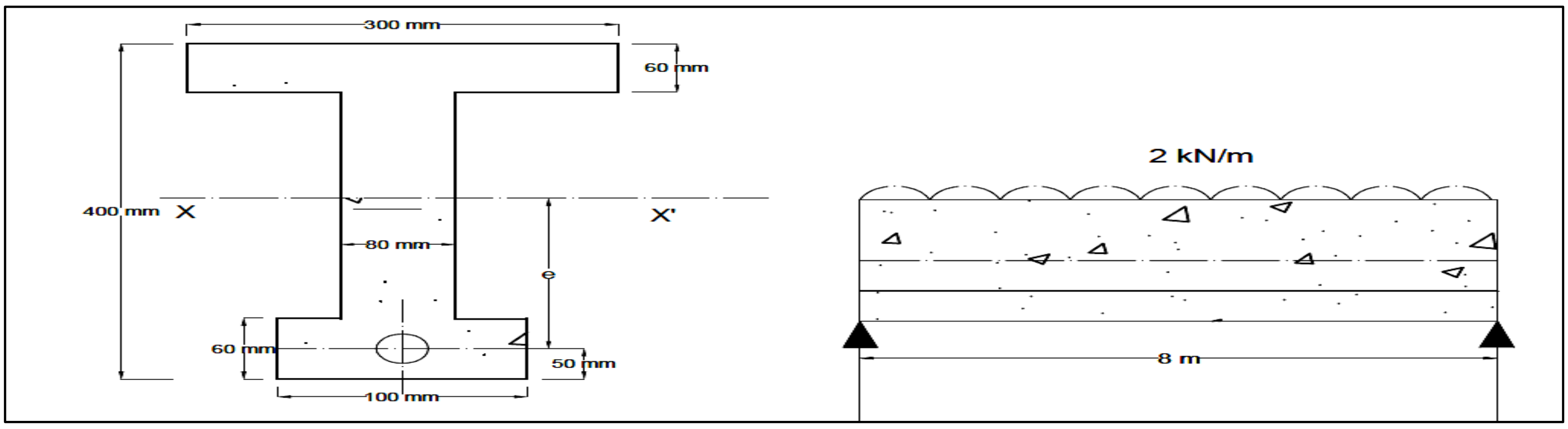


[CO2, Evaluate/HOCQ]

4 + 8 = 12

3. (a) A prestressed concrete beam of section 120 mm wide and 300 mm deep is used over an effective span of 6m to support an uniformly distributed load of 4kN/m, which includes self-weight of the beam. The beam is prestressed by a force of 200kN and located at an eccentricity of 50mm. Determine the location of the thrust line in the beam and plot its position at quarter and central span section. [CO1,Analyze/IOCQ]

(b) An unsymmetrical I-section beam is used to support an imposed load of 2 kN/m over a span of 8 m. At the centre of the span, the effective prestressing force of 100 kN is located at 50 mm from the soffit of the beam shown in the fig. below Estimate the stress at the centre of span section of the beam for the following load conditions:
(i) Prestress + self weight
(ii) Prestress + self weight + live load. [CO1,Evaluate/HOCQ]



5 + 7 = 12

Group – C

4. A prestressed unsymmetrical T-section having overall depth 1400 mm and thickness of web 175 mm. The distance of the top fibre from centroid is 595 mm and distance of the bottom fibre from the centroid is 805 mm. At a particular section, the beam is subjected to an ultimate moment 2200 kN-m. Various required data are given below:
S.F. = 250 kN
Effective depth (d) = 1150mm
Cube strength of concrete (f_{ck}) = 45 N/mm^2
Effective prestress at the extreme tension face of the beam (f_{cp}) = 1500 N/mm^2.
I = 690×10^8 mm^4.
Area of steel (A_p) = 2400 mm^2.
Effective stress in tendons after all the losses (f_{pe}) = 895 N/mm^2.
Estimate the flexure-shear resistance of the section (as per IS 1343:1980). [CO3, Analyze/IOCQ]

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5. (a) A post-tensioned bridge girder with unbonded tendons of box section with dimensions 1200 mm wide by, 1800 mm deep with wall thickness of 150 mm. The high tensile steel are of 4000 mm^2 and located at an effective depth of 1600 mm. The effective prestress in steel after all losses is 1000 N/mm^2 and effective span of girder is 24 m.
If f_{ck} = 40 N/mm^2 and f_p = 1600 N/mm^2, Estimate the ultimate flexural strength of the section. [CO3, Evaluate/HOCQ]

   (b) A post-tensioned prestressed beam of rectangular section of 250 mm wide is to be designed for an imposed load of 12 kN/m, uniformly distributed on a span of 12 m. The stress in the concrete must not exceed 17 N/mm^2 in compression or 1.4 N/mm^2 in tension at any time and the loss of prestress may be assumed to be 15 percent. Calculate minimum possible depth of beam. [CO4, Evaluate/HOCQ]

6 + 6 = 12

Group – D

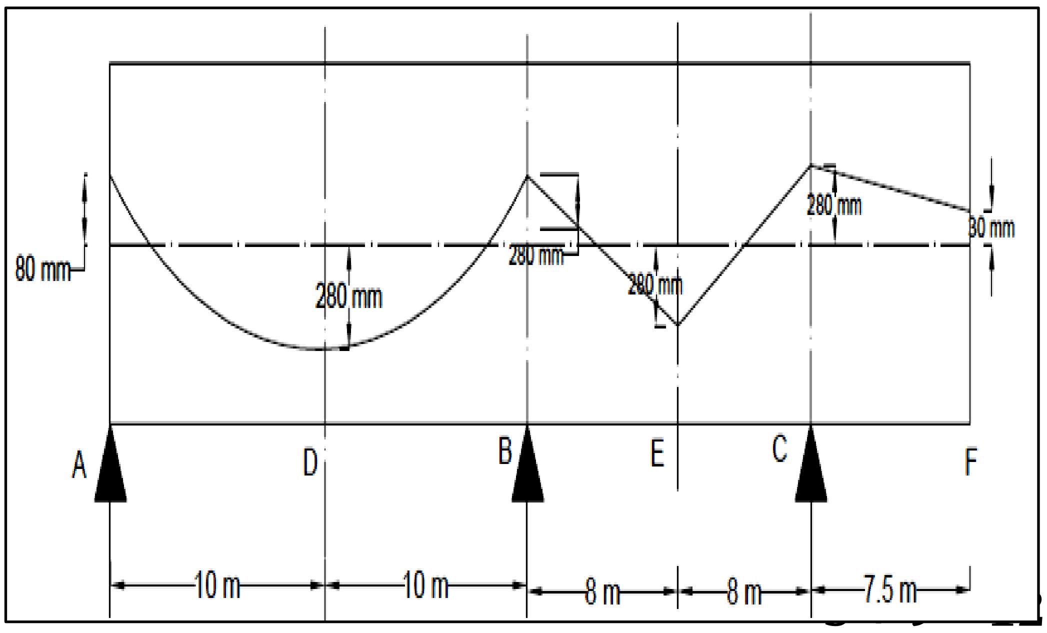
6. (a) Describe the following terms: (also provide necessary diagrams)
(i) End Block (ii) Anchorage zone (iii) Bursting Tension (iv) Splitting crack.
[CO3, Remember/ LOCQ]

   (b) The end block of a prestressed concrete girder is 120 mm × 300 mm. The beam is prestressed by a force of 250 kN is transmitted by a distribution plate of 120 mm wide and 75 mm deep, concentrically located at the ends. Calculate the position and magnitude of maximum tensile stress. [CO4, Analyze/IOCQ]

6 + 6 = 12

7. (a) Explain the method of "**Theorem of three moments**" for the analysis of secondary moments. [CO5.Remember LOCQ]

(b) A prestressed concrete continuous beam is provided with a tendon as shown in figure. The tendon has an eccentricity at A, is parabolic for the span AB, has sharp bends at B, E and C and has an eccentricity at E. The tendon carries a prestressing force of 1500 kN. Draw the resultant B.M. and S.F. diagrams. Locate also the pressure line (C-line) due to the prestress. The beam is 400 mm × 900 mm in section. [CO4, Evaluate/HOCQ]



Group – E

8. A precast pretensioned beam of rectangular section has a breadth of 100 mm and a depth of 200 mm. The beam with an effective span of 5 m, is prestressed by tendons with their centroids coinciding with the bottom kern. The initial force in the tendons is 150 kN. The loss of prestress may be assumed as 15 %. The beam is incorporated in a composite T-beam by casting a top flange of breadth 400 mm and thickness 40 mm. If the composite beam supports a live load of 8 kN/m^2, calculate the resultant stresses developed in the precast and in situ cast concrete assuming the pretensioned beam as:
(i) unpropped and , (ii) propped during the casting of the slab.
Assume the same modulus of elasticity for concrete in precast beam and *in situ* cast slabs.
[CO5, Evaluate/HOCQ]
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9. Design an electric pole of 18 m height and support wires at it's top which can exert a reversible horizontal force of 5 kN. The tendons are initially stressed to 1000 N/mm^2 and loss of stress due to shrinkage and creep is 12%. Maximum compressive stress in concrete shall be limited to 10 N/mm^2. Take E_s = 210 kN/mm^2 and E_c = 38 kN/mm^2 and Ø = 30^0. Unit weight of soil = 18 kN/m^3. [CO6, Evaluate / HOCQ]
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	9	24	67

Course Outcomes (CO):

After the completion of this course, students will be able to:

1. Learn the basic terminologies in Prestressed concrete structures, various methods of prestressing and various losses in prestress in concrete.
2. Develop the design criteria of prestressed concrete section for flexure and shear properties
3. Analyze the anchorage zone stress for post-tensioned members
4. Gain knowledge regarding the methods of Analysis of Statically Indeterminate Structures
5. Gain knowledge regarding the composite construction of Prestress and In-situ concrete
6. Gain knowledge regarding Design of Prestressed concrete poles and sleepers and introduction of partial prestressing.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question