# PRESTRESSED CONCRETE STRUCTURES
## (CIVL 4141)

**Time Allotted : 2½ hrs** **Full Marks : 60**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.***

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

## Group – A

1. Answer any twelve: **12 × 1 = 12**

*Choose the correct alternative for the following*

(i) The grade of concrete for prestressed member should be in the range of:
(a) M 10 to M 20 (b) M 20 to M 30
(c) M 30 to M 60 (d) M 10 to M 15

(ii) 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.

(iii) Loss of stress in due to creep of concrete is influenced by
(a) elastic deformation of concrete (b) anchorage slip
(c) modulus of elasticity of steel (d) area of concrete.

(iv) Relaxation loss for prestressing steel (as per IS 1343:1980) for initial stress for $0.6\, f_{pu}$ is within the range of
(a) 0-0.2 (b) 0.2-0.3 (c) 0.3-1.0 (d) 0.8- 4.5.

(v) According to I.S., the total amount of shrinkage for a pretensioned beam is taken as
(a) $3\times10^{-4}$ (b) $3\times 10^{-5}$ (c) $3\times 10^{-6}$ (d) $3\times10^{-7}$.

(vi) A post-tensioned prestressed concrete beam is subjected to an initial prestressing force of 400kN. The cross-sectional area of the wires in cables is 350mm$^2$. $E_s$= 210kN/mm$^2$. Age of concrete at transfer is 9 days. The loss of prestress due to total residual shrinkage strain as per IS1343 is
(a) 6.3% (b) 4.2% (c) 6.1% (d) 4.5%.

(vii) In the design of prestressed concrete sections, the number of fundamental stress conditions to be considered are
(a) 2 (b) 3 (c) 4 (d) 6.

(viii) Horizontal or axial prestressing of concrete beams
(a) reduces the shear strength of the member
(b) has no effect on the shear strength
(c) increases the shear strength
(d) increases prestressing force.

(ix) Among the mentioned losses which is not present in post-tensioned members
(a) shrinkage of concrete (b) friction and anchorage slip
(c) creep of concrete (d) elastic deformation of concrete.

(x) In anchorage zone of a post-tensioned beam splitting cracks due to bursting tension develop in the direction of
(a) depth of beam (b) inclined at 45° to the axis of the beam
(c) horizontal axis of beam (d) along width of beam.

*Fill in the blanks with the correct word*

(xi) The phenomena of development of internal tensile stress in a concrete member by means of tensioning devices are called as _____.

(xii) Development of early cracks in reinforced concrete is due to _____.

(xiii) The ratio between creep strain and elastic strain of concrete is defined as _____.

(xiv) After tensioning, the space between the tendons and ducts are covered by _____.

(xv) The loss of prestress due to shrinkage of concrete is the product of _____.

## Group - B

2. (a) A prestressed concrete beam, 200 mm wide and 300 mm deep, is used over an effective span of 6m to support an imposed load of 4 kN/m. The density of concrete is 25 kN/m$^3$. At the central span section find the magnitude of eccentric prestressing force located 100mm from the bottom of the beam which would nullify the bottom fibre stress due to loading. *[(CO1)(Apply/IOCQ)]*

(b) A prestressed concrete beam spanning over 8 m is of rectangular section, 150 mm wide and 300 mm deep. The beam is prestressed by a parabolic cable having an eccentricity of 75 mm below the centroidal axis at centre of span and an eccentricity of 25 mm above the centroidal axis at support section. The initial force in the cable is 350 kN. The beam supports an udl of 8 kN/m in addition to its self weight. $E_c$=35 kN/mm$^2$. Neglecting loss of prestress, estimate the short-term deflection due to (prestress+ self weight). *[(CO2)(Analyse/HOCQ)]*

**5 + 7 = 12**

3. A post-tensioned prestressed beam of span length 10 m has a rectangular section of 300 mm wide and 500 mm deep. The beam is prestressed by a parabolic cable concentric at supports with an eccentricity of 100 mm at the centre span. The cross-sectional area of high tensile steel wires in the cable is 300 mm$^2$. The wires are stressed by using jack at the left end so that the initial force in cable at the right end is 250 kN. Using the following data, Calculate
(i) Total loss of stress in wires

(ii) The jacking force required at the left end:
Co-efficient of friction for curvature effect=0.55
Friction co-efficient for wave effect=0.003/m
Anchorage slip at the jacking end =3 mm
Relaxation of steel =4%
Shrinkage of concrete=0.0002
Creep co-efficient =2.2
Modulus of elasticity of steel =210 kN/mm$^2$. *[(CO1)(Analyse/HOCQ)]*

**12**

## Group - C

4. (a) Distinguish between web shear, flexural and flexural-shear cracks in concrete beam with sketches. *[(CO3)(Remember/LOCQ)]*

(b) A prestressed rectangular concrete beam of 300 mm wide and 600 mm deep is prestressed by a parabolic cable which is concentric at support and eccentricity 120 mm at centre of span 11 m. Prestressing force is 250 kN. The uniformly distributed load acts over the span is 30 kN/m inclusive of its self weight. Determine
(i) Maximum principal stress developed 350mm from support.
(ii) Prestressing force required to balance the shear force due to loads at support section. *[(CO3)(Apply/IOCQ)]*

**4 + 8 = 12**

5. (a) Explain strain-compatibility method of prestressed concrete. *[(CO4)(Remember/LOCQ)]*

(b) A post-tensioned bonded T-section has a flange width 800 mm and thickness 250 mm. Thickness of web is 200 mm. The area of high tensile steel located at an effective depth of 1200 mm is 4000 mm$^2$. The characteristic strength of steel and cube strength of concrete are 1500 N/mm$^2$ and 40 N/mm$^2$. The effective prestress after all losses is 900 N/mm$^2$. Estimate the ultimate flexural strength of T-section using IS: 1343-1980. *[(CO4)(Analyse/HOCQ)]*

**4 + 8 = 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 200 mm X 400 mm. The beam is post tensioned by two Freyssinet anchorages each of 80 mm diameter with their centre located at 100 mm from the top and bottom of the beam. The force transmitted by each anchorages being 2000 kN. Compute the bursting force and design reinforcement as per IS codal regulations. *[(CO3)(Apply/IOCQ)]*

**6 + 6 = 12**

7. A continuous prestressed concrete beam ABC (AB=BC=10m) has a uniform rectangular cross-section with a width of 150mm and depth 300mm. The cable carrying an effective prestressing force of 300 kN is parallel to the axis of the beam and located at 100mm from the soffit.
   (i) Determine the secondary and resultant moment at central support B.
   (ii) If the beam supports an imposed load of 2 kN/m, calculate the resultant stresses at top and bottom of the beam at B. Assume unit weight of concrete as 25 kN/m$^3$.
   (iii) Locate the resultant line of thrust through beam AB. *[(CO4)(Analyse/HOCQ)]*

**12**

## Group - E

8. (a) Distinguish between propped and un-propped construction methods in composite construction using stress diagram at various stage of construction. *[(CO5)(Remember/LOCQ)]*

   (b) A precast pretensioned beam of rectangular section has a width of 100 mm and depth of 200 mm. The beam with an effective span of 5 m is prestressed by tendons with their centroids coincide with the bottom kern. The initial force in tendons is 200 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 width 400mm and thickness of 40 mm. If the composite beam supports a live load of 8kN/m$^2$, calculate the resultant stress developed in the pre-cast and in-situ cast concrete assuming the pre-tensioned beam as a) un-propped and b) propped during the casting of the slab. Assume the same modulus of elasticity for concrete in pre-cast beam and in-situ slab. *[(CO5)(Analyse/HOCQ)]*

**4 + 8 = 12**

9. Design an electric pole of height 12 m support wires at its top which can exert a reversible horizontal force of 2500N. The tendons are initially stressed to 1000 N/mm$^2$ and the loss of stress due to shrinkage and creep is 15%. Maximum compressive stress in concrete shall be limited to 12 N/mm$^2$. Take m=6 and φ =30˚. Soil weight = 18 kN/m$^3$. *[(CO6)(Apply/IOCQ)]*

**12**

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| Cognition Level | LOCQ | IOCQ | HOCQ |
|---|---|---|---|
| Percentage distribution | 19 | 30 | 51 |

**Course Outcome (CO):**

After the completion of the course students will be able to
1. Understand the general and mechanical behavior of prestressed concrete.
2. Perform analysis and design of prestressed concrete members and connections.
3. Identify and interpret the appropriate relevant design code
4. Understand the methods of the design and fabrication of prestressed concrete members
5. Perform an industry relevant design project in a team
6. Develop their professional and ethical issues and lifelong learning of the importance of prestressed concrete.

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