Code: 9A01807

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B.Tech IV Year II Semester (R09) Regular Examinations, March/April 2013

PRESTRESSED CONCRETE

(Civil Engineering)

Time: 3 hours

Max Marks: 70

Answer any FIVE questions

All questions carry equal marks

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1 Differentiate between the following:

(a) Externally prestressed members and internally prestressed members.

(b) Pre-tensioning and post tensioning.

(c) Linear prestressing and circular prestressing.

2 Explain the various methods of pre-tensioning and post tensioning systems.

3 A straight post tensioned concrete member 18 meters long with a cross section of 425 mm × 425 mm is prestressed with 920 mm^2 of steel wires. This steel is made up of four tendons with 230 mm^2 per tendon. The tendons are tensioned to a stress 1025 N/mm^2. Determine the loss of prestress in each tendon due to elastic shortening of concrete. Find also the average percentage loss of prestress. If it is desired that after the last tendon is tightened, a stress of 1025 N/mm^2, be maintained in each tendon, calculate the actual stresses to which the individual tendons should be tightened. Take m = 6.

4 A concrete beam of symmetrical I-section spanning 8 m has flange width and thickness of 200 mm and 60 mm respectively. The overall depth of the beam is 400 mm. The thickness of the web is 80 mm. The beam is prestressed by a parabolic cable with an eccentricity of 15 mm at the centre and zero at the supports with an effective force of 100 kN. The live load on the beam is 2 kN/m. draw the stress distribution diagram at the central section for:

(a) Prestress + self weight.

(b) Prestress + self weight + live load. Take the density of concrete as 24 kN/m^3.

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5 A rectangular prestressed beam 150 mm wide and 300 mm deep is used over an effective span of 10 m. The cable with zero eccentricity at the supports, and linearly varying to 50 mm at the centre, carries an effective prestressing force of 500 kN. Find the magnitude of the concentrated load "Q" located at the centre of the span for the following conditions at the centre of span section.

(a) If the load counteracts the bending effect of the prestressing force (neglecting self-weight of the beam), and

(b) If the pressure lines passes through the upper kern of the section under the action of external load, self weight and prestress. Take the density of concrete as 24 kN/m^3.

6 A concrete beam having a rectangular section, 150 mm wide and 300 mm deep, is prestressed by a parabolic cable having an eccentricity of 100 mm at the centre of span, reducing to zero at supports. The span of the beam is 8 m. The beam supports a live load of 2 kN/m. Determine the effective force in the cable to balance the dead and live load on the beam. Estimate the principal stresses at the support section. Take the density of concrete as 24 kN/m^3.

7 A prestressed concrete composite beam section consists of a 500 mm × 75 mm cast in situ flange and 140 mm × 250 mm deep rectangular precast prestressed stem. The stress distribution for the pre cast stem section due to prestressing force alone is 16 N/mm^2 at bottom to zero at top. Find what uniformly distributed live load the composite beam can carry on a simply supported span of 6 m for the condition that the stress at the bottom of pre cast unit is zero for the following conditions:

(a) The dead load of the slab and the weight of the shuttering are carried by the pre cast unit during casting and the shuttering is removed after the slab concrete is hardened.

(b) The dead load of the slab is supported independently at the time of casting. Assume that the shuttering weighs 270 N/m and the ratio elastic modulus for slab/elastic modulus for pre cast unit is 0.65. Take the density of concrete as 24 kN/m^3.

8 A prestressed concrete beam of span 8 m has a section of area 42 × 10^3 mm^2 the moment of inertia of the section being 1.75 × 10^8 mm^4. The beam is prestressed with a parabolic cable providing a prestressing force of 245 kN. The cable has an eccentricity of 50 mm at the centre and no eccentricity at the ends. Ignoring all losses, find the deflection at the centre

(a) when the beam carries its own weight and prestress.

(b) when the beam carries its own weight, prestress and a superimposed load of 1.8 kN/m.

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1 (a) Define the terms pre tensioning and post tensioning.
(b) What are the general principles of prestressing?
(c) What are the advantages of prestressed concrete over reinforced concrete?

2 Explain with the help of neat sketches Gifford Udall system and Le mecall system.

3 A post tensioned concrete beam, 100 mm wide and 300 mm deep, is prestressed by three cables, each with a cross-sectional area of 50 mm^2 and with an initial stress of 1200 N/mm^2. All the three cables are straight and located 100 mm from the soffit of the beam. If the modular ratio is 6, calculate the loss of stress in the three cables due to elastic deformation of concrete only for the following cases:
(a) Simultaneous tensioning and anchoring of all the three cables.
(b) Successive tensioning of the three cables one at a time.

4 An unsymmetrical I-section beam is used to support an imposed load of 2 kN/m over a span of 8 m. The sectional details are top flange, 300 mm wide and 60 mm thick, bottom flange 100 mm wide and 60 mm thick, thickness of the web is 80 mm, overall depth of the beam is 400 mm. At the centre of the span, the effective prestressing force of 100 kN is located at 50 mm from the soffit of the beam for the following load conditions:
(a) Prestress + self weight.
(b) Prestress + self weight + live load.

5 A prestressed concrete beam of rectangular section 400 mm wide × 600 mm deep is provided with a tendon having a parabolic profile with an eccentricity of 100 mm at the centre of span. The span of the beam is 6 m. If the total external load on the beam is 35 kN/m on the whole span, calculate the extreme stresses for the mid span section. The tendon carries a prestressing force of 1000 kN. Calculate the stresses using
(a) Strength concept method.
(b) Stress concept method and
(c) Load balancing method.

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6 A post tensioned beam of rectangular cross-section 200 mm wide and 400 mm deep is 10 m long and carries an applied load of 8 kN/m, uniformly distributed on the beam. The effective prestressing force in the cable is 500 kN. The cable is parabolic with zero eccentricity at the supports and a maximum eccentricity of 140 mm at the centre of span.

(a) Calculate the principal stresses at the supports.

(b) What will be the magnitude of the principal stresses at the supports in the absence of prestress?

7 A precast pre tensioned 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 to be 15 percent. The beam is incorporated in a composite T-beam by casting a top flange of breadth 400 mm and a thickness of 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 pre tensioned beam as

(a) Unpropped.

(b) Propped during the casting of the slab. Assume the same modulus of elasticity for concrete in precast beam and in situ cast slab. Take the density of concrete as 24 kN/m^3.

8 A simply supported concrete beam of span 8 m and rectangular cross-section 125 mm wide and 250 mm deep, is prestressed by a single cable in which the total tensile force is 220 kN. The centre line of the cable is parallel to the axis of the beam and 75 mm above the soffit over the middle-third of the span and is curved upward in a parabola over the outer-thirds of the span to a distance of 175 mm above the soffit at the supports. If the modulus of elasticity of concrete is 35 kN/mm^2 and the density of concrete is 24 kN/m^3, calculate

(a) The upward deflection at mid-span due to prestress only.

(b) The deflection when the beam is supporting its own weight, and

(c) The magnitude of concentrated loads Q placed at the third points of the span, which would result in a limiting short-term deflection of span/500.

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1 (a) Explain bonded and unbounded tendons.
(b) Differentiate between a fully prestressed and a partially prestressed member.
(c) Explain creep and shrinkage losses in concrete.

2 (a) Define the following terms: (i) Fully prestress. (ii) Partially prestress. (iii) Composite prestressing. (iv) Cast in situ prestressing.
(b) Explain the Hoyer system of prestressing.

3 A prestressed concrete beam 200 mm wide and 300 mm deep is prestressed with wires of area 320 mm^2 located at a constant eccentricity of 50 mm and carrying an initial stress of 1000 N/mm^2. The span of the beam is 10 m. Calculate the percentage loss of stress in wires if:
(a) The beam is pre-tensioned and
(b) The beam is post-tensioned, using the following data:
E_S = 210 kN/mm^2 and E_C = 35 kN/mm^2.
Relaxation of steel stress = 5 percent of the initial stress.
Shrinkage of concrete = 300×10^{-6} for pre-tensioning and 200×10^{-6} for post tensioning.
Creep coefficient = 1.6
Slip at anchorage = 1 mm.
Frictional coefficient for wave effect = 0.0015 per m.

4 A prestressed concrete beam supports a live load of 4 kN/m over a simply supported span of 8 m. The beam has an I-section with an overall depth of 400 mm. Thickness of the flange and web are 60 and 80 mm respectively. The prestressing force of 235 kN at a suitable eccentricity such that the resultant stress at the stress at the soffit of the beam at the centre of the span is zero.
(a) Find the eccentricity required for the force.
(b) If the tendon is concentric, what should be the magnitude of the prestressing force for the resultant stress to be zero at the bottom fibre of the central span section?

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5 A prestressed concrete beam section is 250 mm wide and 300 mm deep. The initial prestressing force is 450 kN at an eccentricity of 60 mm. The beam has a span of 5.75 m and has to carry a superimposed load of 7.5 kN/m. Analyze the beam section for the stresses produced at mid span before and after application of the live load. Allow a loss of prestress of 15%. Take the weight of concrete as 24 kN/m^3.

6 A cantilever portion of a prestressed concrete bridge with a rectangular cross-section 600 mm wide and 1650 mm deep, is 8 m long and carries a reaction of 350 kN from the suspended span at the free end, together with a uniformly distributed load of 60 kN/m inclusive of its own weight. The beam is prestressed by 7 cables each carrying a force of 1000 kN, of which 3 are located at 150 mm, 3 at 400 mm and 1 at 750 mm from the top edge. Calculate the magnitude of the principal stresses at a point 550 mm from the top of the cantilever at the support section.

7 A prestressed concrete beam of rectangular section 120 mm and 300 mm deep, spans over 6 m. The beam is prestressed by a straight cable carrying an effective force of 180 kN at an eccentricity of 500 mm. If it supports an imposed load of 4 kN/m and the modulus of elasticity of concrete is 38 kN/mm^2, compute the deflection at the following stages and check whether they comply with the IS code specifications.

(a) Upward deflection under (prestress + self weight) and

(b) Final downward deflection under (prestress + self-weight + imposed load) including the effects of creep and shrinkage. Assume the creep coefficient to be 1.80.

8 A composite beam of rectangular section is made up of a pre-tensioned inverted T-beam having a slab thickness and width of 150 mm and 1000 mm respectively. The rib size is 150 mm by 850 mm. The cast in situ concrete has a thickness and width of 1000 mm with a modulus of elasticity of 30 kN/mm^2. If the differential shrinkage is 100×10^{-6} units, estimate the shrinkage stresses developed in pre cast and cast in situ units.

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1 (a) Mention the advantages of using high strength steel and high strength concrete in prestressed concrete.
(b) What are the various stages of loading to be considered in the design of prestressed concrete structures?

2 (a) Explain length and curvature effect in case of curved cables.
(b) Explain with the help of neat sketch the Freyssinet system of post tensioning.

3 A rectangular concrete beam of cross-section 30 cm deep and 20 cm wide is prestressed by means of 15 wires of 5 mm diameter located at 6.5 cm from the bottom of the beam and 3 wires of diameter of 5 mm, 2.5 cm from the top. Assuming the prestress in the steel as 840 N/mm^2, calculate the stresses at the extreme fibers of the mid-span section when the beam is supporting its own weight over a span of 6 m. If a uniformly distributed live load of 6 kN/m is imposed, evaluate the maximum working stress in concrete. Take the density of concrete as 24 kN/m^3.

4 A rectangular concrete beam, 100 mm wide by 250 mm deep, spanning over 8 m is prestressed by a straight cable carrying an effective prestressing force of 250 kN located at an eccentricity of 40 mm. The beam supports a live load of 1.2 kN/m.
(a) Calculate the resultant stress distribution for the central cross section of the beam. The density of concrete is 24 kN/m^3.
(b) Find the magnitude of the prestressing force with an eccentricity of 40 mm which can balance the stresses due to dead and live loads at the bottom fibre of the central section of the beam.

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5 A concrete beam of 10 m span, 100 mm wide and 300 deep is prestressed by 3 cables. The area of each cable is 200 mm^2 and the initial stress in the cable is 1200 N/mm^2. Cable 1 is parabolic with an eccentricity of 50 mm above the centroid at the supports and 50 mm below at the centre of span. Cable 2 is also parabolic with zero eccentricity at the supports and 50 mm below the centroid at the centre of span. Cable 3 is straight with uniform eccentricity of 50 mm below the centroid. If the cables are tensioned from one end only, estimate the percentage loss of stress in each cable due to friction. Assume $\mu = 0.35$ and K = 0.0015 per m.

6 A prestressed concrete beam of span 10 m of rectangular section, 120 mm wide and 300 mm deep, is axially prestressed by a cable carrying an effective force of 180 kN. The beam supports a total uniformly distributed load of 5 kN/m which includes the self-weight of the member. Compare the magnitude of the principal tension developed in the beam with and without axial prestress.

7 A composite T-beam is made up of pre-tensioned rib 100 mm wide and 200 mm deep, and a cast in situ slab of 400 mm wide and 40 mm thick having a modulus of elasticity of 28 kN/mm^2. If the differential shrinkage is 100×10^{-6} units, determine the shrinkage stresses developed in the precast and cast in situ units.

8 A simply supported beam with a uniform section spanning over 6 m is post-tensioned by two cables, both of which have an eccentricity of 100 mm below the centroid of the section at mid-span. The first cable is parabolic and is anchored at an eccentricity of 100 mm above the centroid at each end, the second cable is straight and parallel to the line joining the supports. The cross-sectional area of each cable is 100 mm^2 and they carry an initial stress of 1200 N/mm^2. The concrete has a cross-section of 2×10^4 mm^2 and a radius of gyration of 120 mm. The beam supports two concentrated loads of 20 kN each at the third points of the span, E_C = 38 kN/mm^2. Calculate using Lin's simplified method.

(a) The instantaneous deflection at the centre of span and

(b) The deflection at the centre of span after 2 years, assuming 20 percent loss in prestress and the effective modulus of elasticity to be one-third of the short term modulus of elasticity.

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