DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

II SEMESTER 2015-2016 MINOR EXAM I Time limit: 1 hr.
CEL 432 DESIGN OF PRESTRESSED CONCRETE STRUCTURES Max Marks = 20
Course Coordinator: Dr. Alok Madan

Instructions: 1. This is a 'closed book' exam. 2. Assume linearly elastic behavior

A simply supported prestressed concrete beam spanning over 18 m has a rectangular cross-section 300 mm wide and 650 mm deep. The beam is prestressed with a parabolic tendon with an eccentricity (with respect to centroidal axis) of 250 mm at the midspan and zero at the end supports. The grade of concrete is M40 with the density of concrete = 25 kN / m^3.

(a) The effective prestressing force in the tendon after transfer is of such a magnitude that the normal bending stress at the extreme tension fiber at mid-span is zero when the beam supports a uniform dead and live load of intensity 18 kN / m **(excluding self-weight of beam)**. Calculate the magnitude of the effective prestressing force. (4 marks)

(b) For the effective prestressing force calculated in part (a), what is the maximum intensity of a uniform load that the beam can support **(in addition to self-weight)** prior to onset of cracking at the extreme tension fiber of the critical section? The modulus of rupture (cracking stress) of concrete f_{cr} = 2.5 Mpa (3 marks)

(c) For the effective prestressing force calculated in part (a), obtain and draw the distribution of normal bending stress over the depth of the sections at **midspan, quarter spans and end spans** when the beam supports a uniform load of intensity 18 kN / m **(in addition to self-weight)** acting on the beam. Using the graphical solution of the normal stress distributions thus obtained, calculate the location of the center of pressure or thrust line (i.e. C-line) at the **mid span, quarter spans and end span** sections by integrating the normal stress distributions. Use the graphical results to plot the C-Line for this loading. (4 marks)

(d) For the effective prestressing force calculated in part (a), use the analytical method based on static equilibrium to derive the analytical equation of the C-Line when the beam supports a uniform load of intensity 18 kN / m **(in addition to self-weight)** acting on the beam. Compare the values resulting from the analytical solution thus derived to those obtained from the graphical solution at **midspan, quarter spans and end spans** in Part(c). (3 marks)

(e) Using the C-Line or Internal Resisting Couple method of elastic analysis, plot the normal stress distributions along the depth of the sections at midspan, quarter spans and end spans due to the **combined effect of the prestress & external uniform load of intensity 16** kN / m **(in addition to self-weight)** for the effective prestressing force calculated in part (a). (4 marks)

(f) Calculate the effective prestressing force required in the cable to balance a uniform load of intensity 20 kN / m **(in addition to self-weight)** on the beam. (By definition, load balancing is achieved when the flexural or bending stresses due to transverse loads are nullified by the prestress and all the sections are in a state of pure axial stress). (2 marks)