EGT3/EGT2
ENGINEERING TRIPOS PART IIB
ENGINEERING TRIPOS PART IIA

Friday 27 April 2018 14.00 to 15.40

Module 4D8

PRESTRESSED CONCRETE

Answer all questions.

Question 1 carries twice as many marks as each of Questions 2 and 3.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

Write your candidate number **not** *your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper
Graph Paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 The symmetrical continuous post-tensioned concrete beam shown in Fig. 1 has a constant rectangular cross section of overall depth 1400 mm and width 700 mm. It contains a draped tendon, the geometry of which consists of three parabolae, as shown. The maximum tendon eccentricity in sagging is 500 mm, and in hogging it is 400 mm. The in-service prestressing force is a constant 5 MN.

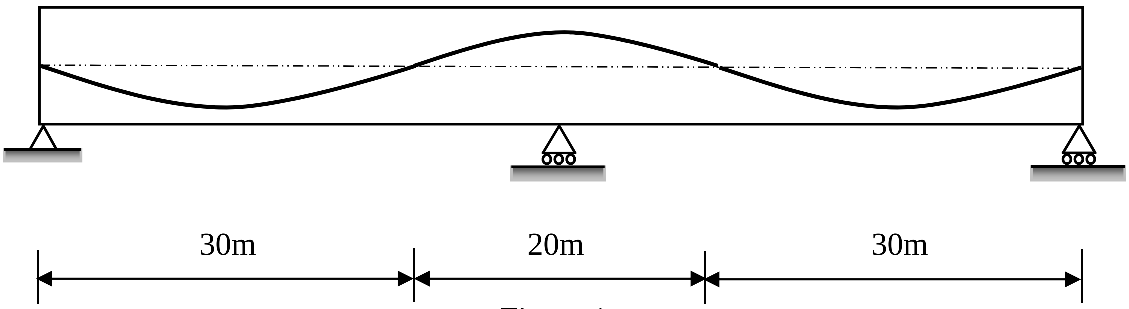
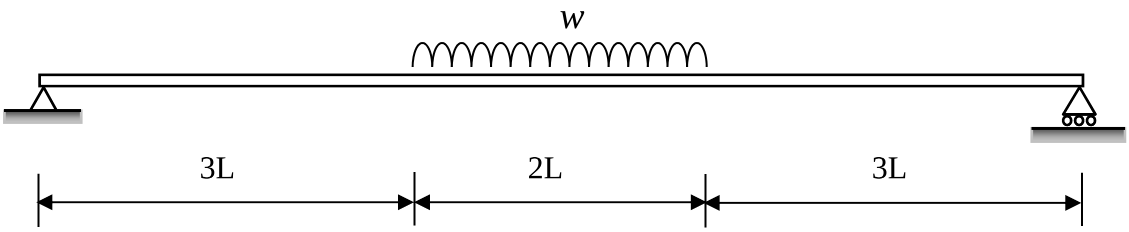


Figure 1
(Not to scale)

(a) Determine the secondary moments induced by this tendon arrangement and sketch their variation across the structure. You may wish to use the fact that the vertical displacement at the centre of the beam shown below in Fig. 2 is:

$$\delta = \frac{497wL^4}{24EI}$$



[50%]

Figure 2

(b) It is decided not to use any initially-unstressed reinforcement in this structure. Assume the strength of the concrete to be 60 MPa, ultimate strain capacity of the concrete to be 0.0035, area of fully-bonded tendon to be 6250 mm^2, k_1 = 0.4, k_2 = 0.5, Young's Modulus for the concrete to be 30 GPa, and make use of the stress-strain relationship for the prestressing steel given in Fig. 3. By taking the depth to the neutral axis to be 500 mm as your ***first and only*** iteration, estimate the ultimate hogging moment capacity of this structure over the central support. [40%]

(c) Do you think it would be sensible to consider secondary moments at the ultimate limit state in this particular structure? Justify your answer. [10%]

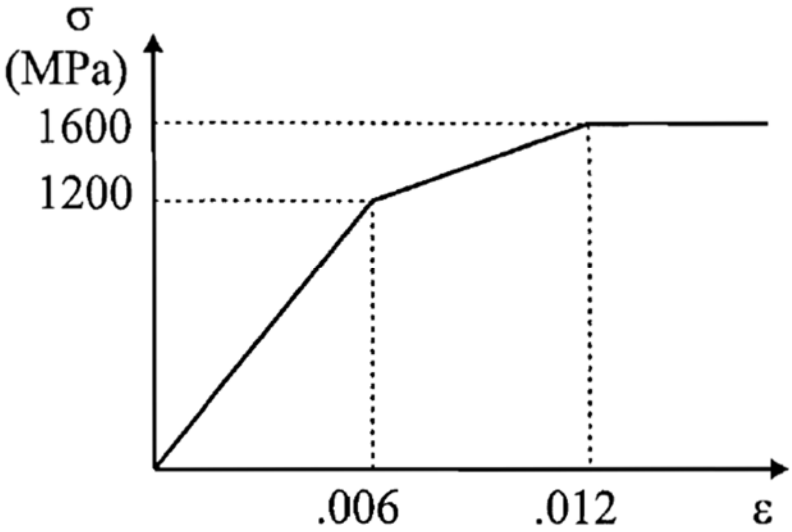


Figure 3

2 A simply-supported prestressed concrete beam has an overall depth of 1250 mm. Its cross-sectional area is 500,000 mm^2 and its second moment of area is 0.106 m^4 with the centroid at a height of 720 mm above the soffit. At the critical cross section, it is subject to a minimum bending moment of 600 kNm and a maximum bending moment of 3000 kNm (both in sagging), and it must satisfy limiting working stresses of 1 MPa in tension and 18 MPa in compression.

(a) Draw a Magnel diagram for this beam. [70%]

(b) The tendon is to be positioned with its centroid 200 mm above the soffit to satisfy stringent cover requirements. What is the minimum effective prestressing force which could be applied to this beam to satisfy the stress requirements above? [30%]

3 A stock of rectangular pre-tensioned concrete beams from the 1940s, each of breadth 250 mm, overall depth 700 mm and length 10,200 mm, are found in a disused mine. By inspecting the ends of the beams, it is found that the prestressing wires are positioned such that on average the prestressing force acts through the lower Kern Point. All beams are in good condition, with no cracking evident at all. The engineer wishes to use these beams on a new-build project, but she needs to discover their properties. She devises a testing regime to be conducted on one of the beams. It is to be simply supported over a span of 10 m, and loaded at its centre through a single concentrated load.

On first loading, the beam suddenly loses considerable stiffness when the imposed load reaches 170 kN. The beam is unloaded fully. It is then reloaded, and this time the beam loses considerable stiffness at an imposed load of 120 kN. The engineer determines that these load levels could not possibly have yielded the steel.

(a) Remembering to take due account of the weight of the concrete (24 kN/m^3), determine the prestressing force in the beam and the tensile strength of the concrete. [80%]

(b) Had this beam been tested back in the 1940s in the same manner as above but just a few minutes after transfer when the concrete was only one week old, what qualitative differences might you have expected to see between the test results then and those of today? Do not carry out any calculations in answering this question. [20%]

END OF PAPER

Answers:
Q1(a). Maximum M_2 = 1,950 kNm. Q1(b). M_{res} = 7,200 kNm.
Q2(b). P_{min} = 3.5 MN.
Q3(a). P = 1.51 MN and f_t = 6.12 MPa.