ENGINEERING TRIPOS PART IIB

Monday 2 May 2005 2.30 to 4

Module 4D8

PRESTRESSED CONCRETE

*Answer **one** question from Section A and **two** questions from Section B.*

*Questions from Section A carry **twice** as many marks as questions from Section B.*

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

There are no attachments.

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

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SECTION A

Long questions – answer one question from this section

1 (a) Explain the principles behind the Magnel Diagram. Sketch an example and show clearly which lines are governed by tension and compression stress limits, which are governed by the top and bottom fibre stresses, and which are governed by maximum and minimum moments. [20%]

(b) The beam shown in Fig. 1 has to carry a sagging moment of 20,000 kNm and a hogging moment of 5,000 kNm. Permissible stresses in the concrete are 20 MPa in compression and zero in tension. Draw a Magnel diagram for this beam and determine the minimum prestressing force that is required and its location. How would your answer be altered if you took into account the likely errors in determining the position and magnitude of the prestressing force? [60%]

(c) By drawing sketches of appropriate Magnel diagrams, describe circumstances when the behaviour of the beam is likely to be governed by compressive stresses. In each case explain why it is compressive stresses, rather than tensile stresses, that govern. [20%]

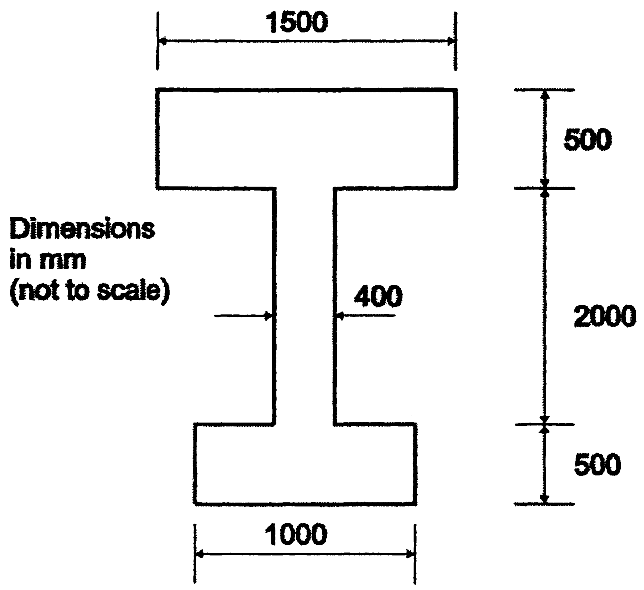

Fig. 1

2 (a) Derive expressions for the secondary moments in a 3-span continuous beam as a function of the actual cable profile (e_s). [40%]

(b) Use an appropriate version of these expressions, and Simpson's rule of numerical integration, to find the secondary moments induced in a 2-span beam whose cable profile is given in the Table below and which has a cable force of 10 MN. Determine the eccentricity of the line of thrust at the internal support. [40%]

(c) Explain why designers deliberately choose cable profiles that induce secondary moments when it is just as easy to design concordant profiles. [20%]

Chainage (m)	Eccentricity (m)	Notes
0	-0.3	Support
4	0.3	
8	0.6	
12	0.2	
16	-1.0	Support
20	0.2	
24	0.7	
28	0.8	
32	0.7	
36	0.4	
40	0.0	Support

Table for Question 2(b)

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SECTION B

Short questions – answer two questions from this section.

3 The beam in Fig. 2 is loaded in sagging bending. Ultimate load failure occurs when the compressive strain in the concrete reaches 0.0035. The concrete may be assumed to have a cube strength of 60 N/mm^2; take the stress block factors to be $k_1 = 0.4$, $k_2 = 0.5$ and ignore the strain in the concrete due to the prestress. The stress in the tendon at transfer is 800 N/mm^2.

The untensioned reinforcement may be assumed to have a yield strength of 500 N/mm^2, and the stress-strain relationship for the prestressing steel is given by

$$\sigma = 2200\left(1 - e^{-125\varepsilon}\right) \quad (N/mm^2)$$

Calculate the moment capacity in sagging bending. [100%]

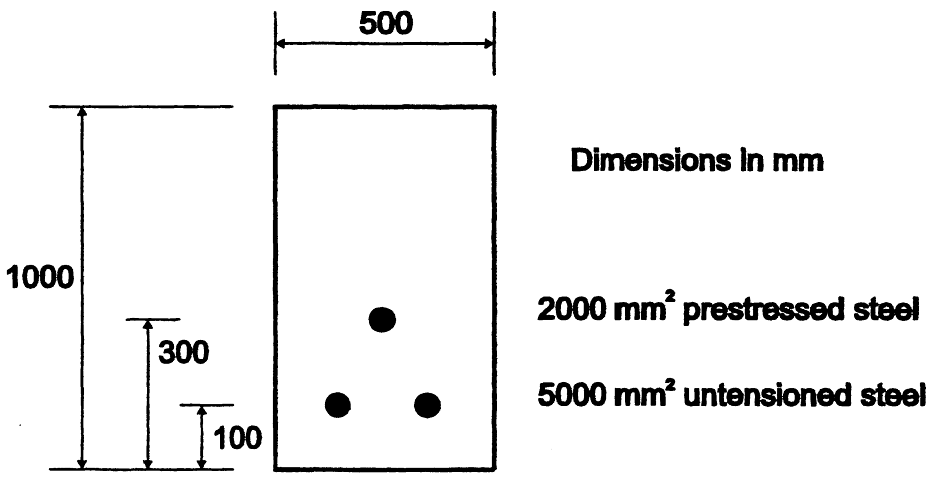

Fig. 2

4 Which of the following statements regarding losses of prestress are true or false? In each case, write a single sentence justifying your conclusion.

(a) Friction losses in prestressing cables are reduced by the use of more flexible ducts. [12%]

(b) Friction losses in continuous beams are increased when the cable profile induces secondary moments. [12%]

(c) Friction losses are increased by the presence of untensioned reinforcement. [12%]

(d) Improving the bond between cable and duct by the use of strong grout reduces the friction losses. [12%]

(e) Creep losses are increased by the presence of untensioned reinforcement. [13%]

(f) Losses due to anchorage slip are more important in long tendons than in short tendons. [13%]

(g) Losses due to elastic shortening can be ignored for pretensioned beams because the tendons are stressed before the concrete is placed. [13%]

(h) Losses due to relaxation of steel are worse for post-tensioned beams than for pretensioned beams. [13%]

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5 (a) Explain the effects of creep on the distribution of bending moments in beams and its interaction with temperature effects. Show that the effect of temperature variation on creep can be taken into account by analysing the structure with a modified Young's modulus. [50%]

(b) Discuss the effect of each of the following bending moment distributions on the creep behaviour of the concrete, and of any interactions between them.

- The monolithic bending moment induced when the structure is built in a single phase.
- The trapped moments induced by phased construction.
- The eventual bending moment distribution after all creep has taken place.
- The bending moment induced by daily temperature variation.
- The bending moment induced by annual temperature variation. [50%]

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