ENGINEERING TRIPOS PART IIB
ELECTRICAL AND INFORMATION SCIENCES TRIPOS PART II

Monday 5 May 2003 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.*

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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Version 2

SECTION A

Answer one question

1 There is a form of construction in which a precast pretensioned beam has *additional* post-tensioning added *after* an in-situ concrete top flange has been added. Ducts are left in the precast beam to allow for the second set of tendons.

The section properties, design moments (which include self-weight) and allowable stresses, for such a beam, are given in the table on the opposite page. The composite section properties take account of any difference in the elastic moduli of the two materials. All losses may be assumed to be negligible. The pre-tension is a force of 3000 kN applied at an eccentricity of 0.1 m.

(a) Calculate the stresses in the precast beam when it is acting alone. [20%]

(b) Determine the loading cases that will cause the limiting stress conditions in the top and bottom fibres of the precast beam and in the top fibre of the in-situ concrete, once the beam is behaving compositely. [20%]

(c) Derive appropriate inequalities for these limiting stress conditions in terms of the additional prestress, P_2, applied at an eccentricity of e_2 relative to the centroid of the composite section. [30%]

(d) Use the results of (c) to plot a Magnel diagram for (P_2, e_2). (A suitable value of P_2 to be used to construct the Magnel diagram is 2000 kN). [30%]

(cont.

	Pretensioned Beam	Composite Beam
Overall Depth (m)	0.8	0.95
Height of Centroid (m)	0.4	0.575
Area (m^2)	0.32	0.47
Second Moment of Area (m^4)	0.017	0.04
Minimum Moment (kNm)	360	360
Maximum Moment (kNm)	360	1560

Allowable Stresses (N/mm^2)	Precast Concrete	In-situ concrete
Tension	0	0
Compression	20	15

Data to accompany Question 1

2 In composite construction, differential creep of the precast and in-situ concrete leads to a set of self-equilibrating forces and moments X_p and M_p respectively. In the lecture course it was shown that these could be found by solving:

$$\begin{bmatrix} \alpha & \beta \\ \beta & \gamma \end{bmatrix} \begin{bmatrix} M_p \\ X_p \end{bmatrix} = \frac{\varphi}{1+\varphi} \begin{bmatrix} P_t e \\ (y_1 e + r_p^2) P_t \end{bmatrix}$$

(a) Define all these variables and derive these equations. [65%]

(b) Without carrying out further detailed derivations, show how the method described here can be modified to take account of differential shrinkage between the insitu and precast concrete. [35%]

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SECTION B

Answer two questions

3 Write short notes to explain which causes of loss of prestress can be expected to be important in **two** of the following types of construction.

(a) A post-tensioned simply-supported bridge is built on falsework. All the concrete is placed over a relatively short time and the prestress is applied in a single operation. [50%]

(b) A bridge is built by balanced cantilever construction from precast elements. Cables are placed in the top of the beam to carry the cantilever moments and additional continuity cables are placed after the spans are complete. [50%]

(c) A bridge is incrementally launched over a series of temporary supports. The beam has only untensioned reinforcement at this stage. The beam is then prestressed with external cables that run from end-to-end of the bridge over deviators and many of the supports are removed to leave the bridge on a small number of permanent supports. [50%]

4 Discuss the advantages and disadvantages of using untensioned reinforcement in a prestressed concrete beam. Your answer should consider the different loading stages in the structure's life, the various limiting conditions that should be designed-for, and the effects on creep and long-term durability. [100%]

5 Discuss the desirability of prestressing advanced composite sheets made from carbon or aramid fibres that are being used to repair existing structures, either for flexure, or for shear, or to provide earthquake resistance. What are the practical difficulties of providing this prestress? [100%]

END OF PAPER