Version CJB/4

EGT3/EGT2
ENGINEERING TRIPOS PART IIB
ENGINEERING TRIPOS PART IIA

Friday 22 April 2016 14.00 to 15.30

Module 4D8

PRESTRESSED CONCRETE

*Answer not more than **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.*

*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

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

SECTION A
Answer one question

1 Some engineers and codes of practice regard reinforced concrete as being the same as prestressed concrete, but with the initial stress in the steel set to zero. Under this model, both types of construction have to satisfy the same limiting conditions, and the same clauses are used in codes.

The alternative is to regard prestressed and reinforced concrete as completely different materials, with different limiting conditions. This leads to different codes, or at least different clauses, for the two materials.

(a) By considering what has been taught in this course, and your own background reading, give a reasoned argument in favour of one or other of these philosophies. You should make reference to the different factors that limit the use of the materials. [80%]

(b) How is your argument altered if the tension elements are made from advanced fibre composites, such as aramid or carbon reinforced polymers. [20%]

2 A 20 m long concrete beam of uniform cross-section is simply supported at one end and 6 m in from the other end. It is to carry a live working load of 60 kN/m, which may be placed over any length of the beam. The beam is to be prestressed, with compressive stress in the concrete at working load to be in the range 0 to 22 MPa.

(a) Determine the required magnitude of section modulus for the beam, and suggest initial choices of overall depth and flange and web dimensions. (You may assume that the critical position in the beam is 1.29 m from the middle of the 14 m span.) [20%]

(b) The beam adopted has cross-sectional area A = 0.40 m^2 and section moduli $Z_t = -0.17$ m^3 , $Z_b = +0.14$ m^3 . Show that the moment due to dead load (for concrete weight 24 kN/m^3) at the critical position given in part (a) is about 125 kNm, and that the maximum and minimum total moments there are about +1.55 and −0.51 MNm respectively. Draw a Magnel diagram for the critical section, and determine the maximum and minimum values of the required prestressing force P. [60%]

(c) A cable force of 3 MN is adopted. Sketch the allowable range of eccentricity e along the beam, giving values at the ends, at the internal support, and at the critical position. Could the beam sensibly be pre-tensioned? [20%]

SECTION B

Answer two questions

3 (a) When considering the ultimate load capacity of prestressed concrete beams, a limit is often placed on the maximum strain in the steel. This is often expressed as a limit of 1% on the additional strain after applying the prestress. The effect is to limit the strain in the steel to much less than its actual strain capacity. Explain why this limit is needed. Would you expect this limit to apply to heavily prestressed or lightly prestressed sections? [60%]

(b) Derive an expression for the amount of prestressing steel needed to prevent this condition governing the ultimate load capacity of a rectangular prestressed concrete beam. Define any variables used. [40%]

4 Two rectangular post-tensioned prestressed concrete beams are identical, other than that one has bonded tendons and the other has unbonded tendons. Each beam has an overall depth of 900 mm, a breadth of 400 mm, and a prestressing tendon of 1800 mm^2 at an eccentricity of 150 mm. The tendons are initially stressed to 800 MPa. The stress-strain curve for the steel is shown in Fig. 1. The beams are designed to be simply-supported at their ends and to be subjected to a uniformly-distributed load.

(a) Without doing detailed calculations, sketch typical load-deflection relations for the two beams, showing the complete behaviour from casting to failure. Indicate the reasons for all changes of slope on these curves, and discuss the similarities and differences. [40%]

(b) Why is a complete analysis of the unbonded beam more complicated than that for the bonded beam? [30%]

(c) Perform an ultimate moment calculation for the unbonded beam, assuming a bond factor of 0.25. Ignore the effects of elastic strains in the concrete due to the prestress and assume that the concrete stress at failure is 30 MPa over the whole of the compression zone. [30%]

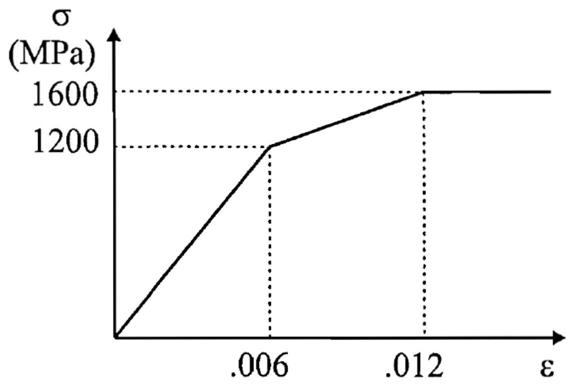

Fig. 1

5 Which of the following statements regarding losses of prestress are true and which are false? In each case, write a short note justifying your conclusion.

(a) 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 in prestressing tendons 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%]

END OF PAPER