ENGINEERING TRIPOS PART IIB
ELECTRICAL AND INFORMATION SCIENCES TRIPOS PART II

Friday 25 April 2003 2.30 to 4

Module 4D10

STRUCTURAL STEELWORK

*Answer not more than **three** questions.*

All questions carry the same number of marks.

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

Unless otherwise indicated, in all questions the given loads are already factored and no partial material factors need to be applied, and self-weight can be ignored.

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.

(TURN OVER

1 The continuous beam, $ABCD$, in Fig. 1 has a uniform cross-section and is simply-supported at both A and C. The support at D freely enables vertical movement but prevents rotation of the beam end. AC and CD each have length L, and the beam is initially free of stresses. A vertical load, W, is applied midway along AC at B, as indicated.

(a) Show that the magnitude of the resulting bending moment at D is $3WL/64$ and, hence, determine the bending moment profile along the beam in terms of W and L. [35%]

(b) The beam is a $457 \times 152 \times 82$ kg/m grade S275 UB, and the total length of AD is 20 m. At the supports and at B, the beam is restrained against both lateral deflection and twist, but is free to warp. By consideration of stability, calculate the maximal value of W for which the beam will be *everywhere* safe. [65%]

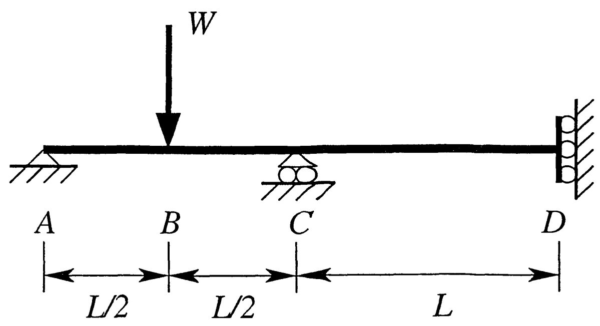


Fig. 1

2 (a) Describe briefly, without calculation, those factors responsible for a decrease in the actual buckling capacity of a pin-ended column compared to the Euler prediction. [10%]

(b) Consider the initially stress-free asymmetric T-frame, $EFGH$, in Fig. 2 of the indicated geometry; it is not drawn to scale. The frame is pinned at both E and H, and the roller at E allows vertical movement but prevents horizontal displacement. The vertical column, HF, is rigidly connected to the beam, EFG, at F: each member is a hot-rolled $305 \times 102 \times 33\ kg/m$ grade S355 UB with its major axis normal to the plane of the page.

Two vertically downward loads, W and $W/10$, are applied to the top beam at F and at G, respectively, as shown. For $W = 750\ kN$, using the CDC method, determine whether or not the column, HF, can sustain the applied load. Assume that the T-frame does not buckle out of the plane of the page and do not assess the top beam. [60%]

(c) The joint at F is fully effective; it transfers both moment and force between the connecting members. Outline *qualitatively* a preliminary design of the joint at F, indicating salient features. [30%]

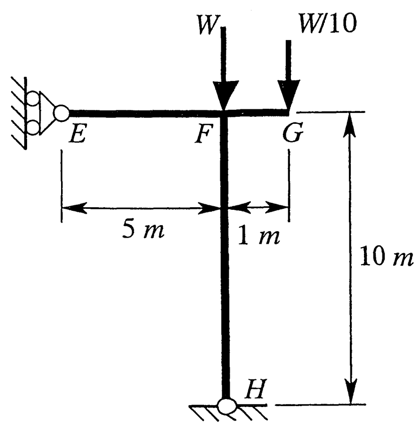


Fig. 2

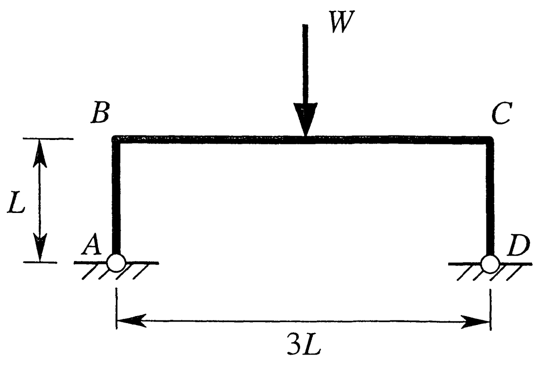
3 The rectangular portal frame, $ABCD$, in Fig. 3(a) is fully pinned at both feet; the height and width of the frame are L and $3L$, respectively, and the bending stiffness is uniform throughout the frame. It is initially free of stresses, and a vertically downwards load, W, is applied to the mid-span, as shown.

(a) For the beam, show that the resulting axial force is $27W/88$ and that the magnitude of the largest bending moment is $39WL/88$. Hence, determine the complete bending moment and shear force profiles for the frame. [40%]

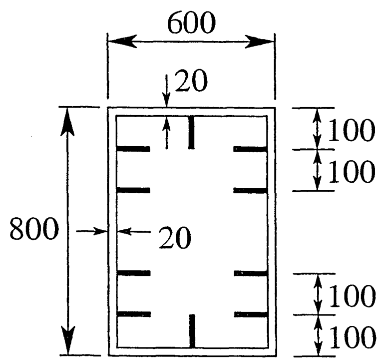
(b) The beam has the uniform plate-girder cross-section with fully effective 100×10 mm stiffeners spaced as shown in Fig. 3(b), which is not drawn to scale; each plate is fabricated from grade S275 steel. Cross-frames (diaphragms) are provided at 1 m centres along the beam. Assuming that the frame does not deflect out of the plane of the page and that the columns do not buckle, for $W = 100$ kN and $L = 6$ m, check:

(i) the adequacy of the top flange as an effective column between cross-frames; [30%]

(ii) the adequacy of the most heavily stressed web panel in the centre of the beam. [30%]



(a)



all dimensions in mm
all stiffeners 100 mm × 10 mm

(b)

Fig. 3

4 A composite floor carries 6.0 kN/m^2 of imposed load as well as 0.5 kN/m^2 of permanent services; the respective load factors are 1.6 and 1.4. The floor consists of a solid concrete slab, of thickness 100 mm, with design strength, $f_{cd} = 30\ N/mm^2$; it acts compositely with $457 \times 191 \times 74\ kg/m$ grade S355 Universal Beams, each of simply-supported span 12 m, placed at 3.5 m centres. Assume the density of concrete to be 2400 kg/m^3.

(a) Show that the floor can carry the specified permanent load, imposed load and self-weight. [50%]

(b) Calculate the total number of 65 $mm \times 13\ mm$ shear studs needed for each UB to achieve a full composite action. [20%]

(c) Estimate the central deflection induced by the short term application of the imposed load. [30%]

END OF PAPER