UNIVERSITY OF LONDON

B.Sc. (ENGINEERING) EXAMINATION 1962

PART I

for Internal and External Students

(2) MATERIALS AND STRUCTURES

Wednesday, 20 June: 10 to 1

Answer SIX questions.

1. A steel bar, 13 in long and $\frac{3}{4}$ in diameter, is turned down at one end to $\frac{5}{8}$ in diameter for a length of 4 in and then placed between two stops as shown in figure 1. Determine the stresses in the two parts of the rod for the following separate changes of condition.

(a) The distance between the stops is reduced by 0·004 in.

(b) The temperature of the rod is increased by 50 deg. C.

For steel $E = 13000$ tonf/in^2 and $\alpha = 12 \times 10^{-6}$ per degree C.

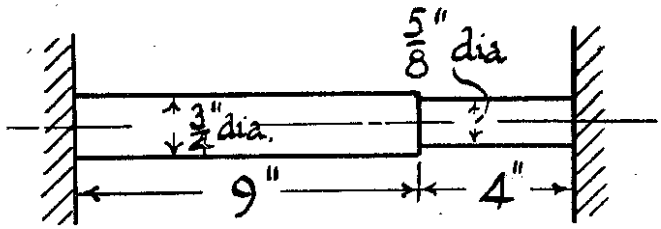

FIGURE 1

2. A beam 24 ft long is simply supported at its ends. It carries a distributed load which increases uniformly from zero value at the left-hand end to $\frac{3}{4}$ tonf/ft at mid-span and is then uniform at $\frac{3}{4}$ tonf/ft on the right-hand half of the beam as indicated in figure 2.

Determine the reactions at the supports and the position and magnitude of the maximum bending moment.

Draw to scale the shearing force and bending moment diagrams for the beam. Scales: space 5 ft to 1 in; shearing force 5 tons to 1 in; bending moment 20 tonf feet to 1 in.

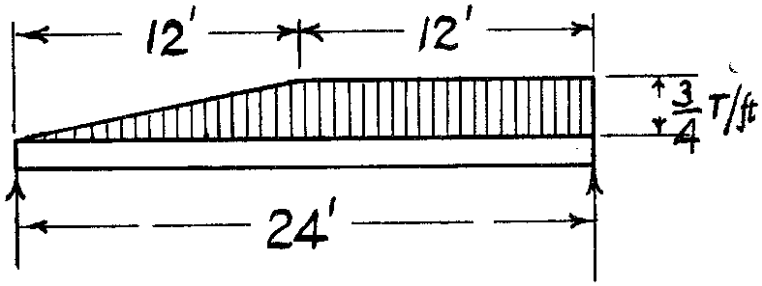

FIGURE 2

Turn over

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3. A 14 in × 6 in standard beam when used as a simply supported beam on a span of 24 ft will carry safely a uniformly distributed load of 0·6 tonf/ft over the whole span; the maximum deflection produced by this load is 0·75 in. $I = 442{\cdot}6$ in^4.

In order to carry a greater load than the above, a 14 in × 6 in beam is strengthened by riveting a 10 in × $\frac{1}{2}$ in steel plate to each flange as shown in figure 3. Determine the safe uniformly distributed load which the strengthened beam may carry and the maximum deflection it will produce.

Assume the maximum bending stress in the compound beam is the same as for the original beam and, in the case of the strengthened beam, ignore the effects of the rivet holes.

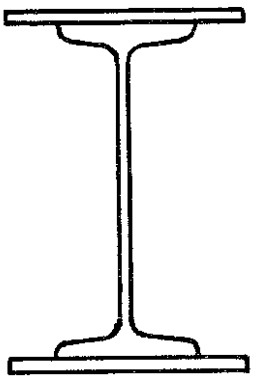

FIGURE 3

4. (a) A beam of uniform section is simply supported at its ends. Write down formulae for the maximum deflection produced by

(i) a point load P applied at the mid-span and

(ii) a load w/unit length on the whole span.

State the meanings of the symbols used and derive one of the two formulae from the general expression for the bending moment at any section.

(b) A beam of uniform section and length l is simply supported at its ends and it carries a uniformly distributed load w/unit length on the whole span. In addition to the end supports the beam is supported at mid-span by a prop which exerts an upward force P of such magnitude that there is no deflection at the prop. What proportion of the total load is carried by the prop?

Sketch the bending moment diagram for the beam and show on it the maximum values of the bending moment both positive and negative.

5. A solid shaft 4 in diameter is to be replaced by a hollow shaft having an outside diameter of $4\frac{1}{2}$ in and which will transmit the same torque as the solid shaft with the same maximum shearing stress. Determine the inside diameter of the hollow shaft and find the ratio of the angles of twist, per unit length, of the two shafts.

If the shaft speed is 400 rev/min and the maximum shearing stress is 3·5 tonf/in^2, what is the horse-power transmitted?

6. Write down or derive formulae for (i) the maximum shearing stress and (ii) the axial deflection, for a close-coiled helical spring made of round wire and subjected to an axial load. Define the symbols used.

A close-coiled helical spring is to be made of round steel wire. The spring is to carry an axial load of 250 lbf, the maximum shearing stress is limited to 40,000 lbf/in^2 and the axial deflection is to be 1·25 in. The ratio of the mean diameter of the coil to the diameter of the wire is to be six. $G = 12 \times 10^6$ lbf/in^2. Determine the mean diameter of the coil, the diameter of the wire and the number of turns.

7. Consider the following problem and define and write out concisely the meaning and significance of the words or phrases enclosed by brackets. The solution of the problem itself is not required and no credit will be given for an attempted solution:

'A (uniform) (rigid) (rectangular) (slab) (rests) on four (supports) (one at each corner). One support is (incompressible); the (other three are compressible but identical) and all are (initially at the same level). Given the (weight of the slab), find the four reactions'.

8. Figure 4 shows a pin-jointed frame which carries vertical loads of three units a B, C and D and horizontal forces of two units at B and C. There is no horizontal reaction at A.

Determine, either graphically or by calculation, the forces in the members BC, BF, CF and FG. State whether members are in tension or compression.

Lever arms of forces may be taken from a scale drawing.

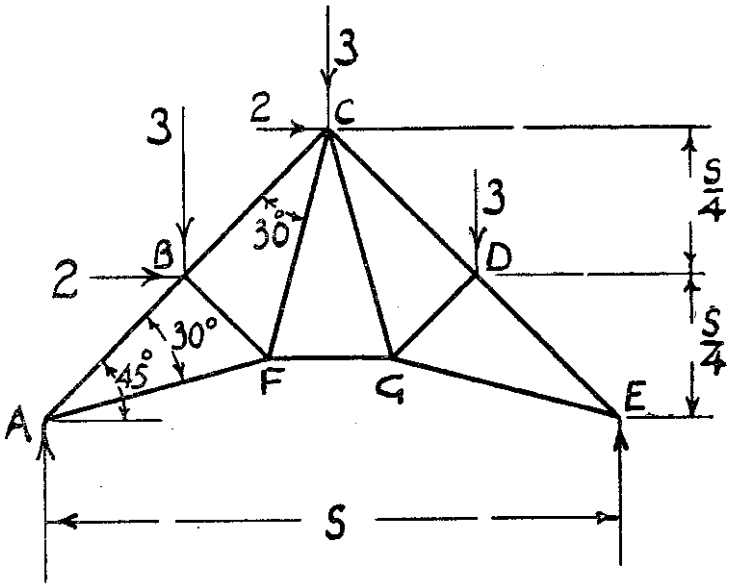

FIGURE 4

9. Figure 5 shows a simple pin-jointed crane which is supported by vertical reactions at A and D. The lengths of the members are: AB = BD = AD = 9 ft, BC = 12 ft and CD = 15 ft. The cross-sections of the members are such that the stresses in all tension members are 8 tonf/in^2 and in all compression members 6 tonf/in^2. Determine the vertical deflection of the joint C.
E = 13000 tonf/in^2.

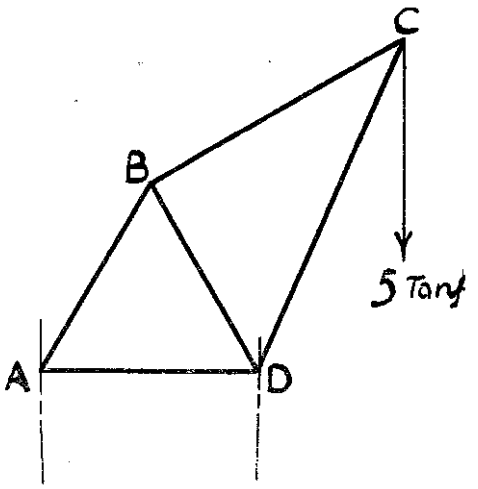

FIGURE 5

10. A cable for a suspension bridge has a span of 180 ft and a dip of 35 ft; the upper ends of the cable are at the same level. If the greatest allowable tension in the cable is 100 tonf, determine the permissible load per foot of span.

The ends of the cable are secured to saddles mounted at the tops of the supporting piers and the backstays attached to the saddles are inclined at 50° to the vertical. Determine the tensions in the backstays and the resultant vertical thrust on each pier.

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