Code : 011406

B.Tech 4th Semester Exam., 2019

MECHANICS OF SOLID—I

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Choose the correct answer of the following (any *seven*) : 2×7=14

(a) The ratio of modulus of rigidity to modulus of elasticity for most of the materials is

(i) 0·5

(ii) >0·5

(iii) <0·5

(iv) >1

(b) Temperature stress is a function of

(i) modulus of elasticity

(ii) change in temperature

(iii) coefficient of linear expansion

(iv) All of the above

(c) Normal stress on a plane, the normal to which is inclined at angle θ with the line of action of uniaxial stress σ is given by

(i) $\sigma \sin^2 \theta$ *(ii)* $\sigma \cos^2 \theta$

(iii) $\sigma / \sin^2 \theta$ *(iv)* $\sigma / \cos^2 \theta$

(d) In a Mohr's circle, the radius gives the value of

(i) minimum normal stress

(ii) maximum normal stress

(iii) minimum shear stress

(iv) maximum shear stress

(e) Variation of shear force in a cantilever carrying a load the intensity of which varies uniformly from zero at the free end to *w* per unit run at the fixed end is given by

(i) cubic law

(ii) parabolic law

(iii) linear law

(iv) None of the above

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(f) In a transversely loaded beam, the maximum tensile stress occurs at

(i) bottom edge

(ii) top edge

(iii) neutral axis

(iv) None of the above

(g) Maximum deflection of a simply supported beam with a centre point load is

(i) $Wl^3/4EI$

(ii) $Wl^3/8EI$

(iii) $Wl^3/24EI$

(iv) $Wl^3/48EI$

(h) Maximum deflection of a fixed beam carrying a uniformly distributed load is

(i) $Wl^4/384EI$

(ii) $Wl^4/96EI$

(iii) $Wl^4/48EI$

(iv) $Wl^4/12EI$

(i) When a shaft is subjected to a twisting moment, every cross-section of the shaft will be under

(i) tensile stress

(ii) compressive stress

(iii) shear stress

(iv) All of the above

(j) The product of the tangential force acting on the shaft and radius of shaft known as

(i) torsional rigidity

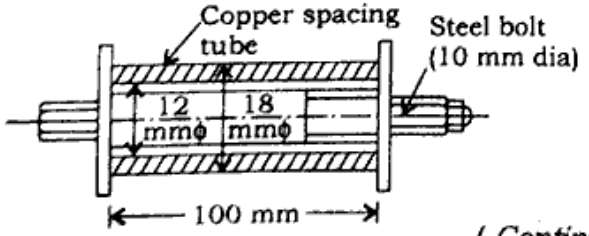
(ii) twisting moment

(iii) bending moment

(iv) flexural rigidity

2. (a) A steel plate, 22 mm thick and 220 mm wide at one end, tappers uniformly to 12 mm thick and 180 mm wide at the other end. Determine the elongation under a pull of 20 kN when the length of the plate is 2·4 m. Assuming $E = 205\ GN/m^2$. 7

(b) The steel bolt shown in the figure below has a thread pitch of 1·6 mm :



If the nut is initially tightened up by hand so as to cause no stress in the copper spacing tube, calculate the stresses induced in the tube and in the bolt if a spanner is then used to turn the nut through 90°. Take, E_C and E_S as 100 GPa and 209 GPa respectively. 7

3. A piece of material is subjected to two perpendicular stresses as follows :

(a) Tensile stresses of 100 MPa and 60 MPa

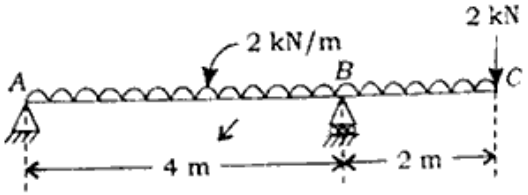
(b) Tensile stress of 100 MPa and compressive stress of 60 MPa

(c) Compressive stress of 100 MPa and tensile stress of 60 MPa

(d) Compressive stresses of 100 MPa and 60 MPa

Determine normal and tangential stresses on a plane inclined at 30° to the plane of 100 MPa stress. Also find the resultant and its inclination with the normal stress. 14

4. An overhanging beam *ABC* is loaded as shown in the figure below :



Draw the shear force and bending moment diagrams. Also locate point of contraflexure. Determine maximum positive and negative bending moments. 14

5. *(a)* State and prove Castigliano's first theorem. 4

(b) A simply supported beam has its support 8 m apart at *A* and *B*. It carries a uniformly distributed load of 6 kN/m between *A* and *B* starting from 1 m and ending at 5 m from *A*. The end *B* of the beam has an overhang of 1 m and at the free end, a concentrated load of 8 kN is applied. Determine deflection of the free end and the maximum deflection between *A* and *B*. Assume, $E = 210$ GPa and $I = 20 \times 10^6$ mm^4. 10

6. *(a)* Establish the relations to find the shear stress across I-section. What is the maximum value of it? 7

(b) A simply supported beam of 2 m span carries an uniformly distributed load of 140 kN per m over the whole span.

The cross-section of the beam is a T-section with a flange width of 120 mm, web and flange thickness of 20 mm and overall depth of 160 mm. Determine the maximum shear stress in the beam and draw the shear stress distribution for the section. 7

7. A steel bar of circular section, 100 mm diameter, carries a longitudinal pull whose line of action is parallel to the axis of the bar. At a certain transverse section, the longitudinal stresses are measured at the surface of the bar at three points *A*, *B* and *C*. These points being equally spaced round the section the tensile stresses at these points are $A = 90\ MN/m^2$, $B = 75\ MN/m^2$ and $C = 30\ MN/m^2$. Find—

(a) the magnitude and location of the greatest and least stresses at the section;

(b) the magnitude and eccentricity of the applied pull.

Make a diagram showing the stresses and their positions relative to the points *A*, *B* and *C*. 14

8. *(a)* Derive expressions for the strain energy in a three-dimensional stress system. 6

(b) A bar, 3·2 m long and 16 mm in diameter, hangs vertically and has a collar attached at the lower end. Determine the maximum stress induced when a weight of 80 kg falls from a height of 32 mm on the collar. If the bar is turned down to half the diameter along half of its length, what will be the value of the maximum stress and the extension? Assume, $E = 205\ GPa$. 8

9. *(a)* Deduce the torsion equation starting the assumption made. Deduce the expressions for the maximum stresses in solid and hollow shaft. 6

(b) A solid alloy shaft of 60 mm diameter is coupled with a hollow steel shaft of the same external diameter in series. If the angle of twist of the steel shaft per unit length is 80% of that of the alloy shaft, then find the inner diameter of the steel shaft. What will be the speed to transmit 300 kW if the limiting stresses in the alloy and the steel are to be 50 MPa and 72 MPa respectively? Take, $G_{steel} = 2G_{alloy}$. 8

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