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Paper Code : ME-302

STRENGTH OF MATERIALS

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) Where the bending moment is maximum, the shear force is

a) zero b) also maximum

c) minimum d) of any value.

ii) If two springs with stiffnesses k_1 and k_2 are connected in series, then stiffness of the composite spring is given by

a) $k_1 + k_2$ b) $1/k_1 + 1/k_2$

c) $1/k_1 - 1/k_2$ d) $k_1 - k_2$.

iii) Moment carrying capacity of a section is

a) $M = \frac{I}{y_{max}} \sigma_P$ b) $M = \frac{1}{y_{max}} \sigma_P$

c) $M = \frac{Z}{y_{max}} \sigma_P$ d) $M = \frac{\tau}{y_{max}} \sigma_P$

iv) Torsional rigidity of a shaft is given by

a) T/G b) T/J

c) GJ d) TJ,

where T is torque, G is modulus of rigidity.

v) The deflection of a closely coiled helical spring under an axial load is given by

a) $\frac{WR^3n}{Gr^4}$ b) $\frac{2WR^3n}{Gr^4}$

c) $\frac{4WR^3n}{Gr^4}$ d) $\frac{8WR^3n}{Gr^4}$

vi) The modulus of elasticity in terms of bulk modulus and modulus of rigidity is

a) $9\,KG/(3K + G)$ b) $9\,KG/(K + 3G)$

c) $(3K + G)/9KG$ d) $(K + 3G)/9\,KG$.

vii) Brittle fracture is more dangerous than ductile fracture because

a) no warning sign

b) crack propagates at very high speeds

c) no need for extra stress during

d) all of these.

viii) The two shafts AB and BC of equal length diameters d and $2d$ are made of same material and joined with a shaft coupling. Twisting moments T_a and T_c are working at the ends, then

a) $T_a = T_c$ b) $T_a = 16T_c$

c) $T_a = 8T_c$ d) $T_a = 4T_c$.

ix) A column has a rectangular cross-section of 10 mm × 20 mm and a length of 1 m. The slenderness ratio of the column is close to

a) 200 b) 346

c) 477 d) 1000.

x) Euler's formula holds good only for

a) short columns

b) long columns

c) both short and long columns

d) weak columns.

xi) Deformation of steel rod is associated with

a) absorption of energy

b) dissipation of energy

c) both (a) and (b) are false

d) tensile force only.

xii) In a cantilever beam with UDL, the shear force diagram is

a) parabolic b) linear

c) cubic d) constant.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. A uniformly taper plate of uniform thickness is loaded as shown in fig. 1. Find the elongation of the plate.

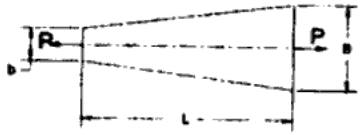

Fig.1

3. A rigid steel plate is supported by three concrete posts having 10 cm × 10 cm cross-section as shown in fig.2. By accident the middle post is 0·05 cm shorter than the other two before load P applied. Find safe value of load P if the working stress for the concrete in compression is 200 kg/cm^2 and the modulus of elasticity $E_c = 12(10)^4$ kg/cm^2.

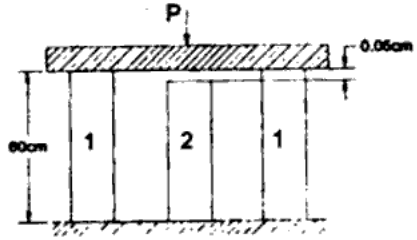

Fig. 2

4. When an element is in a state of simple shear then prove that the planes of maximum normal stresses are perpendicular to each other and these planes are inclined at an angle of 45° to the plane of pure shear.

5. The principal tensile stress at a point across two mutually perpendicular planes are 100 N/mm^2 and 50 N/mm^2. Determine the normal tangential and resultant stresses on a plane inclined at 30° to the axis of the minor principal stress.

6. A member ABCD is subjected to point loads P_1, P_2, P_3 and P_4 as shown in the figure 3.

Calculate the force P_2 necessary for equilibrium, if $P_1 = 45$ kN, $P_3 = 45$ kN. Determine the total elongation of the member, assuming the modulus of elasticity to be $2{\cdot}1 \times 10^5$ N/mm^2.

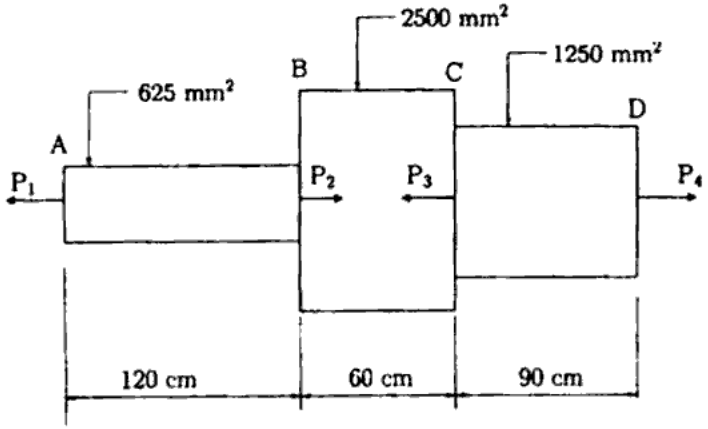

Fig-3

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) A compound shaft 1·5 m long fixed at one end is subjected to a torque of 15 kN-m at the free end and of 20 kN-m at the junction point as shown in Fig. 4. Determine the following :

(i) The maximum shearing in each portion of the shaft.

(ii) The angle of twist at the junction of the two sections and at the free ends.

Take G = 0·82 × 10^5 N/mm^2.

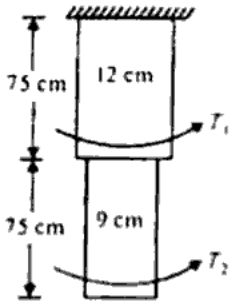

Fig.4

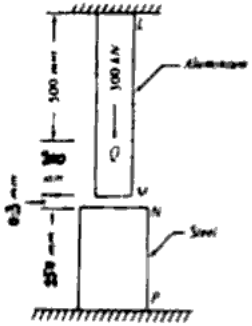

Fig.5

b) A 700 mm length of aluminium alloy bar is suspended from the ceiling so as to provide a clearance of 0·3 mm between it and a 250 mm length of steel bar as shown in Fig. 5. $A_{al} = 1250$ mm^2. $E_{al} = 70$ GN/m^2. $A_s = 2500$ mm^2. $E_s = 210$ GN/m^2. Determine the stress in the aluminium and in the steel due to a 300 kN load applied 500 mm from the ceiling. 7 + 8

8. a) Derive an expression for the critical load in a long column when its one end is fixed and other end is hinged.

b) A hollow circular column of steel of outer diameter 200 mm and thickness 5 mm has a length of 4 m with both ends fixed. Find the Euler's critical load if E = 200 GPa. If the yield stress is 300 mpa, determine the length below which Euler's formula cannot be applied. 10 + 5

9. a) Derive the expression for strain energy stored in a body due to torsion.

b) The stiffness of close-coiled helical spring is 1·5 N/mm of compression under a maximum load of 60 N. The maximum shearing stress produced in the wire of the spring is 125 N/mm^2. The solid length of spring (when the coils are touching) is given as 5 cm. Find : (i) diameter of wire, (ii) mean diameter of the coil and (iii) number of coils required. 7 + 8

10. a) The state of stress at a point are given σ_{xx}=150MPa. σ_{yy} = -50 MPa and τ_{xy} = 25 MPa.

Determine :

(i) Principal stresses and their directions

(ii) Shear stresses and their directions if the plane is inclined at 50° with XX.

b) Prove that the strain energy stored in a 2-dimensional body is given by

$U = \frac{1}{2E}(\sigma_1^2 + \sigma_2^2 - 2\mu\sigma_1\sigma_2)$ per unit volume. The symbols have usual meanings. 10 + 5

11. a) Prove the relation $\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$ for simple bending, the symbols having their usual meanings.

b) A 200 mm × 80 mm *I*-beam is to be used as a simply supported beam of 6·75 m span. The web thickness is 6 mm and the flanges are of 10-mm thickness. Determine what concentrated load can be carried at a distance of 2·25 m from one support if the maximum permissible stress is 80 MPa.

c) A rectangular beam is to be cut out of a cylindrical log of wood with diameter *d*. Determine the ratio of depth to width of the strongest beam which can be had from the log of wood.

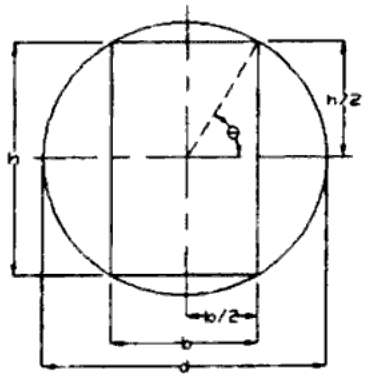

Fig.6

5 + 5 + 5

12. Define a beam. What is a cantilever, a simply supported and an overhung beam ? What is the point of contraflexure ? Draw the shear force and bending moment diagram for the beam as shown in Fig. 7.

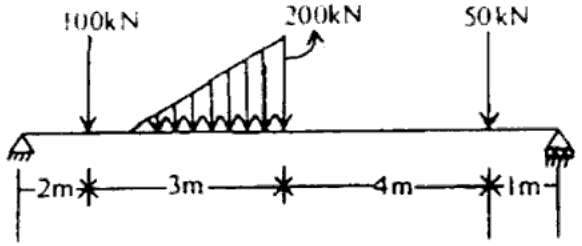

Fig.7