December 2016

## MECHANICS OF STRUCTURE

*Time Allowed: 3 Hours* *Full Marks: 70*

**Answer to Question No.1 is compulsory and to be answered first.**
**This answer is to be made in separate loose script(s) provided for the purpose.**
**Maximum time allowed is 45 minutes, after which the loose answer scripts will be collected and fresh answer scripts for answering the remaining part of the question will be provided.**
**On early submission of answer scripts of Question No.1, a student will get the remaining script earlier.**

**Answer any five questions from the rest.**
**To the point answer will be given additional credit.**

1. A. Choose the correct answer (any ten): 10x1

(i) The bulk modulus of a body is equal to
(a) $\frac{mE}{3(m-2)}$ (b) $\frac{mE}{3(m+2)}$ (c) $\frac{mE}{2(m-2)}$ (d) $\frac{mE}{2(m+2)}$

(ii) Mohr' s circle is a graphical method to find
(a) Bending stresses (b) Bucking stresses (c) Torsional shear stresses (d) None

(iii) Which of the following are statically determinate beams?
(a) Only simply supported beams (b) Continuous beams
(c) Cantilever, overhanging and simply supported (d) Fixed beams

(iv) In a cantilever carrying a uniformly varying load starting from zero at the free end, the shear force diagram is
(a) A horizontal line parallel to x-axis (b) A line inclined to x-axis
(c) Follows a parabolic law (d) Follows a cubic law

(v) A sudden jump anywhere on the Bending moment diagram of a beam is caused by
(a) Couple acting at that point (b) Couple acting at some other point
(c) Concentrated load at the point (d) UDL load or UVL on the beam

(vi) Variation of bending stresses in a beam have
(a) Parabolic variation (b) Linear variation (c) Cubical variation (d) None

(vii) Bending stress will be least at the extreme fibres for
(a) Maximum area of cross section (b) Maximum moment of inertia
(c) Maximum section modulus (d) None

(viii) There will be no net tensile stress in a beam of circular section with eccentricity of load
(a) Within the middle third (b) Within the middle quarter
(c) Within the middle sixth (d) None

(ix) A redundant truss is defined by the truss satisfying the equation
(a) $m = 2j - 3$ (b) $m < 2j + 3$ (c) $m > 2j - 3$ (d) $m > 2j + 3$

(x) Which axial force is determined while analyzing a truss?
(a) Compressive force (b) tensile force (c) both a and b (d) none of these

(xi) The number of independent equations to be satisfied for static equilibrium of a plane structure is
(a) 1 (b) 2 (c) 3 (d) 6

(xii) Strain energy due to suddenly applied load is
(a) Load x extension (b) 2 x Load x extension
(c) 0.5 x Load x extension (d) None

(xiii) Resilience is
(a) Strain energy per unit length (b) Strain energy per unit area
(c) Strain energy per unit volume (d) None

(xiv) Pure bending of beam will have
(a) Tensile and shear stresses (b) Compressive and shear stresses
(c) Tensile and compressive stresses (d) None

(xv) In bending, neutral axis always is
(a) Perpendicular to the centroidal axis (b) Coincides with the centroidal axis
(c) Parallel to the centroidal axis (d) None

(xvi) With bending moment M and section modulus Z, bending stress will be
(a) $\sigma = M Z$ (b) $\sigma = Z/M$ (c) $\sigma = M/Z$ (d) None

(xvii) Section modulus of a beam is
(a) I/y (b) $I/y_{max}$ (c) I/d (d) None

(xviii) A beam will be in pure bending under a
(a) Constant shear force and a constant bending moment
(b) Constant shear force and zero bending moment
(c) Constant bending moment and zero shear force
(d) None

(xix) For a beam of rectangular cross section, the ratio $\tau_{max}/\ \tau_{av}$ is
(a) 2 (b) 1 (c) 1.5 (d) None

(xx) Eccentric load causes
(a) Only bending stress (b) Only normal stress
(c) Bending and normal stress (d) None

(xxi) Props can be used in
(a) Simply supported Beam (b) Cantilever beam
(c) Simply supported beam as well as cantilever (d) None

(xxii) Deflection is found by moment area method by using
(a) First moment of the area (b) Second moment of the area
(c) Third moment of the area (d) None

(xxiii) Props are used to decrease 
(a) Slope (b) Deflection (c) Slope as well as deflection (d) None

(xxiv) In moment distribution method, the sum of distribution factors of all the members meeting at any joint is always
(a) zero (b) less than one (c) 1 (d) greater than one

(xxv) The polar moment of inertia of a solid circular shaft of diameter (d) is
(a) $\frac{\Pi}{16} \times D^3$ (b) $\frac{\Pi}{16} \times D^4$ (c) $\frac{\Pi}{32} \times D^3$ (d) $\frac{\Pi}{32} \times D^4$

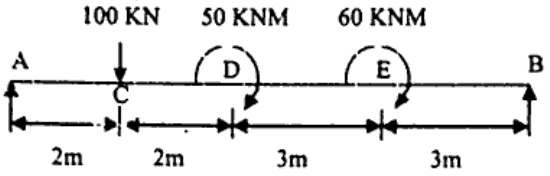
(xxvi) Which of the following assumptions are made in torsion theory?
(a) Shaft is perfectly straight
(b) Material of the shaft is heterogeneous
(c) Twist cannot be uniform along the length of the shaft
(d) All of the above

B. Write the correct answer in a few sentences (any five): 5x2

(i) Explain the term "Distribution factor" and "Carry over factor".
(ii) Define shear stress and state the principal of shear stress.
(iii) State the term "Principal stress" and "Principal planes".
(iv) Distinguish clearly between direct stress and bending stress.
(v) Derive the limit of eccentricity for a hollow rectangular section.
(vi) What is a retaining wall ? Discuss its uses.
(vii) Explain the term "Prop" and "Sinking of Prop"
(viii) Define the term "Torque".
(ix) State the assumptions for shear stress in a circular shaft subjected to torsion.
(x) Describe the assumptions in the Euler's column theory.

2. a) A bar of 40 mm diameter is subjected to a pull of 60KN. The measured extension on gauge length of 200 mm is 0.09 mm and the change in diameter is 0.0045 mm. Calculate the Poisson's ratio and the values of the three moduli.
b) Derive a relation between Modulus of Elasticity and Modulus of Rigidity. 7+3

3. Draw SFD and BMD. 10



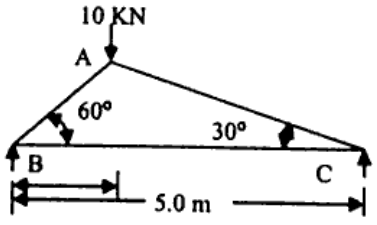

4. a) State the assumptions in the theory of simple bending.
b) A rectangular beam 150 mm X 300 mm is used on a span of 4 m. It carries a uniformly distributed load of 12 KN/m over the whole span. Calculate (i) Maximum bending stress in the beam. (ii) Bending stress at a depth of 10 mm from top at a section 1 m from left support. 3+7

5. A beam of I-section 500 mm overall depth, 200 mm flange width with 25 mm thick & web 15 mm thick. It carries a shearing force of 3000 kg. at a section. Calculate the maximum intensity of shear stress in the section. Also sketch the shear stress distribution across the section. 10

6. A masonry pillar is 8 m high and has a section of 3m X 5m. The pillar is subjected to horizontal wind pressure of magnitude 1200 $N/m^2$ on face 3m X 8m. Find stresses of base and draw stress diagram. Masonry may be taken to weigh 19 $KN/m^3$. 10

7. a) Define the term strain energy, resilience & proof resilience. 
b) Show that stress developed due to sudden load is twice the stress developed due to the same load applied gradually. 3+7

8. a) What is a frame ? Discuss its classification.
b) The truss is shown in figure. Find the forces in the member AB, AC & BC by joint/section method. 3+7




9. a) Derive with the help of moment area method a relation for the deflection of a simply supported beam carrying a udl load 'w' per metre over the whole span.
b) A uniform beam ($I = 7.8 \times 10^7$ $mm^4$) is 6 m long and carries a central point load of 50 KN. Take $E = 210$ $KN/mm^2$, calculate the deflection ( by double integration method) under the load, if the beam is built in at one end and simply supported to the same level at the other. 3+7

10. a) State the Clapeyron's theorem of three moments.
b) A fixed beam of 6 m span, supports two point load of 300 KN each at 2 m from each end. Find the fixing moment at the ends & draw the bending moment & shear force diagram. 3+7

11. Draw bending moment diagram (using moment distribution method) of a continuous beam ABC having a point load 40 KN at mid span of AB and a u.d.l of 20 KN/m over BC. Length of AB = 4 m & length of BC = 6 m. [Simply supported at point B, fixed at point A & C. Flexural rigidity is same throughout]. 10

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