SNS COLLEGE OF TECHNOLOGY

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COIMBATORE,641 035, TAMIL NADU

DEPARTMENT OF AEROSPACE ENGINEERING

23AST205 Aerospace Structures

IAE 2 Question bank

2-mark questions

Fatigue Analysis

1. What is the significance of the S-N curve in fatigue analysis?
2. Define fatigue life and fatigue strength.
3. Explain the difference between low-cycle and high-cycle fatigue.
4. What is the role of stress concentration in fatigue failure?
5. A material has an endurance limit of **250 MPa**. If a component is subjected to a cyclic stress range of **200 MPa**, will it fail due to fatigue? Justify your answer.

Fracture Mechanics

6. Define stress intensity factor (K) in fracture mechanics.
7. Differentiate between ductile and brittle fracture.
8. What is the significance of Griffith's theory in fracture mechanics?
9. A cracked plate experiences a stress of **100 MPa** and has a crack length of **5 mm**. If the fracture toughness of the material is **30 MPa√m**, determine whether the crack will propagate. (Use $K = Y\sigma\sqrt{\pi a}$, assume $Y = 1.12$)
10. Explain the Paris law and its significance in crack growth prediction.

Impact Loading - Creep

11. Define impact loading and explain its effect on material failure.
12. What is the difference between ductile and brittle failure under impact loading?
13. How does temperature influence creep deformation in materials?
14. Explain the three stages of creep with a suitable diagram.
15. A material at **600°C** experiences a constant stress of **50 MPa** and undergoes a strain of **0.002** in **100 hours**. Calculate the creep rate.

Stress Relaxation - Thermal Stresses

16. What is stress relaxation, and how does it differ from creep?
17. Define thermal stress and explain its significance in structures.
18. A steel rod is fixed at both ends and is heated by **100°C**. If the coefficient of thermal expansion is **12×10^{-6} /°C** and Young's modulus is **200 GPa**, calculate the induced thermal stress (Assume no deformation is allowed).
19. Why are thermal stresses more significant in composite materials?
20. Explain how stress relaxation occurs in viscoelastic materials.

Unsymmetrical Bending

1. What is unsymmetrical bending, and when does it occur?
2. How does the orientation of the neutral axis change in unsymmetrical bending?

3. What factors influence bending stress in an unsymmetrical beam?

Principal Axis Methods

4. Define principal axes in the context of beam bending.
5. What are principal moments of inertia, and why are they important?
6. How can the principal axes of a cross-section be determined?

Neutral Axis Methods

7. What is the significance of the neutral axis in bending analysis?
8. How do you locate the neutral axis in an unsymmetrically loaded beam?
9. Why does the neutral axis not always pass through the centroid in unsymmetrical bending?

Bending of Symmetric Beams Subject to Skew Loads

10. What is meant by a skew load in beam bending?
11. How does a skew load affect the bending stress in a symmetric beam?
12. Why do symmetric beams still experience unsymmetrical bending under skew loads?

Bending Stresses in Unsymmetrical Sections

13. Why do unsymmetrical sections experience different bending stresses compared to symmetric sections?
14. How is the bending stress in an unsymmetrical section calculated?
15. What role do the principal moments of inertia play in stress calculation for unsymmetrical sections?

Calculation of Section Modulus

16. Define section modulus and its significance in beam design.
17. How is section modulus different for symmetrical and unsymmetrical sections?
18. Why is the section modulus important in aerospace structural design?

Application to Aerospace Components

19. Give one example of an aerospace component where unsymmetrical bending is significant.
20. Why is the analysis of bending in unsymmetrical sections crucial for aircraft wing design?

16-mark questions

Fatigue Analysis

1. **Explain the mechanism of fatigue failure.** Discuss the factors affecting fatigue life and describe how fatigue testing is performed using the S-N curve.
2. **A rotating shaft is subjected to a fully reversed bending stress with a maximum value of 300 MPa.** Given that the endurance limit of the material is 250 MPa, the ultimate tensile strength is 600 MPa, and the fatigue strength reduction factor is 0.8, estimate the fatigue life using Miner's rule. (Assume suitable values if necessary).
3. **Describe the Goodman and Soderberg criteria for fatigue failure.** How are these methods used to estimate the fatigue life of a component subjected to variable loading?

Fracture Mechanics

4. **Discuss the different modes of fracture (Mode I, Mode II, and Mode III).** Explain the significance of fracture toughness in preventing catastrophic failure.
5. **Using Griffith's theory, derive the equation for critical crack length in a brittle material.** Explain how this theory is extended for ductile materials using Irwin's modification.
6. **A plate with a central crack of length 8 mm is subjected to a tensile stress of 120 MPa.** If the fracture toughness of the material is 35 MPa√m, determine whether the crack will propagate. (Use the formula $K = Y\sigma\sqrt{(\pi a)}$, assume $Y = 1.12$).

Impact Loading - Creep

7. **Explain the concept of impact loading.** Discuss the Charpy and Izod impact tests, their significance, and how they help in material selection for dynamic loading conditions.
8. **Explain the three stages of creep (primary, secondary, and tertiary) with a suitable diagram.** Discuss how creep properties are determined using creep testing.
9. **A turbine blade made of an alloy is operating at 750°C under a stress of 120 MPa.** The steady-state creep rate of the material is given as 2×10−62 \times 10^{-6}2×10−6 per hour. If the component is expected to last for 20,000 hours, determine the total strain accumulated due to creep.

Stress Relaxation - Thermal Stresses

10. **Discuss the concept of stress relaxation in materials.** Explain how stress relaxation occurs in metals and polymers with relevant equations.
11. **Derive the expression for thermal stress in a constrained bar subjected to uniform temperature change.** Explain the practical implications of thermal stress in engineering structures.
12. **A steel rod of length 1 m is heated from 25°C to 150°C.** If the coefficient of thermal expansion is 12×10−612 \times 10^{-6}12×10−6 per °C and Young's modulus is 200 GPa, calculate the induced thermal stress when the ends of the rod are fixed.

Unsymmetrical Bending

1. **Explain the concept of unsymmetrical bending.** Derive the expression for bending stress when a beam is subjected to an oblique loading condition.
2. **A rectangular beam (100 mm × 50 mm) is subjected to an unsymmetrical bending moment of 500 Nm about an inclined axis.** Determine the maximum bending stress in the beam if the principal axes are rotated by 30°.

Principal Axis Methods

3. **Discuss the Principal Axis Method for analyzing beams under unsymmetrical bending.** Explain how the principal moments of inertia are determined.

4. **A beam section has moments of inertia Ix=400×106I_x = 400 \times 10^6Ix =400×106 mm^4 and Iy=100×106I_y = 100 \times 10^6Iy=100×106 mm^4.** If a bending moment of 5 kNm is applied at an angle of 45° to the principal axes, determine the stresses at the extreme fiber.

Neutral Axis Methods

5. **Explain the concept of the neutral axis in bending.** Derive the equation to locate the neutral axis for an unsymmetrically loaded beam.

6. **A thin-walled section is subjected to a bending moment of 200 Nm.** Using the neutral axis method, determine the bending stress distribution if the section is symmetric.

Bending of Symmetric Beams Subject to Skew Loads

7. **Explain how skew loads affect the bending of symmetric beams.** Discuss how the resultant moment components influence the stress distribution.

8. **A symmetric I-section beam is subjected to a skew load inclined at 30° to the major axis.** Determine the bending stresses in the flange and web using appropriate transformations.

Bending Stresses in Unsymmetrical Sections

9. **Derive the expression for bending stresses in unsymmetrical sections.** Explain how to find the maximum stress location in a non-standard section.

10. **An L-section beam with unequal flange and web dimensions is subjected to a bending moment of 600 Nm.** Determine the bending stress distribution using the principal axis approach.

Calculation of Section Modulus

11. **What is section modulus?** Derive the formula for section modulus for an unsymmetrical cross-section and explain its importance in design.

12. **Calculate the section modulus of a Z-section beam with dimensions 120 mm × 60 mm × 10 mm.** Determine its strength compared to a symmetric I-section of the same material.

Application to Aerospace Components

13. **Explain the importance of unsymmetrical bending analysis in aerospace applications.** Discuss how it is used in the design of aircraft wing spars and fuselage frames.

14. **An aircraft wing box section is subjected to a bending moment of 50 kNm due to aerodynamic loads.** Analyze the stress distribution and determine whether the material can withstand the applied load.

Stress Distribution Analysis

15. **Explain how stress distribution in an unsymmetrical beam is analyzed.** Discuss the role of the shear center and warping effects.
16. **Given a T-section beam with known moments of inertia and applied moments, determine the stress distribution across the section using transformation equations.**

Practical Design Considerations – Real-World Applications

17. **Discuss the real-world applications of unsymmetrical bending analysis in aerospace, civil, and automotive engineering.** Provide examples of structural components where this analysis is crucial.
18. **Explain the importance of selecting appropriate cross-sections in aircraft structures.** How do engineers optimize section properties for strength and weight reduction?