THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

Bachelor of Technology (Engineering) – LEVEL 05

FINAL EXAMINATION 2008/2009

MEX 5232 – STRENGTH OF MATERIALS II

DATE : **21 – 03 - 2009**

TIME **2.00p.m – 5.00p.m.**

DURATION :**3 hours**

Read the following instructions carefully before answering the questions

1. This question paper consists of **eight** questions. Answer **any five** questions **only.**
2. All questions carry equal marks.
3. Time allocation for the paper is **03hrs.**
4. Do not spend more than **30 – 35** minutes for a question.

Question 1

(a) State Mohr's first and second theorems as applicable for built-in beams.

(b) A built -in beam has a span of 3m and carries uniformly distributed load as shown in figure Q1.

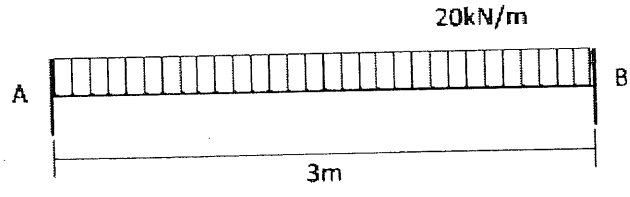


Figure Q1

(i) Sketch the free moment diagram and the fixing moment diagram for the beam.

(ii) Using principle of superposition, sketch the complete bending moment diagram.

(iii) Find the values of fixing moments at A and B by using Mohr's theorems or any other method.

(iv) If a point load of 20kN is applied at the mid span in addition to the uniformly distributed load what is the value of fixing moment at ends?

Question 2

(a) Explain how Lame equations are used graphically to determine radial and circumferential stress distributions of a thick cylinder, when it is subjected to an internal pressure only.

(b) A compound cylinder is formed by two cylinders, the radii of which are given in figure Q2.

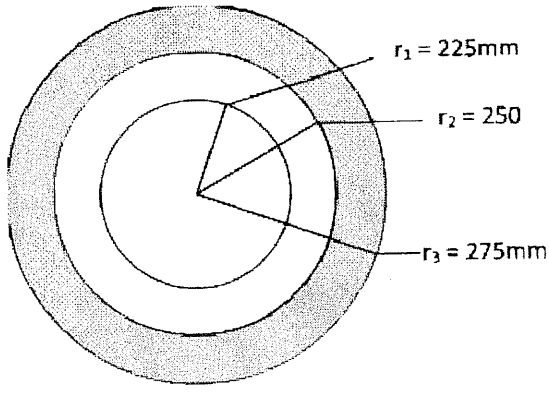


Figure Q2

(i) If the initial shrinkage pressure is 5MN/m^2 find out the **circumferential stresses** at the interface for **both cylinders**.

(ii) Determine the **circumferential stresses** for **both cylinders** at the interface when the cylinder is subjected to an internal pressure of 20MN/m^2.

(iii) Find out the new interface pressure.

Question 3

(a) Explain briefly the following theories of elastic failure.

(i) Maximum principal stress theory

(ii) Maximum shear stress theory

(iii) Maximum shear strain energy per unit volume theory

(b) A shaft has a diameter of 100mm. Calculate the torque that can be transmitted by the shaft with a factor of safety of 3, based on

(i) Maximum shear stress theory

(ii) Maximum shear strain energy per unit volume theory

The yield stress of shaft material is 200MN/m^2.

Question 4

(a) Explain what is meant by asymmetric bending. How are principal axes of a beam section defined?

(b) The resultant internal moment acting on a cross section of a beam is 500Nm (See figure Q4).

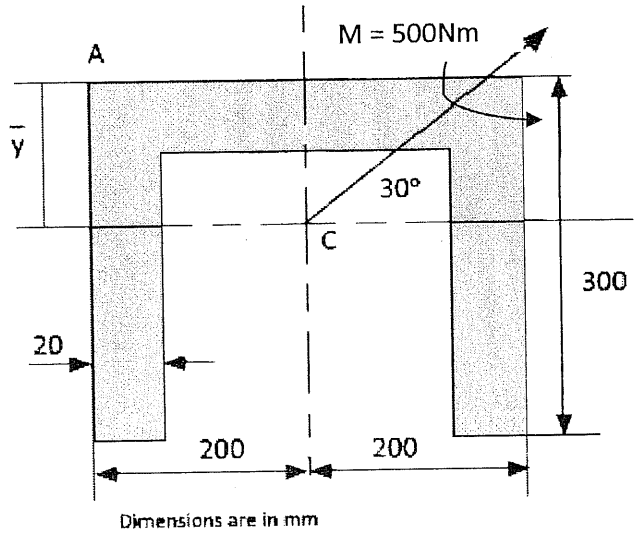


Figure Q4

(i) Determine the value of $\bar{y}$, the location of the center of area of the section.
(ii) Determine the second moment area of the section about principal axes.
(iii) Find out stress at point A.

Question 5

(a) What is meant by Shape Factor referred to in bending of beams beyond elastic limit?

(b) A simply supported beam of length 3m carries a uniformly distributed load of 5kN/m.

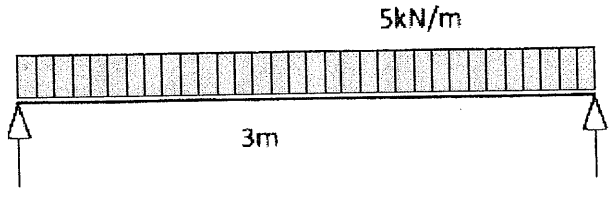


Figure Q 5

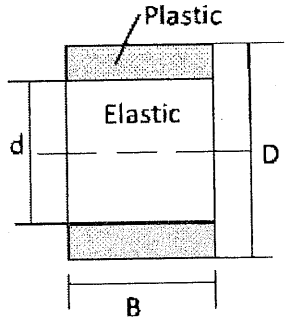
(i) Sketch bending moment diagram indicating maximum value/s.

(ii) If the beam section is 30mm wide and 60mm deep, determine the bending moment that sets in yielding at the top fiber of the beam. Take yield stress as 200MN/m^2. Is the beam plastically yielded or not under this load?

(iii) Determine the position of the beam at which plastic yielding has taken place to a depth of 20mm.

The bending moment when a beam section is in elastic-plastic state is given by the following formula.

$$M_{PP} = \frac{B\sigma_y}{12}\left[3D^2 - d^2\right]$$



Question 6

(a) Show from first principles that the torque carried by a circular shaft of radius R, when it has been yielded to a radius of R/2 is given by the following expression.

$$T_{PP} = \frac{31\pi\tau R^3}{48}$$

Where τ is the yield stress

(b) A solid shaft of diameter 60mm is subjected to a torque T.

(i) Determine the value of T when the shaft starts to yield taking yield stress as 100MN/m^2.

(ii) What is the angle of twist per unit length when yielding begins?

(iii) Find out the torque and the corresponding angle of twist per unit length, when the shaft has yielded a radius of 15mm.

Take Modulus of rigidity as 80GN/m^2.

Question 7

(a) What are the stresses set up in a rotating solid disc? On what factors these stresses depend?

(b) A steel ring of 300mm outer diameter and 200mm inner diameter has been shrunk onto a solid shaft with interference. When the shaft rotates at 6000rpm the interface pressure is 20MN/m^2.

(i) Determine the circumferential stress at the inner radius of the ring.

(ii) Find out the speed at which the interface pressure reduces to 10MN/m^2.

The radial stress and the circumferential stress of a rotating disc are given by the following formulae with usual notations.

$$\sigma_r = A - \frac{B}{r^2} - K_1 r^2 \omega^2 \qquad \sigma_H = A + \frac{B}{r^2} - K_2 r^2 \omega^2$$

K_1 and K_2 are constants depending on materials properties and can be assumed to be 3000kg/m^3 and 1700kg/m^3 respectively.

Question 8

(a) When thin walled closed tube is subjected to an axial torque, the shear stress is given by the following expression.

$$\tau = \frac{T}{2At}$$

With a suitable sketch illustrate the terms τ , T, A and t.

(b) Show that the angle of twist θ per unit length of a thin walled closed tube with uniform thickness t, when subjected a torque T, is given by the following expression.

$$\theta = \frac{Ts}{4A^2Gt}$$

Hint: the strain energy stored when a tube is subjected to torque is given by the following equation with usual notations.

$$U = \frac{T^2 L}{8A^2G} \int \frac{ds}{t}$$

(c) A tube of 3mm wall thickness and 1m length is made out of a material having a modulus of rigidity 36GN/m^2 is subjected to an axial torque of 60Nm.

Find out

(i) Wall average shear stress.

(ii) Angle of twist.

(iii) Total strain energy stored in the tube.