HE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
BACHELOR OF TECHNOLOGY – LEVEL 6
FINAL EXAMINATION 2005/2006

MEX 6330 – MECHANICS OF MATERIALS
DATE : 6th May 2006
TIME : 0930 HRS TO 1230 HRS
DURATION : 3 HOURS

011

Answer any **five** questions. All questions carry equals marks.

1. The state of stress at a point of a body subjected to a system of external loading is given by the stress tensor σ_{ij} where,

$$\sigma_{ij} = \begin{pmatrix} 8 & 3 & 0 \\ 3 & -4 & 0 \\ 0 & 0 & 4 \end{pmatrix} \text{kN/mm}^2$$

Determine the magnitudes of the three principal stresses and their directions with respect to the original coordinate axes.

What would be the uniaxial tensile strength of the material if the body is just about to yield at the point considered? The material is assumed to yield under maximum shear.

2. State the three invariants of the stress tensor σ_{ij}

The generalized Hook's Law for an isotropic body is expressed by

$$\sigma_{ij} = \lambda\varepsilon_{kk}\,\delta_{ij} + 2\,\mu\varepsilon_{ij}$$

where $\delta_{ij} = 1$ for $i = j$
$= 0$ for $i \neq j$

and λ and μ are constants dependant upon the material properties.

a) Obtain an expression for the first invariant of the stress tensor in terms of the first invariant of the strain tensor.

b) By expressing non-diagonal terms of the stress matrix in terms of strain, show that the principal planes (and therefore, the principal axes) of both stress and strain coincide.

c) Using the expression obtained in (a) above derive a relationship between the bulk modulus K and constants λ and μ.

3. Under what conditions a loaded body is said to be in a state of plane stress?

   Write the governing equations for a plane stress problem, where the body forces are assumed to be zero. Hence show that for a plane stress problem with no body forces the displacements u and v must satisfy the relationship;

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \left(\frac{1+\nu}{1-\nu}\right)\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0$$

   Where, ν is the Poisson's Ratio.

4. Fig.Q4 shows a rectangular beam in the X-Y plane having a unit thickness perpendicular to the plane.

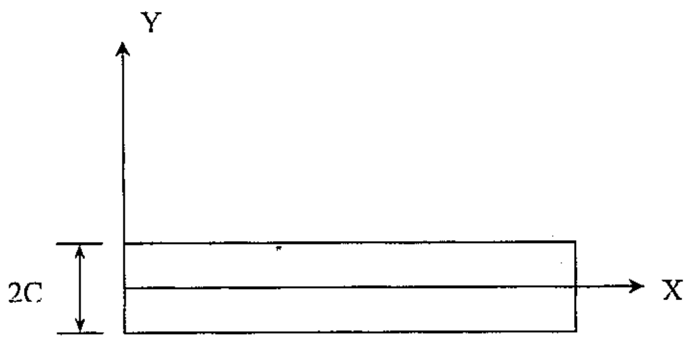

Fig. Q4

The stress distribution, which is uniform across the thickness of the beam, is described by the following stress function.

$$\Phi = \frac{3F}{4C}\left(xy - \frac{xy^3}{3C^2}\right) + \frac{Py^2}{2}$$

Determine the stress field that exists across the beam and state what problem of plane stress is solved by the given stress function.

5.

a) Explain briefly how dummy strain gauges are used in the techniques of strain gauge measurement in order to eliminate any temperature effects.

b) The state of stress at a point in a loaded structural member is determined using the strain rosette arrangement shown in Fig.Q5

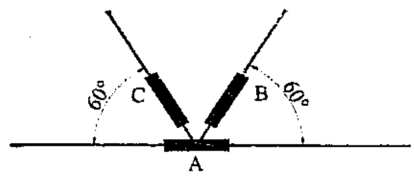

Fig. Q5

The respective strain measurements recorded in the three strain gauges A, B and C are as follows.

$\varepsilon_a = 48x\ 10^{-6}$

$\varepsilon_b = 120x\ 10^{-6}$

$\varepsilon_c = 216x\ 10^{-6}$

Determine;

i. The principal strains and their directions
ii. The principal stresses
iii. The shear stress acting on a plane perpendicular to the orientation of gauge A

6. State the basic principles on which the use of polarized light on photoelastic models in experimental stress analysis is based on.

Describe briefly the main differences in the application of plane polariscope and circular polariscope. Explain what type of photoelastic data can be recorded using each method and how such data are used to determine stress distributions in photoelastic models.

7. State Henkey's theorems and describe how Henkey's first theorem can be used to plot the slip line field for a 2 to 1 plane lubricated indentation.You may assume that the slip line field emanates from the mouth of the die as a fan.

Slip line field for a thick block of metal using a flat punch is shown in Fig.Q7. Determine the indentation pressure using (1)Upper bound method, and (2) Slip line field method, if the maximum shear flow stress of metal being formed is 320 N/m^2. Comment on the results obtained using the two methods.

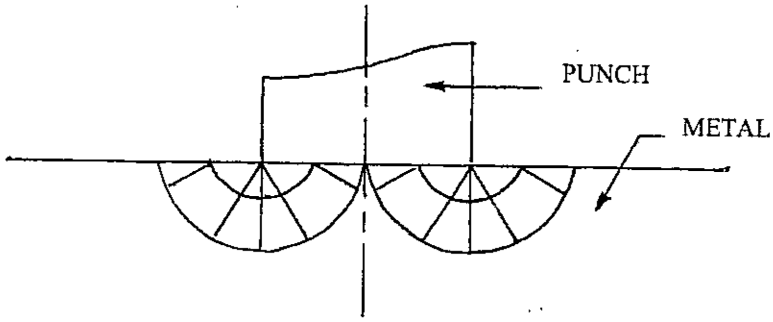

Fig. Q7

8. Comparison of materials on the basis of their fracture toughness should be carried out by comparing the respective plane strain fracture toughness (K_{IC}) values. Explain why.

A high-pressure chamber is fabricated using thick sheets of alloy steel. The sheets are joined together by revetting them along their edges with the heads of the revettes being 12 mm in diameter. The allowable inplane operating stress levels in chamber walls are determined by setting a factor of safety of 3. Which of the three alloys listed below would you select to fabricate the chamber, if catastrophic failure in chamber walls is to be avoided?

Alloy	σ_{ys} (MPa)	K_{IC} (MPa $\sqrt{m}$)
A	630	26.2
B	420	30.8
C	705	32.4