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**FACULTY OF ENGINEERING TECHNOLOGY**
**BACHELOR OF TECHNOLOGY – LEVEL 06**
**FINAL EXAMINATION 2007/2008**
**MEX 6330 – MECHANICS OF MATERIALS**
**DATE :28TH APRIL 2008**
**TIME :0930 HRS - 1230 HRS**
**DURATION :03 HOURS**

046

**WRITE YOUR INDEX NUMBER CLEARLY**

**WRITE YOUR REGISTRATION NUMBER**

**READ THE FOLLOWING INSTRUCTIONS CAREFULY BEFORE ANSWERING THE QUESTION PAPER**

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

**QUESTION 01:**

A component is made of steel for which $K_{IC}$ = 54 $MNm^{-3/2}$. Non destructive testing by ultrasonic methods shows that the component contains a crack of up to $2a$=0.2 mm in length. Laboratory tests show that the crack growth rate under cyclic loading is given by, $da/dN = A(\Delta K)^4$, where A = 4 x $10^{-13}$ $(MNm^{-2})^{-4}m^{-1}$. The component is subjected to an alternating stress of range $\Delta\sigma$ =180 $MNm^{-2}$ about a mean stress of $\Delta\sigma/2$.

Given that $\Delta K = \Delta\sigma\sqrt{\pi a}$, calculate the number of cycles to failure.

**QUESTION 02:**

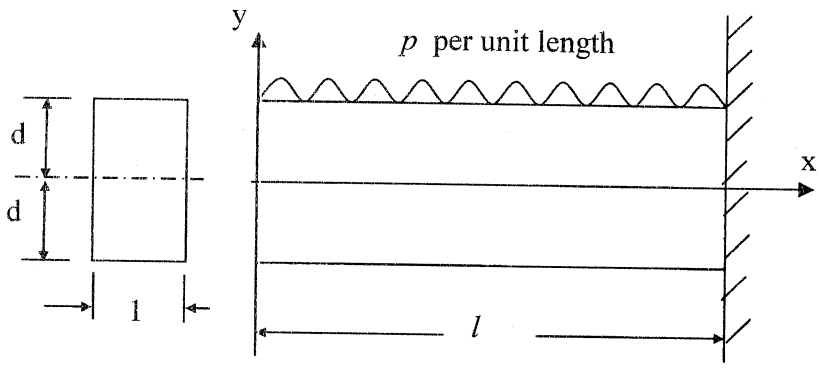



Fig.Q2

Fig.Q2 shows a cantilever beam subjected to a uniformly distributed load of '***p***' per unit length. Following function $\phi$ is proposed as an Airy Stress Function for the solution of this problem:

$$\phi = Ax^2 + By^3 + Cx^2y + Dx^2y^3 + Ey^5$$

Where A, B, C, D and E are constants to be determined.

(a) Obtain an equation involving some of these constants by requiring $\phi$ to satisfy $\nabla^4\phi = 0$ so that it becomes an admissible Airy's Stress Function.

(b) By imposing the boundary conditions at the top and the bottom boundaries (i.e. at y = +d and y = - d) obtain three more equations.

(c) By prescribing boundary conditions at the left end (i.e. at x = 0) in terms of the stress resultants (bending moment, shear force and axial force) obtain another non-trivial equation.

(d) Determine the constants A,B,C,D, and E. Hence show that the distribution of $\sigma_{xx}$ is given by:

$$\sigma_{xx} = \frac{px^2/2}{2d^3/3}y + \frac{p}{4}\left[\frac{3}{5}\left(\frac{y}{d}\right) - \left(\frac{y}{d}\right)^3\right]$$

**QUESTION 03:**

(a) Briefly explain the different methods used for experimental stress analysis.

(b) Name the main characteristics of a strain gauge.

(c) The following strains were recorded on a rectangular strain rosette.

$\varepsilon_a = 450x10^{-6}$ $\varepsilon_b = 230x10^{-6}$ $\varepsilon_c = 0$

Determine,

(i) The principal strains and the directions of the principal strain axes.
(ii) The principal stresses if E = 200 GN/m$^2$ and $\upsilon = 0.3$

**QUESTION 04:**

(a) Discuss the differences of the following terms

(i) Plane Polarisation (ii) Circular Polarisation (iii) Elliptical Polarisation

(b) Write down the Stress Optic Law of Photoelasticity.

(c) Make a comparative evaluation between the photoelastic method of stress analysis and electrical strain gauge technique considering the suitability of each method for a particular application.

**QUESTION 05:**

(a) Discuss five causes of fatigue failure and five methods to improve the fatigue strength of metals.

(b) Discuss how the temperature, time, and strain relate to creep behaviour of metals.

**QUESTION 06:**

(a) Write down all six independent stress components in terms of strains using the constants **E** and **υ**.

(b)

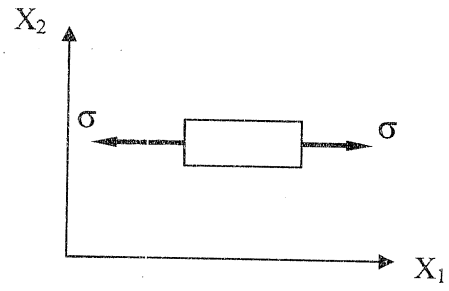



Fig.Q6

For an element subjected to a two dimensional stress system as shown in Fig.Q6, verify that the Youngs Modulus (E) and the Poisson's ratio (υ) are given by

$$E = \mu(3\lambda + 2\mu)/(\lambda + \mu) \quad \text{and} \quad \nu = \lambda/(\lambda + \mu)$$

Where $\lambda$ and $\mu$ are constants.

**QUESTION 07:**

(a) Explain the following terms

(i) Stress tensor (ii) Volumetric strain

(b) The stress tensor at a point is given by

$$[\sigma_{ij}] = \begin{bmatrix} 13 & 0 & 0 \\ 0 & 8 & -5 \\ 0 & -3 & 6 \end{bmatrix}$$

(i) Determine the invarients $I_1$, $I_2$ and $I_3$.

(ii) Considering the invarients write down an equation to find the principal stresses.

**QUESTION 08:**

. Define and describe the following four terms in relation to fatigue behaviour.

(a) stress amplitude
(b) mean stress
(c) fatigue limit
(d) endurance limit




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