The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX6330 Mechanics of Materials**
Academic Year	:	2013/14
Date	:	04th September 2014
Time	:	0930hrs – 1230hrs
Duration	:	03 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

Question 1:

a) State the generalized Hook's law.

b) Show that for an isotropic linearly elastic solid, volumetric strain is given by

$$\frac{\delta V}{V} = \frac{1}{E}(\sigma_x + \sigma_y + \sigma_z)(1 - 2\,\nu).$$

c) Hence or otherwise, prove that bulk modulus K = E/3(1-2 v)

d) The stresses in a flat steel plate in a condition of plane stress are σ_x = 1000 N/m^2, σ_y = -500 N/m^2 and τ_{xy} = 500 N/m^2. If the value of modulus of elasticity E = 210 x 10^9 N/m^2 and Poission ratio v = 0.25, find the magnitudes and directions of all the principal strains and the value of first invariant of strain tensor $\mathbf{J_1}$.

Question 2:

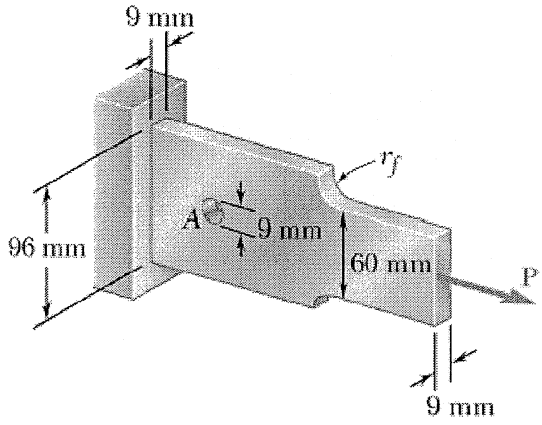

Fig.Q1

Fig.Q1 shows a one end fixed plate of thickness 9 mm, with a hole ***A*** having a diameter of 9 mm subjected to a tensile load ***P***.
If the allowable stress is 100 MPa, determine;

a) The corresponding maximum allowable load ***P***.

b) The radius of the fillets (r_f) for which the same maximum stress occurs at both the hole ***A*** and the fillets.

You may use the relevant graphs shown in Fig.Q1.1.

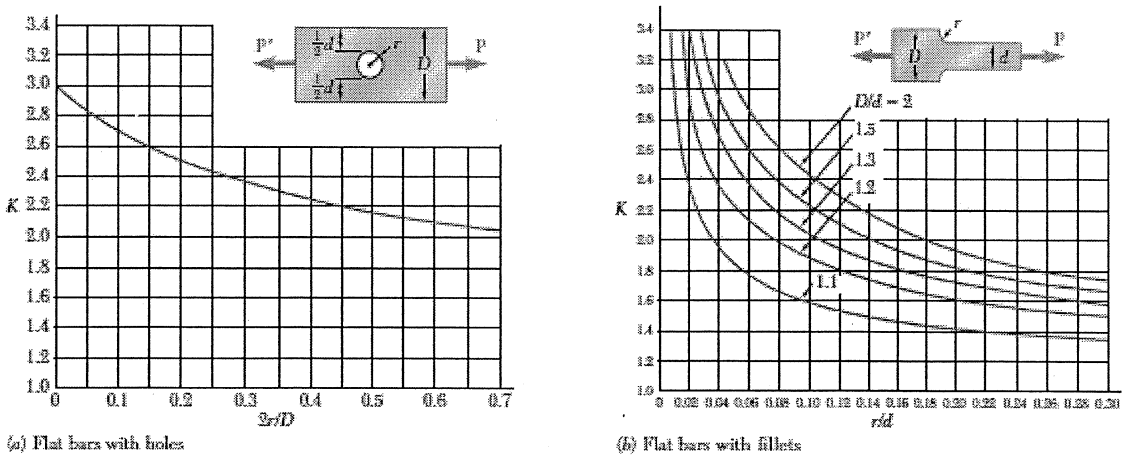

Fig.Q1.1: Stress concentration factors for flat bars under axial loading

Question 3:

a) Write down the properties of stress tensor

b) A state of stress is given by

$$\sigma_{ij} = \begin{bmatrix} 0 & 10 & -10 \\ 10 & 0 & 20 \\ -10 & 20 & 0 \end{bmatrix}$$

(i) Find the invariants I_1, I_2 and I_3.

(ii) Write the equation that can be used to find the principal stresses using these invariants.

(iii) Determine the magnitudes and directions of the principal stresses for the given stress tensor.

Question 4:

a) List the main components of the plane polariscope.

b) Briefly discuss the following, underlining the main differences among them.

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

c) Write down the Stress Optic Law of Photoelasticity.

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

Question 5:

a) By giving suitable examples describe how you would improve fatigue resistance in machine components.

b) A shaft is made of alloy steel for which K_{IC} = 87 $MNm^{-3/2}$. 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 $A = 5 \times 10^{-13}$ $(MNm^{-3/2})^{-4}m$. The component is subjected to an alternating stress of range $\Delta\sigma$ =220 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 6:

a) Write down the expressions for the circumferential and radial stresses developed in a rotating solid disc clearly identifying all the notations.

b) A steel disc of uniform thickness and of diameter 800 mm is rotating about its axis at 2100 rpm. Determine the radial and circumferential stresses at the center and at the outer radius if the density of the material is 7800 kg/m^2 and Poisson's ratio = 0.25.

c) Prove that in the case of a rotating solid disc, the maximum radial stress is

i) at radius r=$\sqrt{r_1 \times r_2}$ and

ii) given by $(\sigma_r)_{max} = \frac{\rho \times \omega^2}{8}(3 + \mu)(r_2 - r_1)^2$

Question 7 :

a) Discuss **five** causes of fatigue failure and **five** methods by which we can improve the fatigue strength of metals.

b) Write shorts notes on the following.

i) Stress relaxation

ii) Creep test

iii) Griffith crack theory

Question 8:

a) Describe briefly how you would experimentally determine the principal stresses present in a machine element under the action of a complex stress system, with the aid of a strain gauge.

b) The strains determined by the use of a strain gauge rosette as shown in Fig.Q8, attached to the surface of a machine element are $\epsilon_1 = -93.1 \times 10^{-6} mm/mm$ $\epsilon_2 = +385 \times 10^{-6} mm/mm$ and $\epsilon_3 = +210 \times 10^{-6} mm/mm$.

Determine,

i) orientation and magnitude of the principal strains in the plane of the rosette.
ii) the maximum in-plane shearing stress.

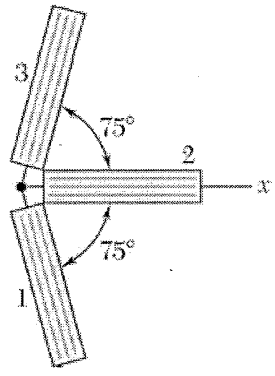

Fig.Q8

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