00154

THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 03
FINAL EXAMINATION 2009/2010
MEX 3231 – STRENGTH OF MATERIALS 1
DATE :17TH MARCH 2010
TIME :0930 HRS - 1230 HRS
DURATION :03 HOURS

ANSWER ANY FIVE (05) QUESTIONS. ALL QUESTIONS CARRY EQUAL MARKS.

Question 01:

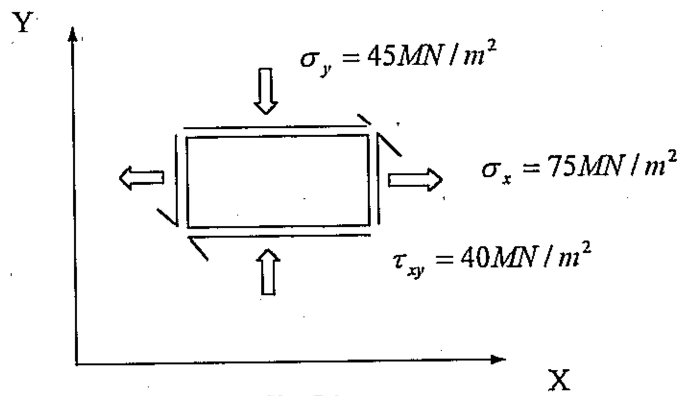

Fig.Q1

A thin plate whose stress element is shown in Fig.Q1 is made of a material with poison's ratio $\upsilon = 0.3$ and modulus of elasticity E = 200 GN/m^2 . If the plate is subjected to stresses

$\sigma_x = 75MN/m^2$ (tensile)

$\sigma_y = 45MN/m^2$ (compressive) and

$\tau_{xy} = 40MN/m^2$, draw a Mohr's circle of stresses and determine the principal stresses and the maximum shear stress.

(20 marks)

Question 02:

A copper bar 25 mm in diameter is enclosed centrally within a steel tube. The internal and external diameters of the tube are 30 mm and 36 mm respectively. At 0^0 C, the ends of the bar and the tube are rigidly fastened. The compound bar is then heated to a temperature of 80^0 C. Determine the stresses in the bar and the tube. Derive any formula used.

$E_{steel} = 200 \times 10^3$ N/mm^2

$E_{copper} = 100 \times 10^3$ N/mm^2

Linear coefficient of expansion for steel = 6×10^{-6} / ^{0}C

Linear coefficient of expansion for copper = 1×10^{-5} / ^{0}C

(20 marks)

Question 03:

a) Show that the Eular buckling load 'P_c' for a slender strut of length **L** and second moment of area **I**, pin jointed at each end is given by $\mathbf{P_c = (\pi/L)^2 EI}$
Where **E** is the modulus of elasticity of the material.

(08 marks)

b)

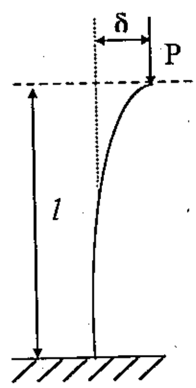

Fig.Q2

A steel rod 9 mm in diameter is rigidly built in at one end with its free end protruding horizontally 0.5 m normal to the wall. An axial load is applied to the free end of the rod, causing a deflection as shown in Fig.Q2. Determine

(i) Euler buckling load.
(ii) Deflection of free end (δ) of the rod, when the total compressive stress reaches the elastic limit.
Assume: E_{steel} = 200 GN/m^2 and the stress at elastic limit is 300 MN/m^2

(12 marks)

QUESTION 04:

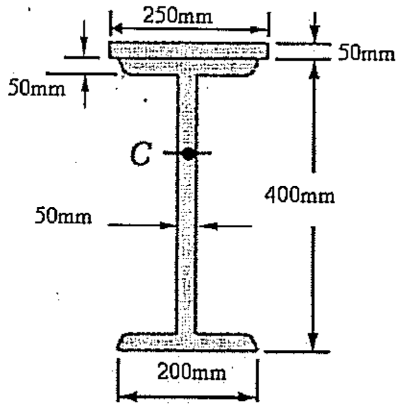

Fig.Q3

The strength of a W14x38 rolled steel **I** beam is increased by attaching a plate to its upper flange as shown in Fig.Q3.
Determine the moment of inertia with respect to an axis which is parallel to the plate and passes through the centroid of the section.

(20 marks)

QUESTION 05:

(a) Explain the meaning of each symbol in the simple torsion formula given by

$$\frac{T}{J}=\frac{\tau}{r}=G\frac{\theta}{l}$$

(05 marks)

(b) A uniform hollow, circular cylindrical shaft has a cross section with an inner radius *a* and an outer radius *b*. Show that the T-θ relationship in the linear elastic range is given by:

$$T=\frac{\pi}{2}\left(b^4-a^4\right)\frac{G}{l}\theta$$

(08 marks)

(c) In a torsion test on a uniform hollow circular shaft with $a = 10$ mm, $b = 25$mm and length $l = 500$ mm, following observations have been recorded.

θ (rad)	10×10^{-3}	15×10^{-3}	20×10^{-3}	25×10^{-3}	30×10^{-3}	35×10^{-3}	40×10^{-3}
T (Nm)	955	1435	1915	2390	2720	2880	2970

Using this data (and the results of part (b) above, if necessary) estimate the value of G for the shaft material.

(12 marks)

QUESTION 06:

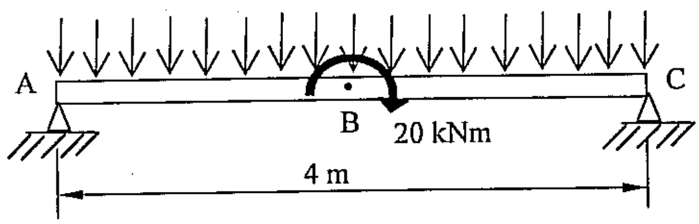

Fig.Q6

(a) A beam of length 4 m. simply supported at its ends A and C. carries a uniformly distributed load of 8 kN/m, as shown in Fig.Q6. Draw shear force and bending moment diagrams for the beam (without the applied moment shown at B).

(10 marks)

(b) An additional clockwise moment of 20 kNm is introduced at the center (B) of the beam. Using the principle of superposition draw the resulting shear force and bending moment diagrams for the beam and hence show that the maximum bending moment occurs at the beam center.

(05 marks)

(c) If an external moment of 20 kNm is applied at point A instead of point B, determine the position and magnitude of the maximum bending moment.

(05 marks)

QUESTION 07:

Explain the followings.

(i) Fatigue failure
(ii) Castigliano Theorem
(iii) Stress concentration factor
(iv) Reciprocal Theorem
(v) Tresca Theory

(20 marks)

QUESTION 08:

(a) Write down the assumptions that must be made to determine how much steel reinforcement is required for a given concrete beam section to carry a given moment.

(05 marks)

(b)

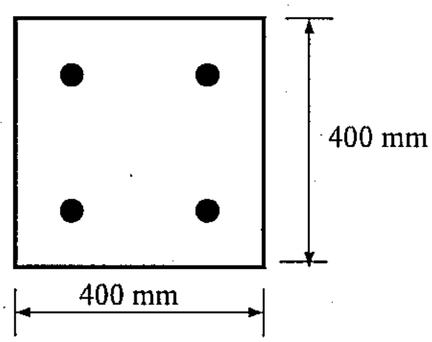

Fig.Q8

A reinforced concrete column, 5m high, is subjected to 1500 kN compressive force. The allowable shortening of the column is 1.8mm. The steel bars have to be fixed as shown in Fig.Q8. Find out the diameter of the steel bars that should be used under above compressive force.

Young's modulus of steel = 200 kN/mm^2
Young's modulus of concrete = 15 kN/mm^2

(15 marks)