COVENANT UNIVERSITY NIGERIA

TUTORIAL KIT
OMEGA SEMESTER

PROGRAMME: BUILDING TECHNOLOGY

COURSE: BLD 224

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BLD 224: STRUCTURAL THEORY AND STRENGTH OF MATERIAL II

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1. A steel bar of rectangular cross-section, 3 cm by 2 cm, carries an axial load of 30 kN**.** Estimate the average tensile stress over a normal cross-section of the bar.

2. A cylindrical block is 30 cm long and has a circular cross-section 10 cm in Diameter. It carries a total compressive load of 70 KN**,** and under this load it Contracts by 0.02 cm. Estimate the average compressive stress over a normal Cross-section and the compressive strain.

3. Explain the following terms: Linear of proportionality, Elastic limit and Breaking point.
4. A steel bolt, 2.50 cm in diameter, carries a tensile load of 40 kN**.** Estimate the average tensile stress at the section *a* and at the screwed section b, where the diameter at the root of the thread is 2.10 cm.

5. A tensile test is carried out on a bar of mild steel of diameter 2 cm. The bar Yields under a load of 80 kN. It reaches a maximum load of 150 KN**,** and breaks finally at a load of 70 kN**.**
Estimate:
(1) The ultimate tensile stress;
(ii) The tensile stress at the yield point;
(iii) The average stress at the breaking point, if the diameter of the fractured neck is 1 cm.

6 Differentiate between brittle and ductile material and give examples

7 The piston of a hydraulic ram is 40 cm diameter, and the piston rod 6 cm diameter. The water pressure is 1 MN/m^2. Estimate the stress in the piston rod and the elongation of a length of 1 m of the rod when the piston is under Pressure from the piston-rod side. Take Young's modulus as E = 200 GN/m^2.

8 A bar of cross-section 2.25 cm by 2.25 cm is subjected to an axial pull of 20 **kN.** Calculate the normal stress and shearing stress on a plane the normal to which makes an angle of 60^o with the axis of the bar, the plane being Perpendicular to one face of the bar.

9 At a point of a material the two-dimensional stress system is defined by
бx* = *60.0 MN/m2, tensile
бy = 45.0 MN/m2, compressive
ʈxy, = 37.5 MN/m2, shearing.

10. The state of stress at a point in a loaded structure is given by the strength tensile.

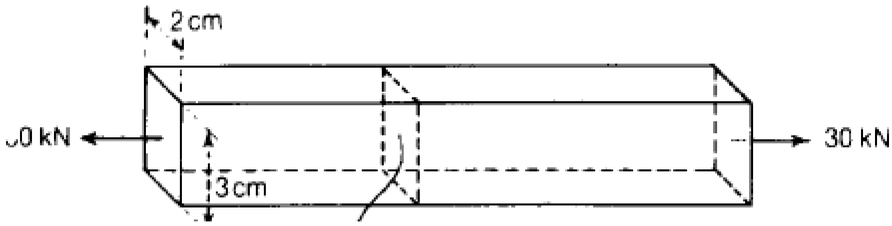
$$T\sigma = \begin{matrix} 140 & 60 & 0 \\ 60 & -90 & 0 \\ 0 & 0 & 0 \end{matrix}$$

Determine

a. The maximum principal stress
b. The minimum principal stress
c. The maximum and minimum shear strain
d. The maximum and minimum shear stress

Taking $E = 2.1 \times 10^5 N/mm^2$ $J = 0.32$

SOLUTION

1. 

The area of a normal cross-section of the bar is

Tension and compression: direct stresses

$A = 0.03 \times 0.02 = 0.6 \times 10^{-3}\ m^2$

The average tensile stress over this cross-section is then

Б= P/A

Б= 30 x $10^3 / 0.6 \times 10^{-3} = 50 MN/m^2$.

2. The area of a normal cross-section is

$A = \prod/4\ (0.10)^2 = 7.85 \times 10^{-3}\ m^2$

The average compressive stress over this cross-section is then

Б $= P/A = 70 \times 10^3 / 7.85 \times 10^{-3} = 8.92 MN/m^2$

The average compressive strain over the length of the cylinder is

$E = 0.02 \times 10^{-2} / 30 \times 10^{-2} = 0.67 \times 10^{-3}$

5. The original cross – section of the bar is

$A_0 = \prod/4\ (0.020)^2 = 0.314 \times 10^{-3} m^2$

(i) The average tensile stress at yielding is then

Бy $= P_y/A_o = 80 \times 103 / 0.314 \times 10^{-3} = 254 MN/m^2$

Where $P_{y\,=}$ load at the yield point.

(ii) The ultimate stress is the normal stress at the maximum load

Бult $= P_{max}/ A_o = 150 \times 10^3 / 0.314 \times 10^{-3} = 477 MN/m^2$

Where Pmax is maximum load

(iii) The cross-sectional area in the fracture neck is

$A_{F} = \prod/4\ (0.010)^2 = 0.0785 \times 10^{-3} m^2$

The average stress at the breaking point is then

$Бf = p_f/\ A_f = 70 \times 10^3/\ 0.0785 \times 10^{-3} = 892 MN/m^2$

Where P_f = final breaking load.

8. We have $\theta = 60^o$, P = 20KN and $A = 0.507 \times 10^{-3}\ m^2$. Then

$Бx = 20 \times 10^3/\ 0.507 \times 10^{-3} = 39.4\ MN/m^2$

The normal stress on the oblique plane is

$Б = бx \cos^2 60^o = (39.4 \times 10^6)1/4 = 9.85 MN/m^2$

The shearing stress on the oblique plan is

$½\ бx \sin 120^o = ½\ (39.4 \times 10^6)\ \sqrt{3}/2 = 17.05 MN/m^2$

10.

$$Тб = \begin{matrix} 140 & 60 & 0 \\ 60 & -90 & 0 \\ 0 & 0 & 0 \end{matrix} = \begin{matrix} бx & Ʈxy & Ʈxz \\ Ʈyx & бy & Ʈyz \\ Ʈzx & Ʈzy & бz \end{matrix}$$

Base on the similarity of matrix

$бx = 140\ N/mm^2$

$Ʈxy = Ʈyx = 60\ N/mm^2$

$бy = -90\ N/mm^2$

Maximum Principal Stress $(б1) = (бx + бy)/2 + 1/2\sqrt{}\ (бxx – бyy)^2 + 4Ʈ^2xy$

Substituting into the equation

$Б1 = (140 – 90)/2 + 1/2\sqrt{}\ (140 + 90)^2 + 4\ (60)^2$

$25 + ½\ \sqrt{}52,900 + 14,400$

$25 + ½\ \sqrt{}67300$

$25 + ½ \times 259.42$

$25 + 129.71$

$Б1 = 154.71 N/mm^2$

Minimum Principal Stress $(б1) = (бx + бy)/2 - 1/2\sqrt{}\ (бxx – бyy)^2 + 4Ʈ^2xy$

Substituting into the equation

$Б2 = (140 – 90)/2 + 1/2\sqrt{}\ (140 + 90)^2 + 4\ (60)^2$

$25 - ½ \sqrt{52,900 + 14,400}$

$25- ½ \sqrt{67300}$

$25 - ½ \times 259.42$

$25 - 129.71$

Б2 = -104.71 N/mm^2

SHEAR STRESS

Ʈmax = ½ (б1 – б2)

Substituting in the formula

Ʈmax = ½ [(155 – (-105)] =130 N/mm^2

Ʈmin = -1/2 [(155 + 105) = -130 N/mm^2