**Lecture No. 1**

**-Review of strength of material-**

* 1. **Direct stress: -**

**P**

**P**

1. Tensile stress.

**P**

**P**

1. Compression stress.

**σaxial=**$\frac{P}{A}$ $\frac{N}{m^{2}}$ ………….1.1

Where: -

σaxial = axial stress.

 P = axial load (N).

A= cross section area (m2).

**ε=**$ \frac{σ}{E}$ ……….…1.2

Where: -

ε= Strain

 E= modulus of elasticity

**2-2** **Bending stress: -**

σb =$\frac{My}{I}$….……….1.3

**Where: -**

**P**

 M= moment (N.m)

**R2 =P/2**

**R1 =P/2**

 I= moment of inertia (m4)

**I=** $\frac{πD^{4}}{64}$

**D**

**B.M.D.**

**S.F.D.**

 I= $\frac{π(D^{4}-d^{4})}{64}$

**D**

**d**

 I = $\frac{BH^{3}}{12}$

**H**

**B**

**2-3 Shear stresses: -**

The shear stress may be : -

1. Direct shear: - This occurs over an area parallel to the applied load.

 τavg= $\frac{P}{A}$ $\frac{N}{m^{2}}$ ……..1.4a

**P**

Where: -

 τavg =Average shear stress.

 P = Shear force.

 A = Area of the section.

**d**

1. Induced shear: - This occurs over section (or face shear).

 τavg= $\frac{P}{A}$ $\frac{N}{m^{2}}$ …….1.4b

**P**

**P**

Where: -

Arivet = $\frac{πd^{2}}{4}$

1. **Torsion: -**



τmax = $\frac{TR}{J}$ ……1.5

ϴ = $\frac{TL}{JG}$ ……1.6

Where: -

T= Torque.

τmax

L= Length of shaft.

G= Shear modulus or Modulus of rigidity.

R

ϴ= Angle of twist.

J = Polar moment of inertia.

Shear stress distribution in circular shaft

For solid shaft J = $\frac{πD^{4}}{32}$.

For hollow shaft J = $\frac{π(D^{4}-d^{4})}{32}$.

**2-4 Combined stresses: -**

In sections 2.1, 2.2 and 2.3, we studied three basic types of loading, axial, flexural (bending), shear and torsion. Each of three types was discussed on the assumption that only one of these loadings was acting on a member at a time, but in actual condition in most cases one or more of these loading act simultaneously upon a member. There are four possible combinations of these loadings.

1. Axial and Flexural loadings.
2. Axial and Torsional loadings.
3. Torsional and Flexural loadings.
4. Axial, Torsional and Flexural loadings acting simultaneously.

Combined stresses principal stresses (σ1, σ2, σ3).

 Max. Shear stress (τmax).

σy

τxy

σ1 or σmax = $\frac{σ\_{x}+σ\_{y}}{2}$ + $\frac{1}{2}\sqrt{(σ\_{x}-σ\_{y})^{2}+4τ\_{xy}^{2}}$ …1.7

σx

σ2 or σmin =$\frac{σ\_{x}+σ\_{y}}{2} $- $\frac{1}{2}\sqrt{(σ\_{x}-σ\_{y})^{2}+4τ\_{xy}^{2}}$ …1.8

Where: -

σ1 > σ2

τmax = $\frac{1}{2}\sqrt{(σ\_{x}-σ\_{y})^{2}+4τ\_{xy}^{2}}$ …1.9

**2-5 Thin wall cylinders subjected to internal pressure:-**

Cylinders or spherical vessels are commonly used in industry to serve as boilers or tanks. When vessel under pressure, the material of which they are made is subjected to loading from all directions.

In general “thin wall” refers to a vessel having an inner radius to wall thickness ratio of 10 or more.

i.e. $\frac{r}{t}$ ≥ 10

σh



σL

σ h = $\frac{Pd}{2t}$ (Hoop stress) ….1.10

σL =$\frac{Pd}{4t}$ (Longitudinal stress). … 1.11

Where: -

 P= Internal pressure (Pa or $\frac{N}{m^{2}}$ ).

 d= 2r= Internal diameter.

 t= Cylinder thickness.

For spherical vessel: -

σh



σh

 σh =σ = $\frac{Pd}{4t}$ ….1.12

Where: -

d=spherical radius (inner).

**Prob.1** Asteel bar ***ABCD*** consists of three sections: ***AB*** is of **20mm** diameter and 200 mm long, ***BC*** is **25 mm** square and **400 mm** long, and ***CD*** is of **12 mm** diameter and **200 mm** long. The bar is subjected toan axial compressive load which induces a stress of **30 MN/m2** onthe largest cross-section. Determine the total decrease in the length of the bar when the load is applied. For steel **E =** **210GN/m2**.

**Prob.2** Abeam AB, **1.2 m** long, is simply-supported at its ends A and Band carries two concentrated loads, one of **10 kN** at **C**, the other **15 kN** at **D**. Point **C** is **0.4 m** from **A**, point **D** is **1 m** from **A**. Draw the **S.F.** and **B.M.** diagrams for the beam inserting principal values.

**Prob.3** An I-section girder, **200 mm** wide by **300 mm** deep, with flange and web of thickness **20 mm** is used as a simply supported beam over a span of **7 m**. The girder carries a distributed load of ***5* kN/m** and **a** concentrated load of **20 kN** at mid-span. Determine: (a) the second moment of area of the cross-section of the girder, (b) the maximum stress set-up.

**Prob.4** Determine the dimensions of a hollow shaft with a diameter ratio of **3:4** which is to transmit **60** **kW** at **200 rev/min**. The maximum shear stress in the shaft is limited to **70 MN/m2** and the angle of twist to **3.8º** in a length of **4 m**.

For the shaft material **G = 80 GN/m2**.

**Prob.5** A circular bar ***ABC,* 3 m** long, is rigidly fixed at its ends ***A*** and ***C.*** The portion ***AB*** is **1.8 m** long and of **50 mm** diameter and ***BC*** is **1.2 m** long and of **25 mm** diameter. If a twisting moment of **680 N.m** is applied at ***B,*** determine the values of the resisting moments at ***A*** and ***C*** and the maximum stress in each section of the shaft. What will be the angle of twist of each portion?

For the material of the shaft **G = 80 GN/m2**.

**Prob.6** A hollow shaft is **460 mm** inside diameter and **25 mm** thick. It is subjected to an internal pressure of **2 MN/m2**, a bending moment of **25 kN.m** and a torque of **40 kN.m**. Assuming the shaft may be treated as a thin cylinder, make a neat sketch of an element of the shaft, showing the stresses resulting from all three actions.

Determine the values of the principal stresses and the maximum shear stress.

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