UNIT I

1.1 STRESS AND STRAIN

1.1STRENGTH OF MATERIALS

Strength of materials is a subject which deals with the detailed study about the effect of external forces acts on materials and ability of material to resist deformations due to cohesion between the molecules The study of strength of materials often refers to various methods of calculating the stresses and strains in structural members, such as beams, columns, and shafts.

1.1.2STIFFNESS

The Stiffnessmay be definedasanabilityofamaterialtowithstandloadwithout deformation.

1.1.3STRESS

When an external force acts on a body it undergoes some deformation and at the same time the body resists deformation. The magnitude of the applied force is numerically equal to the applied force. This internal resisting force per unit area is called stress

Mathematically

$$\text{Stress}(\sigma) = \frac{Force(P)}{Area(A)}$$

TheunitofStressisN/mm^{2}orKN/m^2.dependingupontheunitsofForceandArea

1.1.4.STRAIN

When a bodyissubjected toan external force, there issomechange indimensionof the body. The ratio of change in dimension to the original dimension is known as strain.

$$\text{Strain} = \frac{\text{Changeindimenstion}}{\text{Originaldemension}}$$

Ithasnounit.

1.1.5.TYPESOFSTRESSES

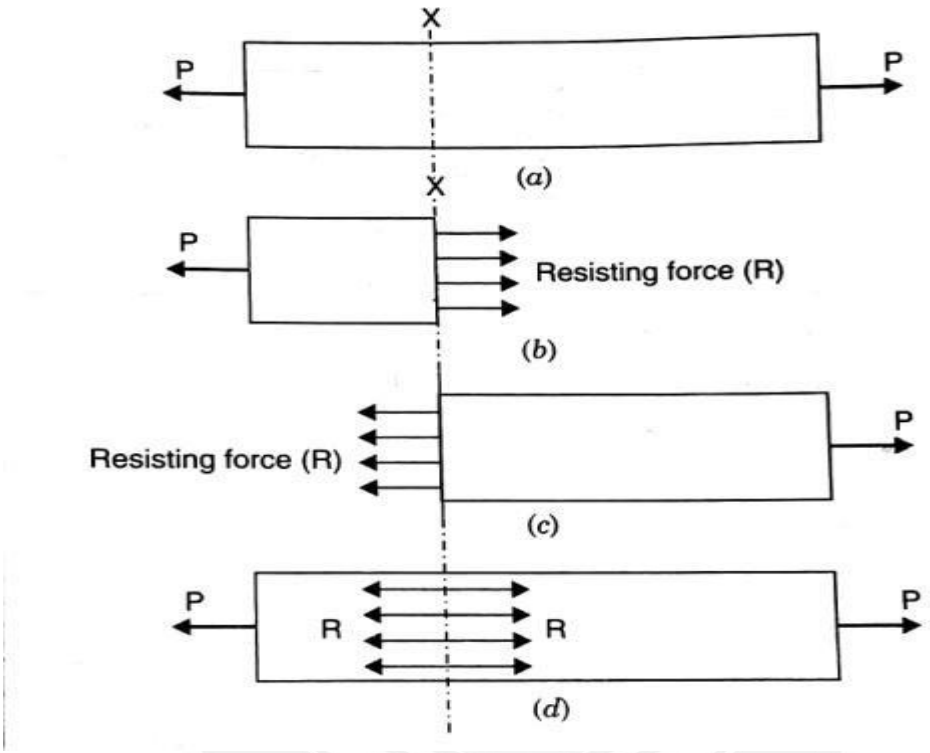
Therearemainlythreetypesofstresses.Theyare: a.Tensile stress,

b.Compressivestressand c.Shear stress.

a.Tensilestress&TensileStrain

When a member is subjected to equal and opposite pulls as shown in figure, as a result of this there is increased in length. The Stress induced at any crosssectionofthememberiscalledTensileStress.

$$\text{TensileStress} = \frac{Tensile\ load}{Area}$$

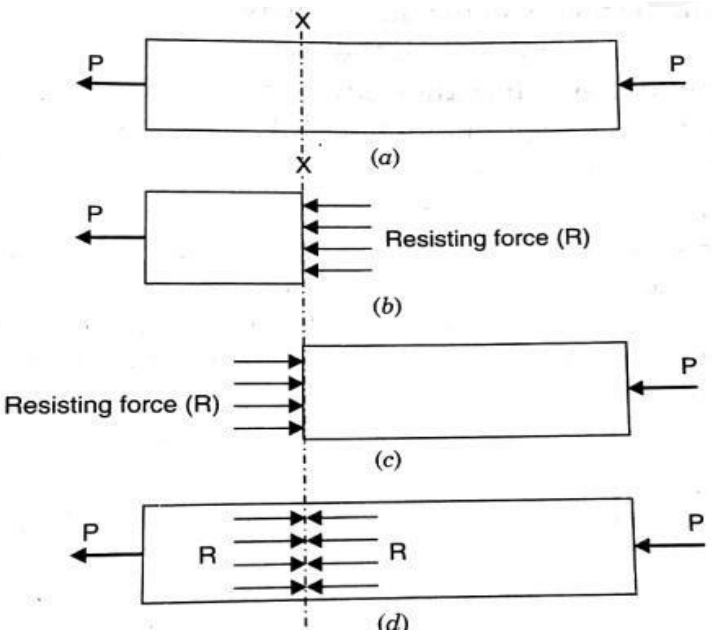


Theratioofincreaseinlengthtotheoriginallengthisknownas TensileStrain

$$\text{TensileStrain(e)} = \frac{\text{Increaseinlength}(\Delta l)}{\text{Originallength}(l)}$$

b.CompressiveStressandCompressiveStrain

Whenamemberissubjectedtoequalandoppositepushesasshowninfigure,asa resultofthisthereisdecreasedinlength.TheStressinducedatanycrosssectionofthe member is called CompressiveStress.

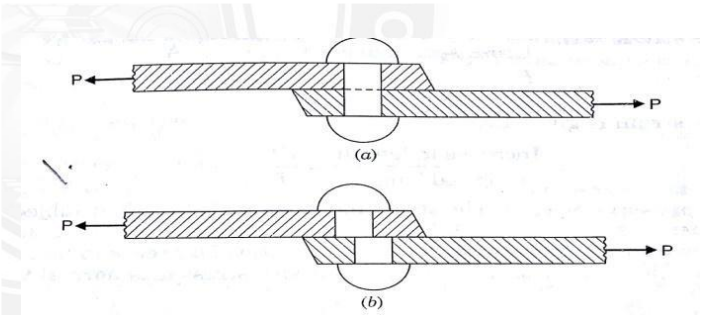


$$\text{CompressiveStress} = \frac{\text{Compressive load}}{\text{Area}}$$

Theratioofincreaseinlengthtotheoriginallengthisknownas Tensile Strain

$$\text{TensileStrain(e)} = \frac{\text{decreaseinlength}(\Delta l)}{\text{Originallength}(l)}$$

C.ShearStressandShearStrain



When the member is subjected to equal and opposite forces acts tangentially at any cross sectional plane of a body the body tending to slide one part of the body over the other part as shown in figure the stressinducedinthat sectioniscalledshear stressandthecorrespondingstrainisknownasshearstrain.

1.1.6.VOLUMETRICSTRAIN

Volumetricstrainisdefinedastheratioofchangeinvolumetotheoriginalvolume

$$\text{VolumetricStrain} = \frac{\text{ChangeinVolume}(\Delta v)}{\text{Original Volume}(v)}$$

1.1.7.HOOKE'SLAW

ItStatesthatwhenamaterialisloaded,withinitselasticlimit,thestressisdirectly proportional to the strain.

$$\text{Stress}(\sigma) \propto \text{strain}$$

1.1.8.FACTOROFSAFETY

Itisdefinedastheratioofultimatestresstothe Permissiblestress(workingstress)

$$\text{Factorofsafety} = \frac{\text{UltimateStress}}{\text{PermissibleStress}}$$

Problem1.1 Amildsteelrod2mlongand3Cmdiameterissubjectedtoanaxialpullof 10KN.If E for steel is 2×10^5 N/mm^2.Find (a) Stress, (b)Strain,(C) Elongation of the rod.

Given:

Length of the rod, L = 2m = 2000mm;

Diameter of the rod, D = 3cm = 30mm;

Axialload, P=10KN=10×10^3N;

Young'sModulus, E=2×10^5N/mm^2

Tofind:

(a)Stress,(b)Strain,(C)Elongationoftherod

Solution:

Weknowthat,

$$\text{Stress}(\sigma) = \frac{Loa(P)}{Area(A)} = \frac{10\times10^3}{\frac{\pi}{4}\times D^2} = \frac{10\times10^3}{\frac{\pi}{4}\times30^2}$$

(σ)=**14.14N/mm^2.**

$$\text{Young'Smodulus,(E)} = \frac{\text{Stress}}{\text{Strain}}$$

$$\therefore\text{Strain(e)} = \frac{\text{Stress}}{\text{Young's Modulus}}$$

$$= \frac{14.14}{2\times10^5}$$

$$=\mathbf{7.07}\times10^{-5}$$

$$\text{Strain(e)} = \frac{\delta l}{l}$$

$$\text{or} \quad 7.07\times10^{-5} = \frac{\delta l}{2000}$$

$$\delta l = 2000\times7.07\times10^{-5}$$

$$=\mathbf{0.141mm}$$

Problem:1.2 AhollowCylinder2mlonghasanoutsidediameterof50mmandinside diameter of 30mm.If the cylinder is carrying a load of 25KN.Find the stress in the cylinder. Also find the deformation of the cylinder.Take E=100Gpa.

GivenData:

Length, L=2m= 2000mm,

Outsidediameter, D=50mm,

Insidediameter, d=30mm,

Load, $P=25kN=25\times10^3N$

Young'smodulus, $E=100GPa=100\times10^9Pa$

$= 100\times10^9N/m^2= 100\times\frac{10^9}{10^6}N/mm^2$

$=100\times10^3N/mm^2$

Tofind: Stress(σ)andDeformation(Δl)

Solution:

Stress(σ) $= \frac{Load(P)}{Area(A)}$

$=\frac{25\times10^3}{\frac{\pi}{4}\times(D^2-d^2)}\frac{\pi}{4}\times(50^2-30^2)\times100\times10^3$

$=\frac{25\times10^3}{\frac{\pi}{4}\times(50^2-30^2)}$

$=19.89N/mm^2.$

Deformation(δl)= $\frac{Pl}{AE}$

$=\frac{(25\times10^3\times2000)}{\frac{\pi}{4}\times(50^2-30^2)\times100\times10^3}$

=0.398mm

Problem:1.3A short hollow cast iron cylinder of external diameter 200mm is to carry a compressive load of 1.9MN.Determine the inner diameter of the cylinder, if the ultimate crushing stress for the material is $480MN/m^2$. Use the factor of safety of 4.

GivenData:

ExternalDiameter, D=200mm,

Load, P=1.9MN=1.9×106N,

UltimateStress, σ_u =480MN/m^2=480$\frac{10^6 N}{10^6}$/mm^2

=480N/mm^2,

Factorof Safety =4

ToFind: Internaldiameter(d)

Solution:

WorkingStress $(\sigma)= \frac{\text{UltimateStress}}{\text{FactorofSafety}}$

$= \frac{480}{4}$

=120N/mm^2

Stress(σ) $= \frac{Load(P)}{Area(A)}$

Or $120=\frac{\pi}{4}\frac{1.9\times10^6}{\times(200^2-d^2)}$

Or $40000-d^2=\frac{\pi}{4}\frac{1.9\times 10^6}{\times 120^2}$

Or d^2=40000-20159.58

=19840.4mm^2

∴ $d=\sqrt{19840.4}$

=140.856mm

=say**141mm**