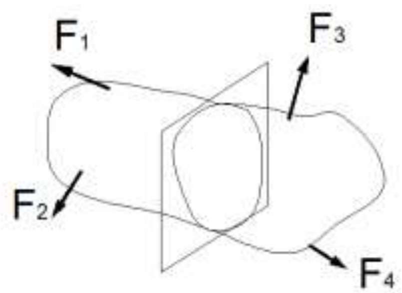
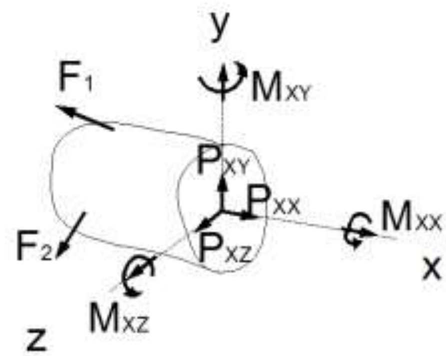
Chapter: 1
Introduction to Strength of Material & Concepts of Stress-Strain

Statics and dynamics are devoted primarily to the study of the external effects of forces on rigid bodies i.e. for which the change in shape can be neglected.

Strength of material deals with the relation between externally applied loads and their internal effects on bodies. Moreover the bodies are no longer assumed to be rigid, the deformation however the small, are of major interest. The basic two fundamental concepts are **strength** and **rigidity**.

Analysis of internal forces:



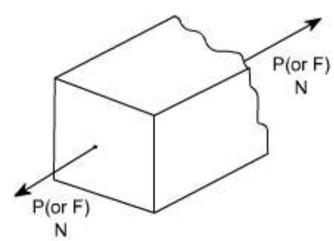


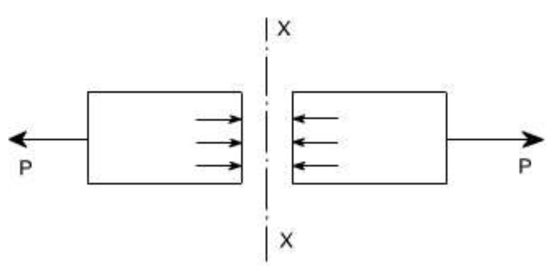
P_{XY} – The forces on the X- plane acting on the Y- direction.
P_{XX} – Axial force. This component measures the pulling or pushing action perpendicular to the section.
P_{XY} ,P_{XZ} – shear force. These are the components of the total resistance to sliding the portion to one side of the exploratory section.
M_{XX} – Torque. This component measures the resistance to twisting the member.
M_{XY} ,M_{XZ} – Bending moment. These components measure the resistance to bending the member about y or z axes.

Simple stress:

Whenever some external system of forces acts on a body, it undergoes some deformation. As the body undergoes some deformation, it sets up some resistance to deformation. This resistance per unit area to deformation is known as stress. i.e. $\sigma = P/A$.

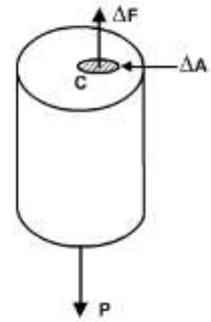
Let us consider a rectangular bar of some cross – sectional area and subjected to some load or force (in Newtons)





Let us imagine that the same rectangular bar is assumed to be cut into two halves at section XX. The each portion of this rectangular bar is in equilibrium under the action of load P and the internal forces acting at the section XX has been shown.

But in the equation σ = P/A, dividing load by area does not give the stress at all points in the cross sectional area, it simply determines the average stress.



Consider a small area ΔA on the cross section with the force acting on it ΔP as shown in figure above. Let the area contain a point C.

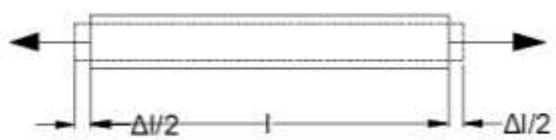
Now, the stress at the point C can be defined by dividing differential load ΔP by differential area ΔA over which it acts i.e. $\sigma = \lim_{\Delta A \to 0} \frac{\Delta P}{\Delta A} \approx \frac{dP}{dA}$

The condition under which the stress is constant or uniform is known as simple stress. A uniform stress distribution can exist only if the resultant of the applied body passes through the centroid of the cross section.

Simple strain:

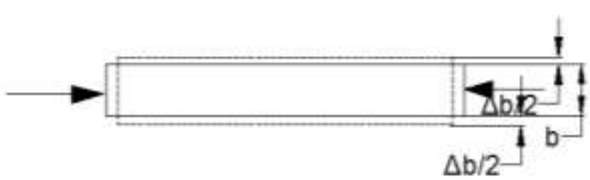
No material is perfectly rigid. Under the action of forces everything undergoes changes in shape and size. The change in dimension (length/breadth/diameter) per unit along the line of forces (tensile/compressive) is called linear strain.

The lateral strain is defined as change in dimension per unit along the perpendicular line of forces.



Linear strain (e_x) = $\frac{change\ in\ length}{original\ length} = \frac{\Delta l}{l}$

Lateral strain (e_y) = $\frac{change\ in\ lateral\ dimension}{original\ lateral\ dimension} = \frac{\Delta b}{b}$

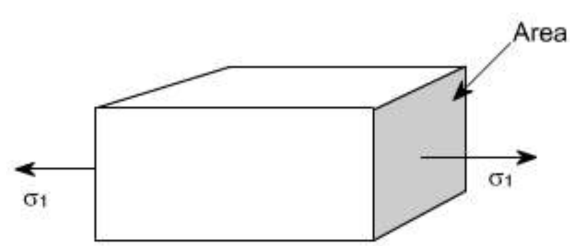


<u>TYPES OF STRESSES :</u>

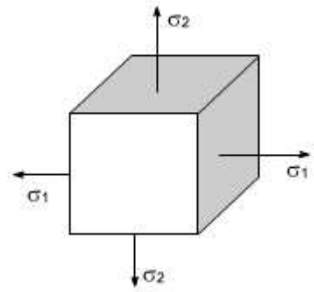
Only two basic stresses exists : (1) normal stress and (2) shear stress. Other stresses either are similar to these basic stresses or are a combination of these e.g. bending stress is a combination tensile, compressive and shear stresses. Torsional stress, as encountered in twisting of a shaft is a shearing stress.

Normal stresses:

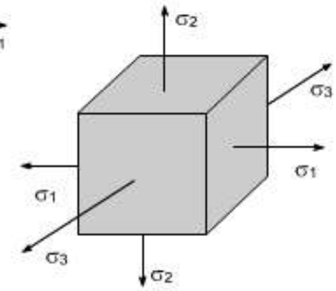
We have defined stress as force per unit area. If the stresses are normal to the areas concerned, then these are termed as normal stresses. The normal stresses are generally denoted by a Greek letter (σ)



This is also known as uniaxial state of stress, because the stresses acts only in one direction however, such a state rarely exists, therefore we have biaxial and triaxial state of stresses where either the two mutually perpendicular normal stresses acts or three mutually perpendicular normal stresses acts as shown in the figures below :



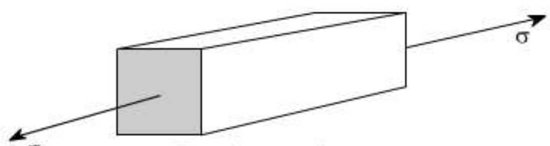
(Biaxial state of stress)



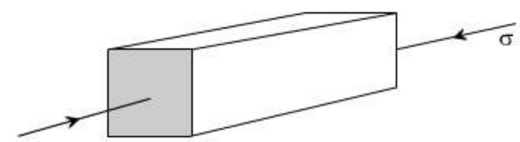
(Triaxial state of stress)

Tensile or compressive stresses:

The normal stresses can be either tensile or compressive whether the stresses acts out of the area or into the area.

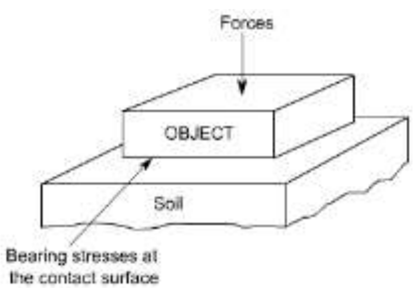


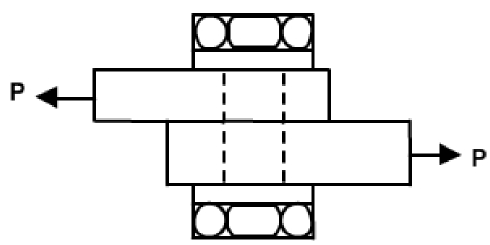
(Tensile stress)

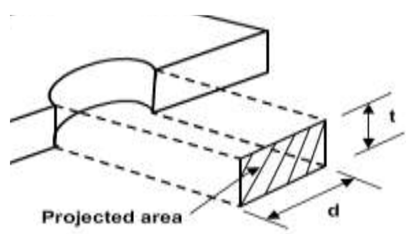


(Compressive stress)

Bearing Stress: When one object presses against another, it is referred to a bearing stress (They are in fact the compressive stresses).





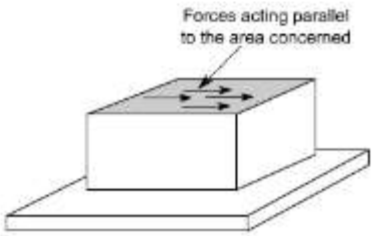


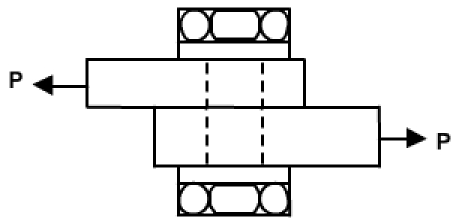
In the bolted connection in figure above, a highly irregular pressure gets developed on the contact surface between the bolt and the plates.
The average intensity of this pressure can be found out by dividing the load P by the projected area of the contact surface. This is referred to as the *bearing stress*.
The projected area of the contact surface is calculated as the product of the diameter of the bolt and the thickness of the plate.

Bearing stress, $\sigma = \frac{P}{A} = \frac{P}{t \times d}$

Shear stresses:

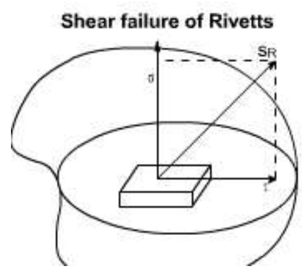
Let us consider now the situation, where the cross – sectional area of a block of material is subject to a distribution of forces which are parallel, rather than normal, to the area concerned. Such forces are associated with a shearing of the material, and are referred to as shear forces. The resulting force intensities are known as shear stresses, the mean shear stress being equal to $\tau = \frac{P}{A}$; Where P is the total force and A the area over which it acts.





As we know that the particular stress generally holds good only at a point therefore we can define shear stress at a point as $\tau = \lim_{\Delta A \to 0} \frac{\Delta P}{\Delta A}$

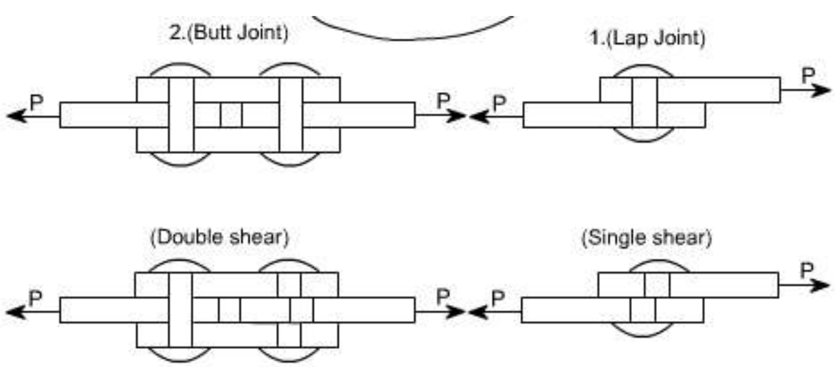
However, it must be borne in mind that the stress (resultant stress) at any point in a body is basically resolved into two components σ and τ one acts perpendicular and other parallel to the area concerned, as it is clearly defined in the following figure.



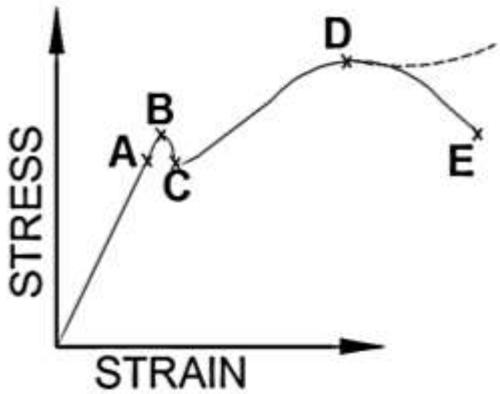
The single shear takes place on the single plane and the shear area is the cross - sectional of the rivet, whereas the double shear takes place in the case of Butt joints of rivets and the shear area is the twice of the X - sectional area of the rivet.

For single shear the stress is given by $\tau = \frac{shearing\ force}{shearing\ area} = \frac{P}{\frac{\pi d^2}{4}}$

For double shear the stress is given by $\tau = \frac{shearing\ force}{Total\ shearing\ area\ of each\ rivets} = \frac{P}{2.\frac{\pi d^2}{4}}$



SIMPLE STRESS & STRAIN DIAGRAM :(mild steel/ductile material)



A tensile test is generally conducted on a standard specimen to obtain the relationship between the stress and the strain which is an important characteristic of the material. In the test, the uniaxial load is applied to the specimen and increased gradually. The corresponding deformations are recorded throughout the loading. Stress-strain diagrams of materials vary widely depending upon whether the material is ductile or brittle in nature. If the material undergoes a large deformation before failure, it is referred to as ductile material or else brittle material.

Proportional limit(P) is that limiting point up to which stress strain diagram is a straight line i.e. stress is proportional to strain.

Elastic limit(E) is the stress beyond which the material; will not return to its original shape when unloaded but will retain a permanent deformation called permanent set.

The **yield point(Y)** is the point at which there is an appreciable elongation or yielding of the material without any corresponding increase of load.

Upper yield point is the point at which the load starts reducing and the extension increases.

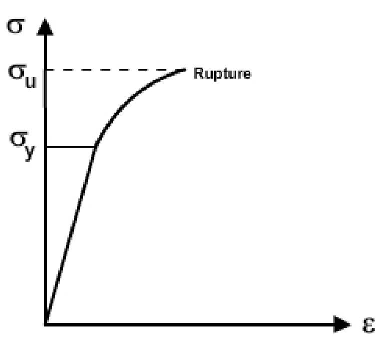
Lower yield point is the point at which the stress remains same but strain increases for some time.

The **yield strength** is closely associated with the yield point. For materials that don't have a well defined yield point, yield strength is determined by the offset method.

The **ultimate stress(U)** is the highest ordinate on the stress strain curve i.e. the maximum stress the material can resist.

The **rupture strength(R)/ breaking point** is the stress at failure.

In case of brittle materials like cast iron and concrete, the material experiences smaller deformation before rupture and there is no necking.



Hooke's law:

It states that the stress is proportional to strain up to elastic limit. Mathematically, $\sigma \alpha$ e;

Where σ stress and e is is strain.

Hence σ=E.e, where E is the constant of proportionality of the material, known as elastic limit.

True stress and true strain

In drawing the stress-strain diagram as shown in figure above, the stress was calculated by dividing the load P by the initial cross section of the specimen.

But it is clear that as the specimen elongates its diameter decreases and the decrease in cross section is apparent during necking phase.

Hence, the actual stress which is obtained by dividing the load by the actual cross sectional area in the deformed specimen is different from that of the engineering stress that is obtained using undeformed cross sectional area as in equation

True stress or actual stress, $\sigma_{Act} = \frac{P}{A_{Act}}$

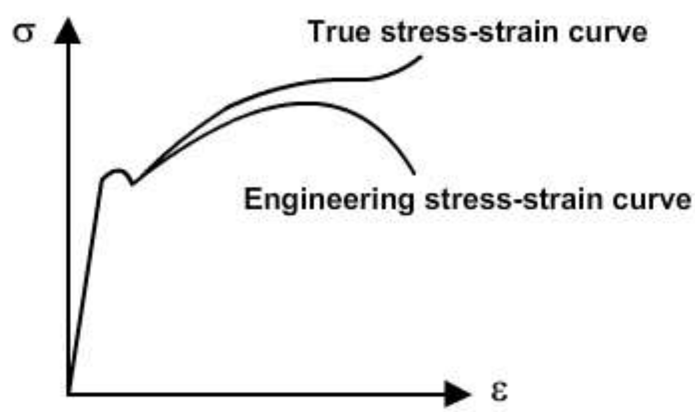
Though the difference between the true stress and the engineering stress is negligible for smaller loads, the former is always higher than the latter for larger loads.

Similarly, if the initial length of the specimen is used to calculate the strain, it is called engineering strain as obtained in equation $\varepsilon = \frac{\delta}{L} = \frac{L-L_0}{L}$

But some engineering applications like metal forming process involve large deformations and they require actual or *true strains* that are obtained using the successive recorded lengths to calculate the strain.

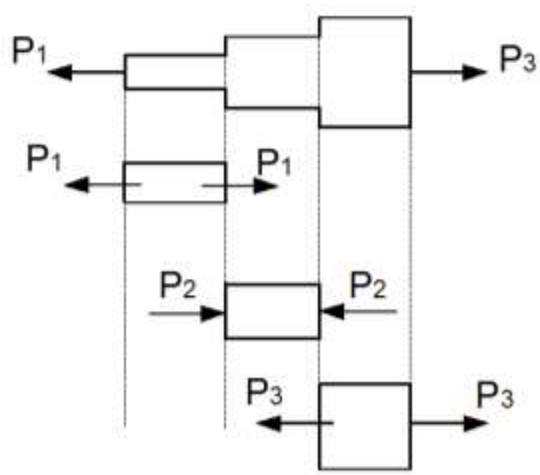
True strain = $\int_{L_0}^{L} \frac{dL}{L} = \ln \frac{L}{L_0}$

True strain is also called as actual strain or natural strain and it plays an important role in theories of viscosity. The difference in using engineering stress-strain and the true stress-strain is noticeable after the proportional limit is crossed as shown in figure



Principle of superposition:

When a body is subjected to number of different forces acting along the axis of the member at different cross section of the body, the forces are split up to consider the effects of individual sections. The total deformation is found out by the algebraic sum of deformations of individual sections. This is known as principle of superposition.



WORKING STRESS:

A good design of a structural element or machine component should ensure that the developed product will function safely and economically during its estimated life time.
The stress developed in the material should always be less than the maximum stress it can withstand which is known as ultimate strength
During normal operating conditions, the stress experienced by the material is referred to as working stress or *allowable stress* or design stress. The ratio of ultimate strength to allowable stress is defined as *factor of safety.*

$$\text{Factor of safety} = \frac{\text{Ultimate stress}}{\text{Allowable stress}};\ \text{or, Factor of safety} = \frac{\text{Ultimate load}}{\text{Allowable load}}$$

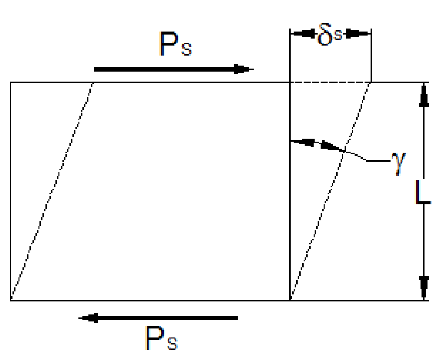
POISSON'S Ratio:

Consider a rod under an axial tensile load P as shown in figure 1.6 such that the material is within the elastic limit. The normal stress on x plane is $\sigma_{xx} = \frac{P}{A}$ and the associated longitudinal strain in the x direction can be found out from $\varepsilon_{xx} = \frac{\sigma_{xx}}{E}$. As the material elongates in the x direction due to the load P, it also contracts in the other two mutually perpendicular directions, i.e., y and z directions.
Hence, despite the absence of normal stresses in y and z directions, strains do exist in those directions and they are called lateral strains.
The ratio between the lateral strain and the axial/longitudinal strain for a given material is always a constant within the elastic limit and this constant is referred to as *Poisson's ratio*. It is denoted by $1/m = \mu = \frac{\text{Lateral strain}}{\text{linear strain}}$ = constant.

Since the axial and lateral strains are opposite in sign, a negative sign is introduced in above equation to make μ positive
The lateral strain in the material can be obtained by, $\varepsilon_y = \varepsilon_Z = -\mu\varepsilon_X = -\mu\frac{\sigma_{xx}}{E}$
Poisson's ratio can be as low as 0.1 for concrete and as high as 0.5 for rubber. In general, it varies from 0.25 to 0.35 and for steel it is about 0.3.

Modular ratio:
The ratio of modulus of elasticity of stronger material to that of lighter material is known as modular ratio. For example modular ratio of steel and wood is m, then $m = \frac{E_S}{E_W}$

Shear Stress:



Shearing force cause a shearing deformation, as axial forces cause elongation, but with an important difference. An element subject to tension undergoes an increase in length; an element subject to shear does not change the length of its sides, but it undergoes change in shape from a rectangle to parallelogram.

Shearing strain, $\tan\gamma = \delta_S/L$ or $\gamma = \delta_S/L$
Shear stress $\tau = G.\gamma$; where G is the modulus of rigidity
And $\delta_S = VL/A_S G$; where V = shear force and A_S = shear area.

Volumetric strain:

The ratio of change in volume to the original volume, is known as volumetric strain. $\varepsilon_v = \delta v/v$

Bulk modulus:

When a body is subjected to three mutually perpendicular stresses of equal intensity, the ratio of direct stress to the corresponding volumetric strain is known as bulk modulus.

k = Direct stress/ volumetric strain

$= \sigma/(\delta v/v)$

Relation between the elastic constants:

$$E = 3K\left(1 - \frac{2}{m}\right) = 2G\left(1 + \frac{1}{m}\right) = \frac{9KG}{3K+G}$$

MECHANICAL PROPERTIES OF MATERIALS:

Elasticity: whenever a material is subjected to some external load it undergoes some deformation and regains its original shape when the load is removed up to a certain limit. The property by virtue of which the material comes back to its original configuration after the external load disappears is called elasticity.

Plasticity: the property by virtue of which the material does not come back to its original shape after the external load is completely removed and there is a permanent deformation in the body is called plasticity.

Ductility: it is the property of the material by virtue of which it can be drawn into a thin wire under tensile load & the material can undergo a considerable amount of large deformation without rupture.

Brittleness: it is the property of the material by virtue of which it cannot undergo any deformation when subjected to some external load and as a result it fails by rupture without showing any deformation.

Malleability: it is the property of the material by virtue of which it can withstand deformation under compression without rupture and can be rolled into thin sheets.

Stiffness: it is the property of a material due to which it is capable of resisting deflection or elastic deformation under applied loads.

Hardness: it is the property of the material by virtue of which it can resist against penetration under a localized pressure or abrasion.

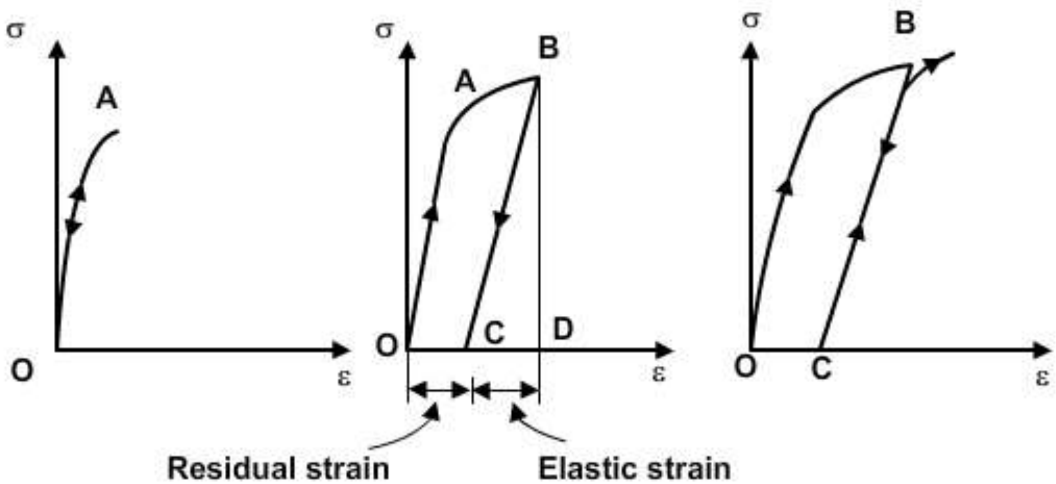
Resilience: **it** is a common term used for the total strain energy in a body. Sometimes resilience is also defined as the capacity of a strained body for doing work (when it springs back) on the removal of straining force i.e. the measure of the capacity of a material to absorb energy within elastic limit.

Fatigue: the property of a material which decides its behavior under a particular type of loading, in which a much smaller load than one required for material failure in a single application is repeatedly applied innumerous times is called fatigue.

Creep: the property of a material due to which it is progressively deformed at a slow rate with time at a constant stress is called creep.

Elasticity and Plasticity

If the strain disappears completely after removal of the load, then the material is said to be in elastic region. The stress-strain relationship in elastic region need not be linear and can be non-linear as in rubber like materials.

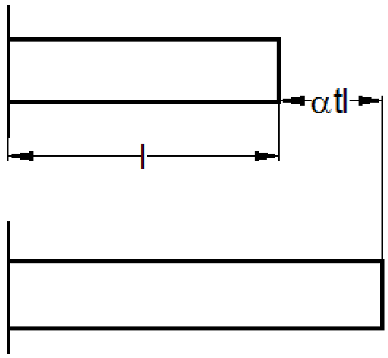


The maximum stress value below which the strain is fully recoverable is called the *elastic limit*. It is represented by point A in above figure. When the stress in the material exceeds the elastic limit, the material enters into plastic phase where the strain can no longer be completely removed. To ascertain that the material has reached the plastic region, after each load increment, it is unloaded and checked for residual strain. Presence of residual strain is the indication that the material has entered into plastic phase. If the material has crossed elastic limit, during unloading it follows a path that is parallel to the initial elastic loading path with the same proportionality constant E. The strain present in the material after unloading is called the residual strain or plastic strain and the strain disappears during unloading is termed as recoverable or elastic strain. They are represented by OC and CD, respectively in above figure. If the material is reloaded from point C, it will follow the previous unloading path and line CB becomes its new elastic region with elastic limit defined by point B. Though the new elastic region CB resembles that of the initial elastic region OA, the internal structure of the material in the new state has changed. The change in the microstructure of the material is clear from the fact that the ductility of the material has come down due to strain hardening. When the material is reloaded, it follows the same path as that of a virgin material and fails on reaching the ultimate strength which remains unaltered due to the intermediate loading and unloading process.

Thermal Stress:

Every material expands when temperature rises and contracts when temperature falls. The change in length due to change in temperature is found to be directly proportional to length of the member and also to change in temperature (t) and L is the length of the member then change in length Δ is given by $\Delta = \alpha. t .L$.

The constant of proportionality α is called coefficient of thermal expansion, and is defined as change in unit length of the material due to unit change in temperature. If the changes due to temperature are permitted freely, no stress develop in the member, only extension of the member of amount $\alpha.t.L$ takes place. If the free expansion is prevented fully or partially the stresses are induced in the member and these stresses are called Thermal Stresses.



If the bar is free to extend when the temperature is increased by ‘t’ degrees its free expansion would have been $\alpha.t.L$ But the extension is completely prevented by forces developed at supports as shown in figure. This support force P is such that it causes shortening (Δ) of the bar by $\alpha.t.L$

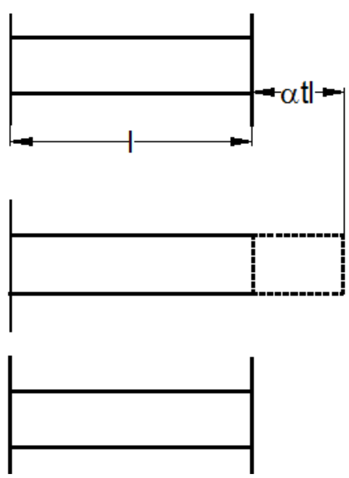
Hence, $\Delta = \alpha.L.t$

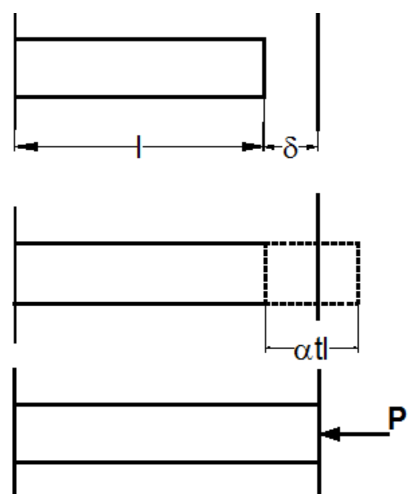
$\therefore$ $P.L/A.E = \alpha.L.t$

or, $P/A = E.\alpha.t$

$\therefore$ $\sigma_t = E.\alpha.t$;

[where σ_t = thermal stress.]





If free expansion is prevented partially as in the case shown in figure, the shortening caused by support reaction P is given by $\Delta = \alpha.L.t - \partial$

$$P.L/A.E$$

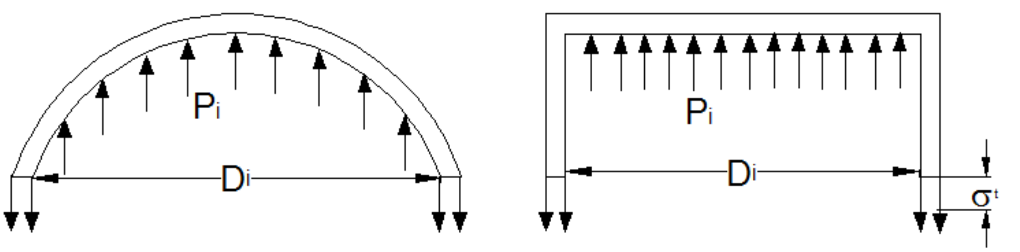
$$= \alpha.L.t - \partial$$

THIN CYLINDERS:

Cylindrical pressure vessels are divided into two groups - thin and thick cylinders.

A cylinder is considered thin when $D_i/t > 15$. Boiler shells, pipes and tubes and storage tanks are treated as thin cylinders.

There are two principal stresses in the thin cylinders: the circumferential stress σ_t and longitudinal stress σ_l . It is assumed that stresses are uniformly distributed over the wall thickness.



P_i = internal pressure (N/mm^2)
D_i = internal diameter of the cylinder (mm)
t = cylinder wall thickness.(mm)
Considering equilibrium of forces acting on the half portion of the cylinder of unit length $D_i.P_i = 2\sigma_t.t.$

$\sigma_t = (P_i .D_i)/2.t$

Now considering the forces in longitudinal direction,

$P_i.(\pi.D_i^2/4) = \sigma_l(\pi.D_i.t)$

$\sigma_l = (P_i .D_i)/4.t$

$\sigma_l = ½ \sigma_t$

CHANGE IN DIMENSIONS OF A THIN CYLINDRICAL SHELL DUE TO AN INTERNAL PRESSURE:-

When a thin cylindrical shell is subjected to an internal pressure, there will be an increase in the diameter as well as the length of the shell.

The increase in the diameter of the shell due to an internal pressure is given by, $\partial d = P.d^2 .(1-\mu/2)/2.t.E$

The increase in length of the shell due to an internal pressure is given by

$\partial l = P.d .l(1/2 - \mu)/2.t.E$

Questions

Theory:

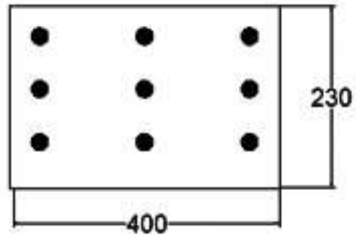
1. Define different types of stress and strain.
2. Define: a) elasticity b) plasticity c) ductility d) brittleness
3. Define ultimate stress, working stress and factor of safety.
4. Draw the stress-strain diagram for mild steel showing different salient points.
5. Distinguish between ductility and malleability
6. With proper sketch explain a) tensile stress b) compressive stress c) shear stress.
7. Define Hooke's law. Prove that $\partial l = \frac{Pl}{AE}$ with their usual notation.
8. Define poison's ratio.
9. What do you mean by principle of super-position.
10. **Problems:**

1. A steel bar 20mm in diameter, 20cm in long was tested to destruction. During the test following observations were recorded.
   Load at elastic limit = 65 kN
   Extension at elastic limit = 0.22mm
   Maximum load = 130kN
   Breaking load = 110kN
   Diameter at neck = 25cm.
   Determine i) modulus of elasticity ii) upper yield stress iii) ultimate stress iv) rupture stress v) percentage elongation vi) reduction in area.

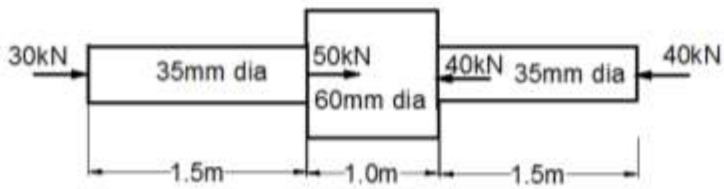
2. A M.S rod of 12mm diameter was tested for tensile strength, with a gauge length of 60mm. following observations were taken:
   Final length = 78mm.
   Final diameter = 7mm,
   Yield load = 34 kN,
   Ultimate load = 61 kN

Calculate a) yield stress b) ultimate tensile stress c) percentage reduction & d) percentage elongation

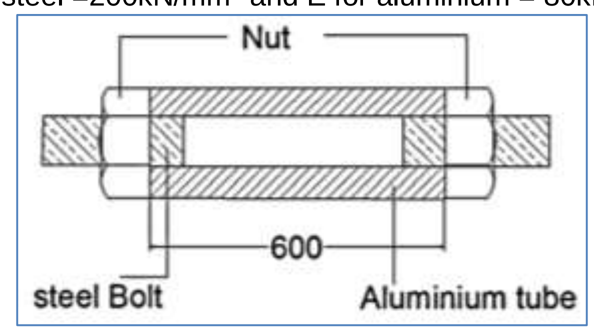
3. A hollow steel column of external diameter 200mm has to support an axial load of 2400kN. If the ultimate stress for the steel column is 480N/mm^2, find the internal diameter of the column allowing a factor of safety 4.
4. Calculate the force required for punching a hole of 20mm diameter through a mild steel plate 5mm thick. The maximum shear stress of mild steel is 250N/mm^2. Also find the compressive stress developed in the punch.
5. A load of 100kN is suspended by a steel pipe of 100mm external diameter and 2m long. If the ultimate tensile stress of steel is 500N/mm^2 and the working stress of steel is 125N/mm^2, find i)F.O.S ii)thickness of pipe and iii)elongation of the pipe. Take E_S = 200kN/mm^2.
6. The young's modulus of a material is 206kN/mm^2 and its modulus of rigidity is 82 kN/mm^2. Determine the poisson's ratio and bulk modulus.
7. A bar of uniform cross section A and length L is suspended from top. Find the expression of the bar due to self weight only if Young's modulus is E and unit weight of the material is γ.
8. A solid conical bar of uniformly varying diameter has diameter D at one end and zero at the other end. If length of the bar is L, modulus of elasticity E and unit weight γ, find the extension of the bar due to self weight.
9. A reinforced concrete column of size 230mm x 400mm has 8 steel bars of 12mm diameter as shown in figure. If the column is subjected to an axial compression of 600kN, find the stress developed in steel and concrete,



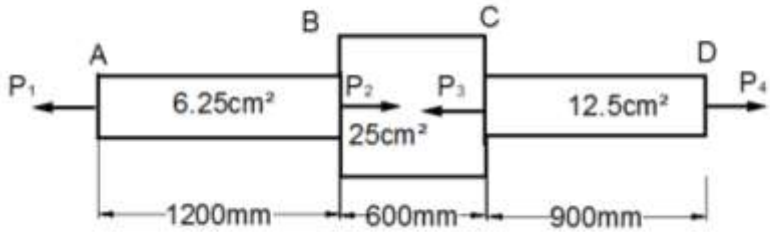
10. A short masonry pillar of rectangular section 600mmX500mm and 4m height carries an axial load of 500kN. Taking unit weight of masonry equal to 19000N/m^3, find the compressive stress induced at the base of the pillar.
11. A 100mm long bolt has a diameter 50mm for one half of its length and 45mm for the other half. It is subjected to an axial tensile force of 200kN. Determine the total elongation of the rod and maximum stress developed. Take E = 210GN/m^2.
12. A 6m long vertical timber post of square cross section 100mm X 100mm is rigidly fixed at its upper end and lower ends. A collar is attached to the post at 3.5m from the upper end and transmit an axial load of 19.2 KN. Neglecting the self weight of the post, find the stresses produced in the upper and lower portion of the post.
13. A stepped steel rod is subjected to loads as shown in figure below. Determine the total change in length of the rod. Take E = 200GPa.



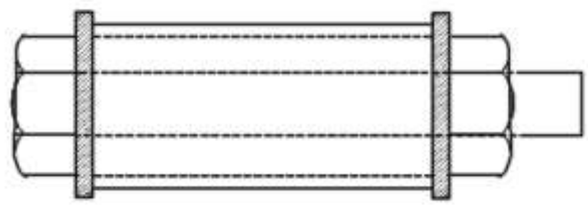
14. A steel bolt having a cross sectional area of 600mm^2 is passed through a hollow aluminium tube of 120mm^2 sectional area and 600mm long as shown in figure. Over the threaded ends of the bolt, nuts are turned till they just touch the aluminium tube. If one of the nuts is forcibly tightened further through 1/4th of a turn, find the stresses produced in the bolt and the tube, pitch of the bolt thread =2mm. take E for steel =200kN/mm^2 and E for aluminium = 80kN/mm^2.



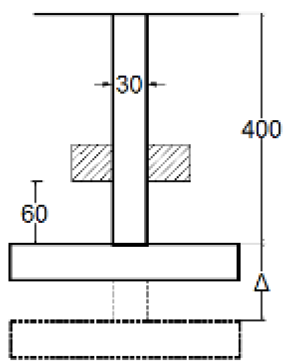
15. An aluminium tube 40mm external diameter, 25mm internal diameter, 800mm long is snugly fitted on a solid steel rod of 25mm diameter. The composite member is subjected to an axial pull of 45kN. Compute the stress in each material. Assume for steel E = 210GPa, for aluminium E = 70GPa.
16. A member ABCD is subjected to a point loads P_1, P_2, P_3 &P_4 as shown in figure. Calculate the force P_2 necessary for equilibrium, if P_1= 4.5kN, P_3=45kN and P_4=13kN. Determine the total change in length of the member, assuming modulus of elasticity to be 200 GN/m^2.



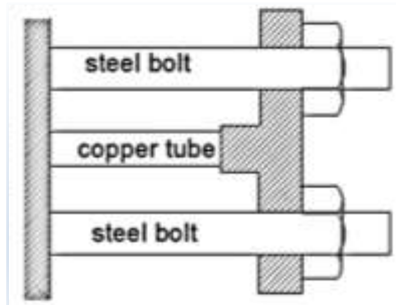
17. With a punch for which the maximum crushing stress is 4times the maximum shearing stress of the plate, show that the biggest hole cane the punched in the plate is of diameter equal to the plate thickness.
18. A steel bar 20mm diameter and 1m long is freely suspended from a roof and is provided with a collar at other end. If modulus of elasticity is $2x10^5$N/mm^2 and maximum permissible stress is 300N/mm^2, find
    a. The maximum load which can fall from a height of 50mm on the collar
    b. The maximum height from which a 600N load can fall on the collar.
19. A steel bolt of 16mm diameter is passing centrally through a copper tube of internal diameter 20mm and external diameter 30mm. The length of the whole assembly is 500mm. After tight fitting of the assembly, the nut is over-tightened quarter of a turn. What are the stresses introduced in bolt and tube, if pitch of nut is 2mm, take E_S = 200GPa.



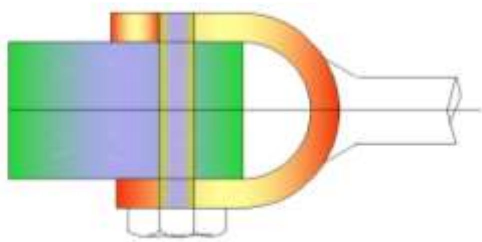
20. A 100N load falls from a height of 60mm on a collar attached to a bar of 30mm diameter and 400mm long. Find the instantaneous stress and extension of produced in the bar. Take E = $2x10^5$N/mm^2. What is the percentage error, if extension of the bar is neglected if final work done by the load?



21. Two steel bolts of 20mm diameter pass through a rigid casting as shown in figure. After inserting a copper tube of internal diameter 25mm and thickness 10mm between rigid support and the rigid casting assembly was just fitted. Then the nuts are given 60^0 turn. What are the stresses introduced in bolt and tube, if E_S = $2x10^5$N/mm^2 and E_C = $1.2x10^5$N/mm^2 and pitch of nut is 3mm.



22. A material has modulus of rigidity equal to 0.4×10^5 N/mm^2 and bulk modulus equal to 0.75×10^5 N/mm^2. Find the Young's modulus and Poisson's ratio.
23. A circular rod of100mm diameter and 500mm long is subjected to a tensile force of 1000kN. Determine the modulus of rigidity, bulk modulus and change in volume if Poisson's ratio = 0.3 and $E = 2 \times 10^5$ N/mm^2.
24. A bar of 20mm diameter is tested in tension. It is observed that when a load of 37.7kN is applied, the extension measured over a gauge length of 200mm is 0.12mm and contraction in diameter is 0.0036mm. Find Poisson's ratio and elastic constants E, G and K.
25. Two bars A and B are connected by bolt of 25mm diameter as shown in figure. The cross section of bar A is rectangular 25mmx62mm and that of bar B is circular 50mm in diameter. If the bar is subjected to a load of 100kN, calculate the tensile stress in the two bars and shear stress in the bolt.



26. Two MS plates each of 15cm x 1.2cm in section are connected by a 20mm diameter rivets with double riveted lap joint as shown below. Calculate the safe load which can be applied to the plates if the allowable tensile stress in the plate material is 800N/mm^2 and allowable shear stress in the rivet material is 600N/mm^2.