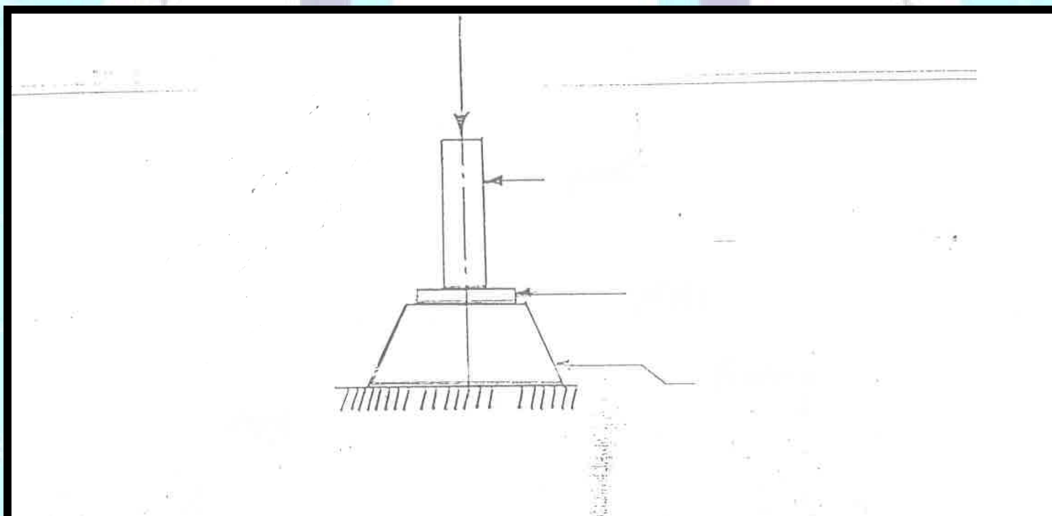
Bearing stress (اجهاد الاسناد او اجهاد التحمل):-

Bearing stress occurs (يحدث) when there is contact (تلامس) between two bodies.

The external applied force(القوة المسلطة) is known as bearing and the contact pressure (ضغط) between the two bodies is known (تعرف) as a bearing stress.

Bearing occurs between the post (عمود) and plate (صفيحة) , plate and footing (الاساس) , and between the footing and the soil (تربة).

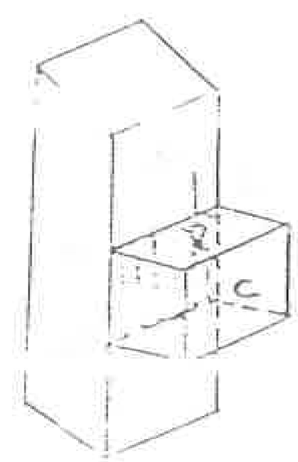
$$Bearing\ stress = \frac{Bearing\ force}{normal\ area\ carrying\ the\ load}$$



Shearing stress (اجهاد القص):-

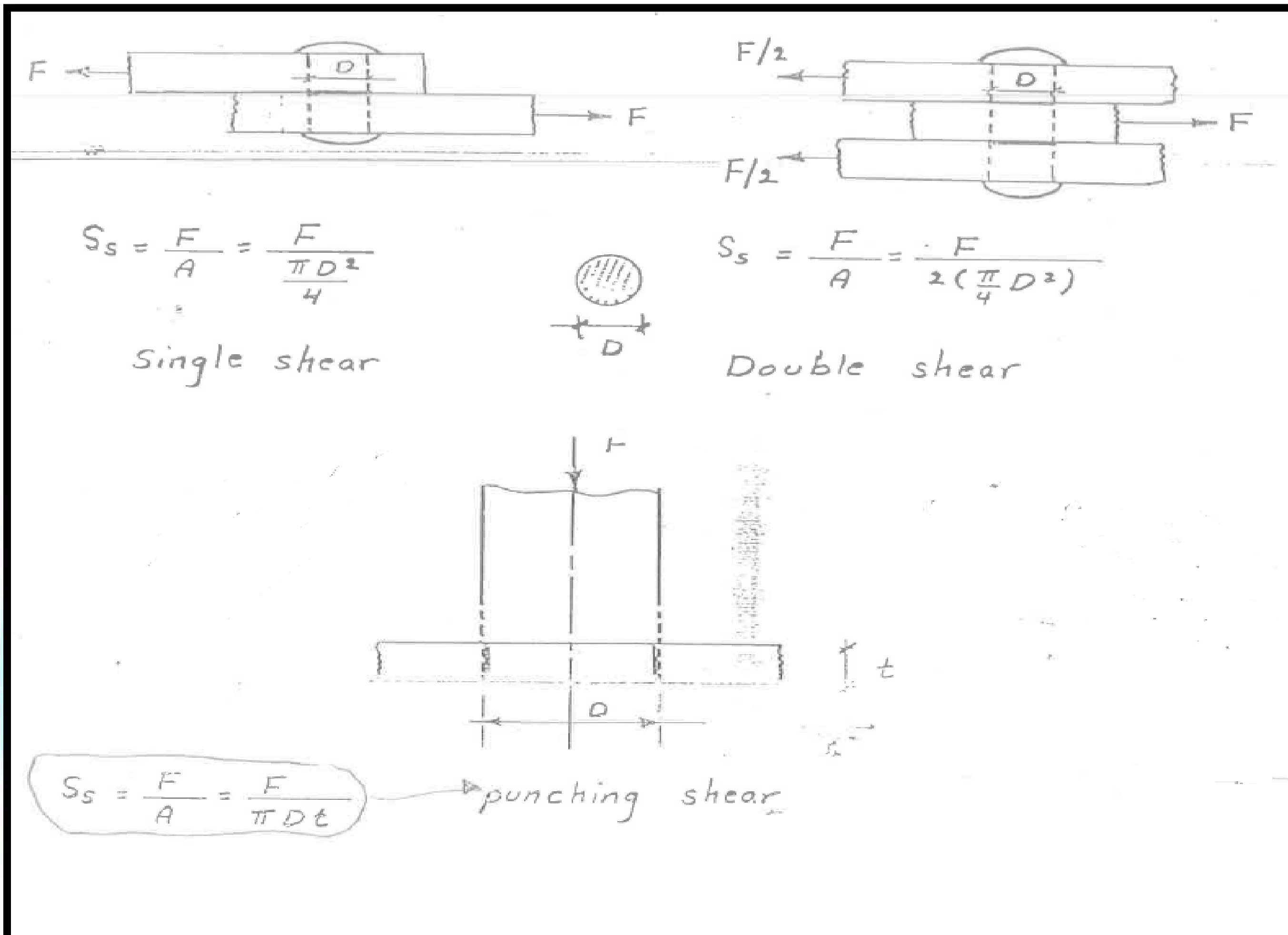
Shearing stresses occur when the force being resisted acts in the plane of the reacting area.

$$Shearing\ stress = \frac{Shearing\ force}{Area\ being\ sheared}$$



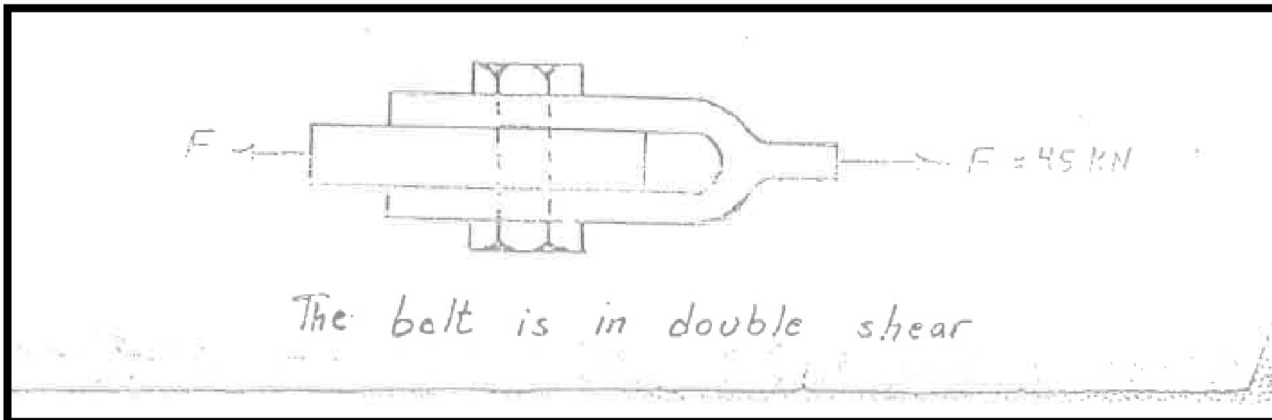
$$Ss = \frac{F}{Area\ (abcd)}$$

Some examples of shearing stresses:-



Example:-

The bar shown in fig. below must carry (يحمل/ينقل) a load of 45 Kn. Calculate the shear stress in the bolt (البرغي) , if the diameter (القطر) =12.5 mm.

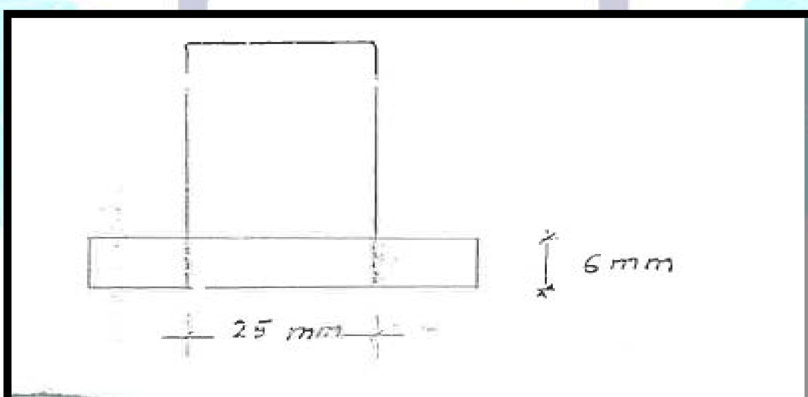


Sol/ The shear area $= 2 \times \left(\frac{\pi}{4} \times D^2\right) = 2 \times \left(\frac{\pi}{4} \times (12.5)^2\right) = 245 \text{ mm}^2$

$$Ss = \frac{F}{A} = \frac{45 \times 1000}{245} = 183.67\ N/mm^2$$

Example (H.W):-

A punch is used to punch (مثقب) a (25mm) dia. Hole (فجوة) in a plate (6mm) thickness (سمك). If the ultimate (أقصى) shearing stress in the material is 345 Mpa .Determine the necessary (ضروري) shearing force.



Deformation (δ) (التشوه):-

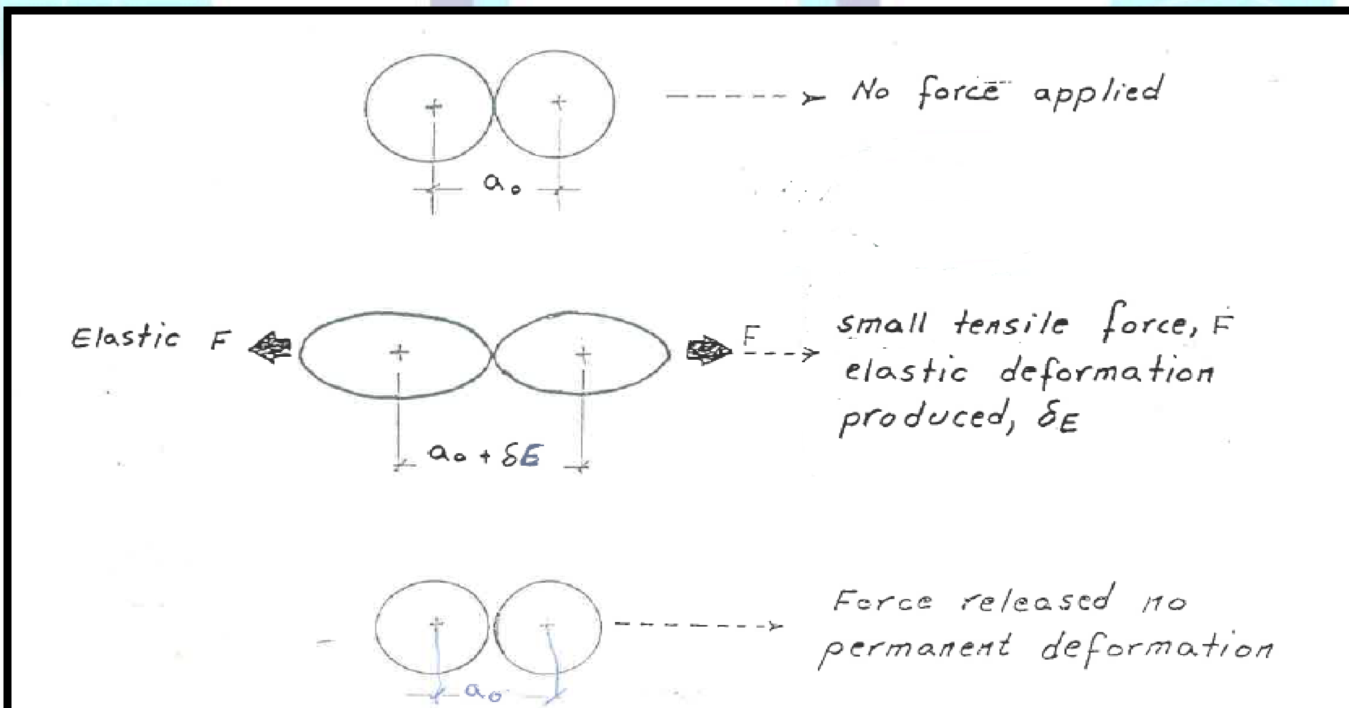
When an engineering material is subjected to force that can change in the shape dimensions .the total change in a dimension due to an applied force is known as deformation (δ) .

Elastic deformation (التشوه المرن):-

If the atoms (ذرات) can resume (تستمر) their equilibrium (التوازن) position (موقع) when the imposed forces (القوى المسلطة) are released (تتحرر), the deformation is called reversible (قابل للعكس) where the body can return (يعود) to it's original state(حالته الاصلية) , recoverable (يسترد) and indicates (يبين / يشير) the relative resistance (المقاومة النسبية) of a material.

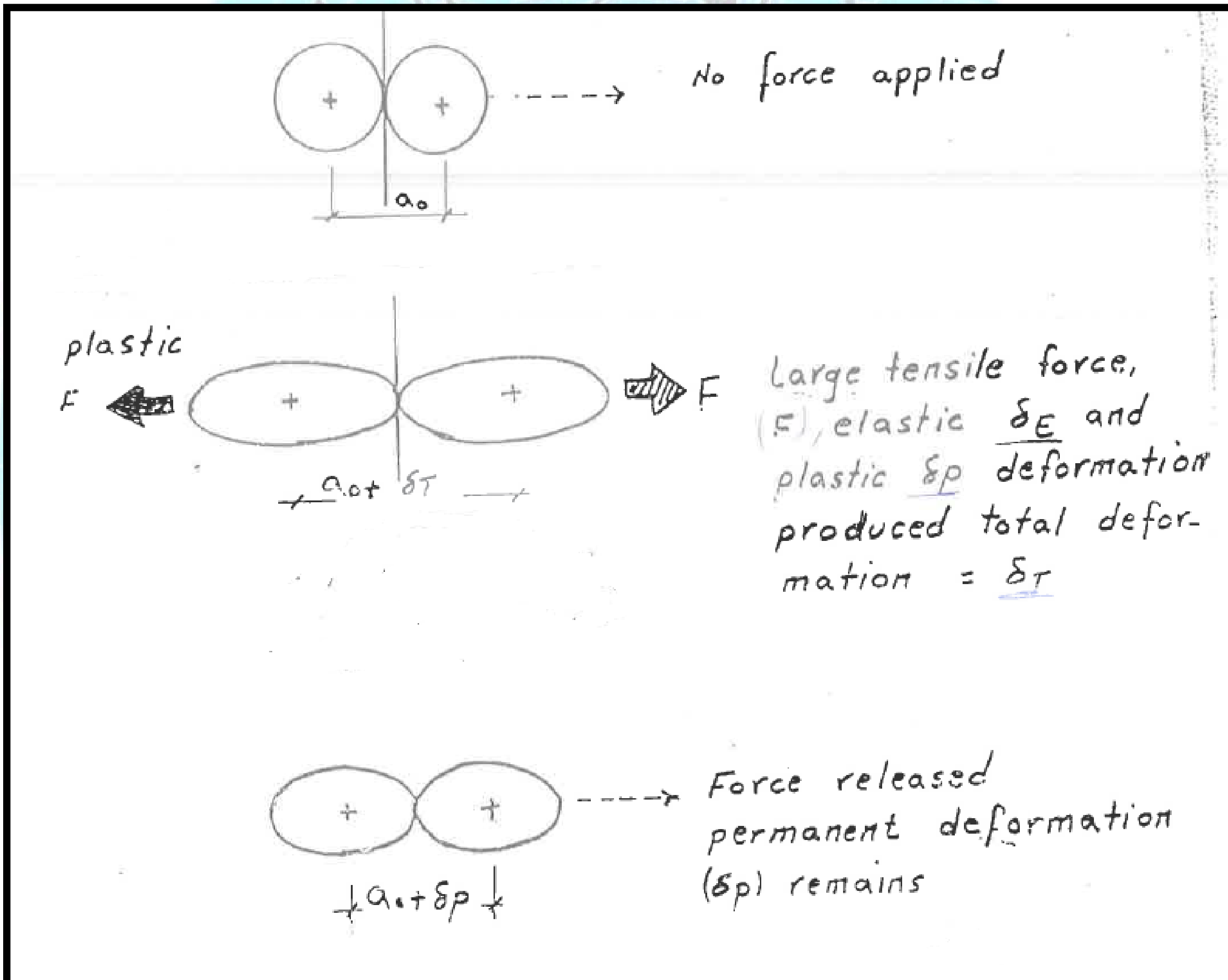
Elasticity:-

Is the property (خاصية) of a material to return to it's initial (ابتدائي) form and dimensions after the deforming forces is removed(تزال) . The process of elastic deformation is presented(تظهر) in fig. below.



Plastic deformation (التشوه اللدن):-

If an engineering material undergoes (تخضع) deformation which exceed (يتجاوز) the elastic capability (الامكانية) (elastic limit) , the deformation is permenant (دائمي) and termed(يدعى) plastic. Plastic deformation is non-recoverable (لا يسترد) and leaves (يترك) the atoms permanently displaced (ازاح) from their original position when the forces are released(تتحرر) .The process of plastic deformation is shown in fig. below.



Strain (Engineering Strain) (الانفعال الهندسي):-

When a member (عضو) is subjected to a tensile or compressive stress , it undergoes a deformation (δ). Tensile stress causes (تسبب) elongation (استطالة) of the body , while compressive stress causes a shortening (تقصير) of the dimension of the body in the direction (اتجاه) of the force.

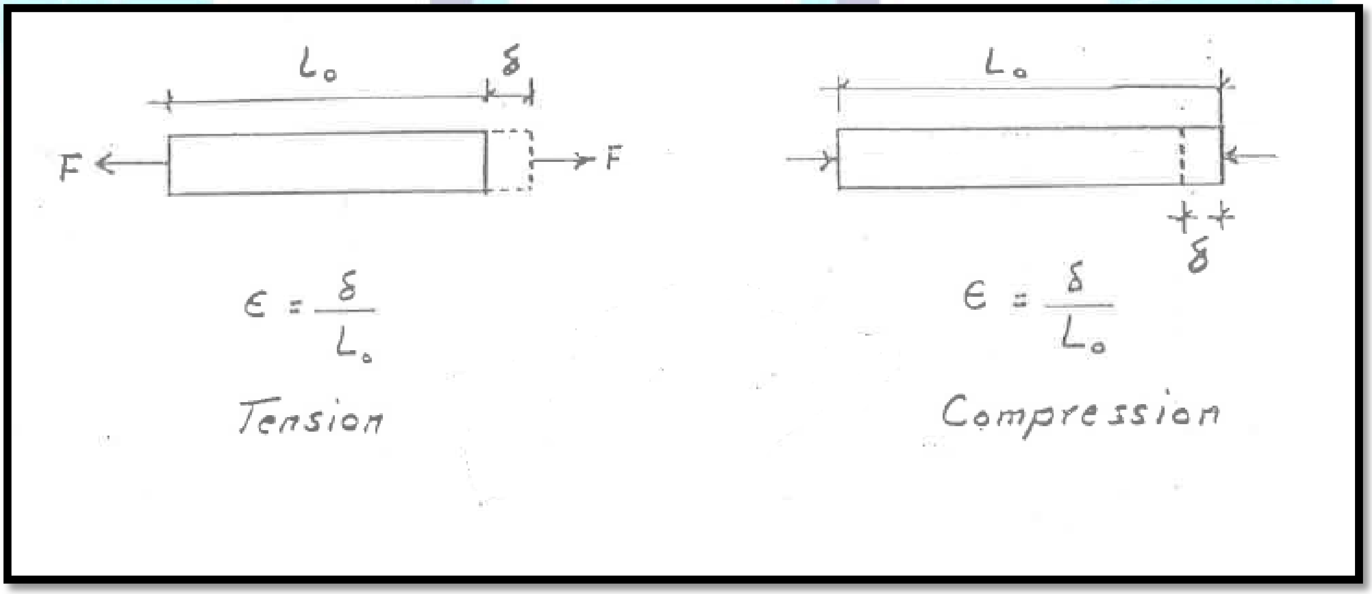
The elongation (or shortening) per unit length is called (Strain (Є)) and expressed as :-

$$Average\ Strain\ \epsilon = \frac{\delta}{L_{\circ}}\ ,\frac{mm}{mm}\ \ dimensionless$$

Where :-

$L_{\circ} = is\ the\ original\ length$

The tensile and compressive strain are shown in fig. below.



The strain at any position is more correctly (بشكل صحيح) named as (True strain) , i.e the ratio of the change in dimensions to the instantaneous(فورا) dimension.

For the bar in tension , $\epsilon_{true} = \frac{dL}{L}$

$$\epsilon_{true} = \int_{L_o}^{L_f} \frac{dL}{L} = \left[\ln L \right]_{L_o}^{L_f}$$

$$= (\ln L_f) - (\ln L_o)$$

$$\epsilon_{true} = \ln \frac{L_f}{L_o}$$

Engineering strain $\epsilon = \frac{L_f - L_o}{L_o}$

$$\epsilon = \frac{L_f}{L_o} - 1$$

$$\frac{L_f}{L_o} = \epsilon + 1$$

$$\boxed{\epsilon_{true} = \ln(\epsilon + 1)}$$

Example:-

A metal rod (100 mm) in length is pulled (سحب) in tension to a length of (102 mm) :-

A- What is the value (قيمة) of the engineering strain produced in the bar ?

B- What is the true strain ?

Sol/

(a) $\delta_L = L_f - L_o = 102 - 100 = 2\ mm$

average strain (engineering strain) (linear strain) $= \frac{\delta}{L_o} = \frac{2\ mm}{100\ mm}$

$= .02\ mm/mm$

(b) true strain $\epsilon_{true} = \ln(\epsilon + 1)$

$= \ln(.02 + 1)$

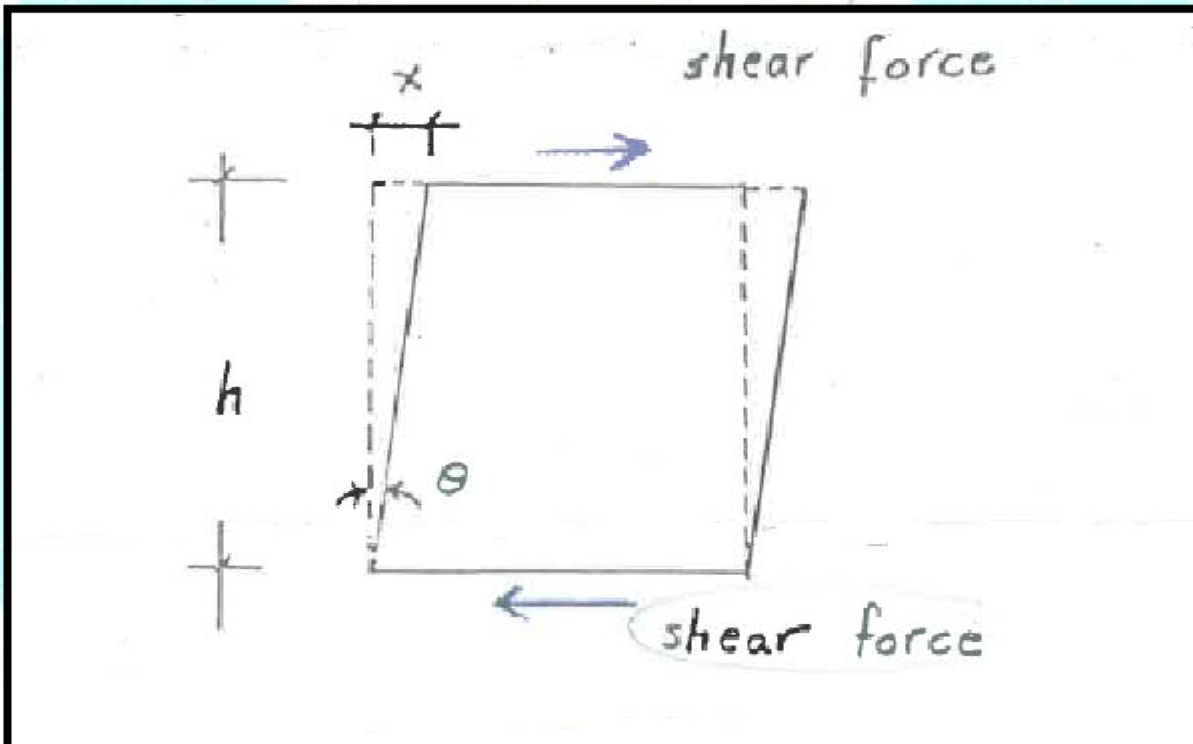
$= \ln 1.02 = 0.0198$

Shear Strain (انفعال القص):-

In the addition to linear strain an engineering material can experience (تعاني / تواجه)

Shear strain (γ) . This type of strain is due to the displacement of parallel planes through a certain angle (Ɵ) as shown in fig. below , Shear strain is defined (يعرف) as (The ratio of displacement (X) to the distance (مسافة) (h) between the planes (مستويات) , expressed as follow:-

$$\gamma = \frac{X}{h} = tan\ \theta$$



In the case (حالة) of elastic strain (Ɵ) is small :-

$$\gamma = tan\ \theta = \theta \qquad in\ radians$$

Hooke's Law (قانون هوك):-

Hooke's law (قانون) states (تبين) that in elastic bodies stress is proportional (متناسب) to strain provided that the elastic limit is not exceeded.

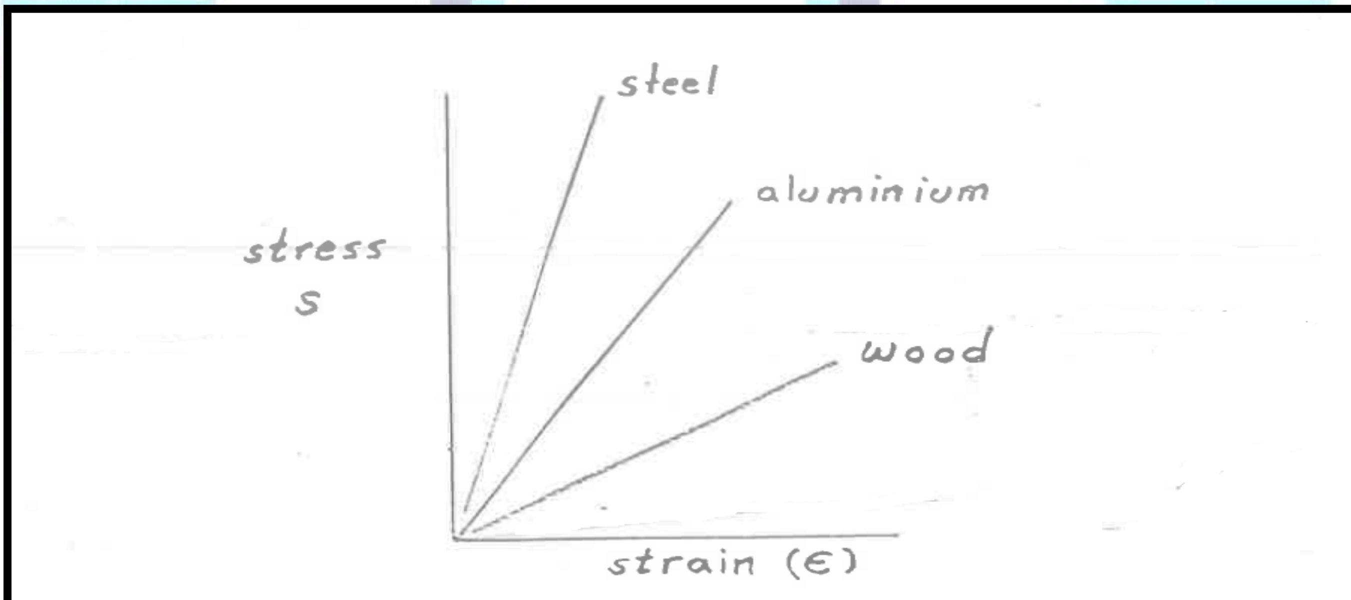
$$s \propto \epsilon$$

$$s = E \times \epsilon \text{ Hooke's law}$$

Where (E) is the constant (ثابت) of proportionality relation (علاقة) stress and strain. It is sometimes known as Young's modulus (معامل يونك) , or more commonly(عادة) the modulus of elasticity(مرونة) , (E) has the same units as (S).

$$\frac{Stress}{Strain} = constant \ (E)$$

Hence , plotting (ارسم) stress against strain gives a straight-line (خط مستقيم) relationship , as shown below for typical materials (مواد نموذجية).



It is sometimes (في بعض الاحيان) more convenient (ملائم) to express (يعبر) hooke's law in terms of the total deformation (δ) , the length of the member (L) , the cross sectional(مساحة المقطع العرضي) area (A) , and the applied load (F).

$$s = E \times \epsilon$$ حفظ

$$\frac{F}{A} = E \times \frac{\delta}{L}$$

$$\delta = \frac{F\,L}{A\,E}$$ حفظ

A similar proportionality (التناسب) exists between shear stress (Ss) and shear strain (γ). It can be written as :-

$$Ss = G \times \gamma$$ حفظ

Where (G) is the shear modulus of elasticity (modulus of rigidity) . The table shown below gives some typical values of (E) for some common materials :-

Material	E , N/mm^2
Steel	210 x 10 ^{3}
Aluminium	70 x 10 ^{3}
Wood	11 x 10 ^{3}
Plastics	1 x 10 ^{3}
Rubber	0.01 x 10 ^{3}

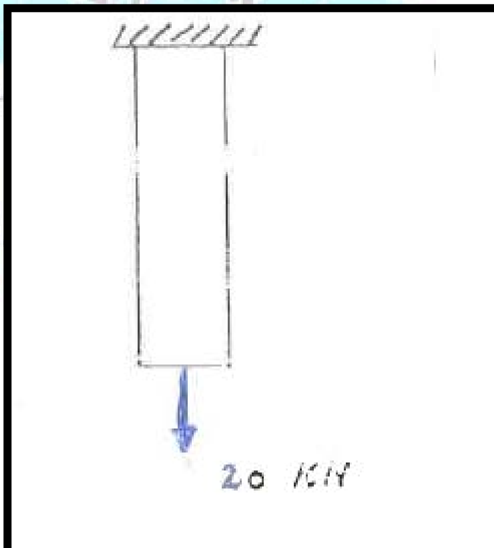
Example:-

A steel rod is used to support (يسند) a weight of (20 Kn). If the allowble stress (الاجهاد المسموح) is (137.895 kn/m^2). Determine the diameter of the rod and its elongation if it is (60.9 cm) long. The modulus of elasticity (معامل المرونة) for steel is (206.85 x 10^6 Kn/m^2).

Sol/

$$D \longrightarrow ?$$

$$\delta \longrightarrow ?$$



$$S = \frac{F}{A} \qquad A = \frac{F}{S}$$

$$A = \frac{20}{137.895} = 0.000145 \text{ m}^2$$

$$A = \frac{\pi}{4} \times (D)^2$$

$$0.000145 = \frac{\pi}{4} \times (D)^2$$

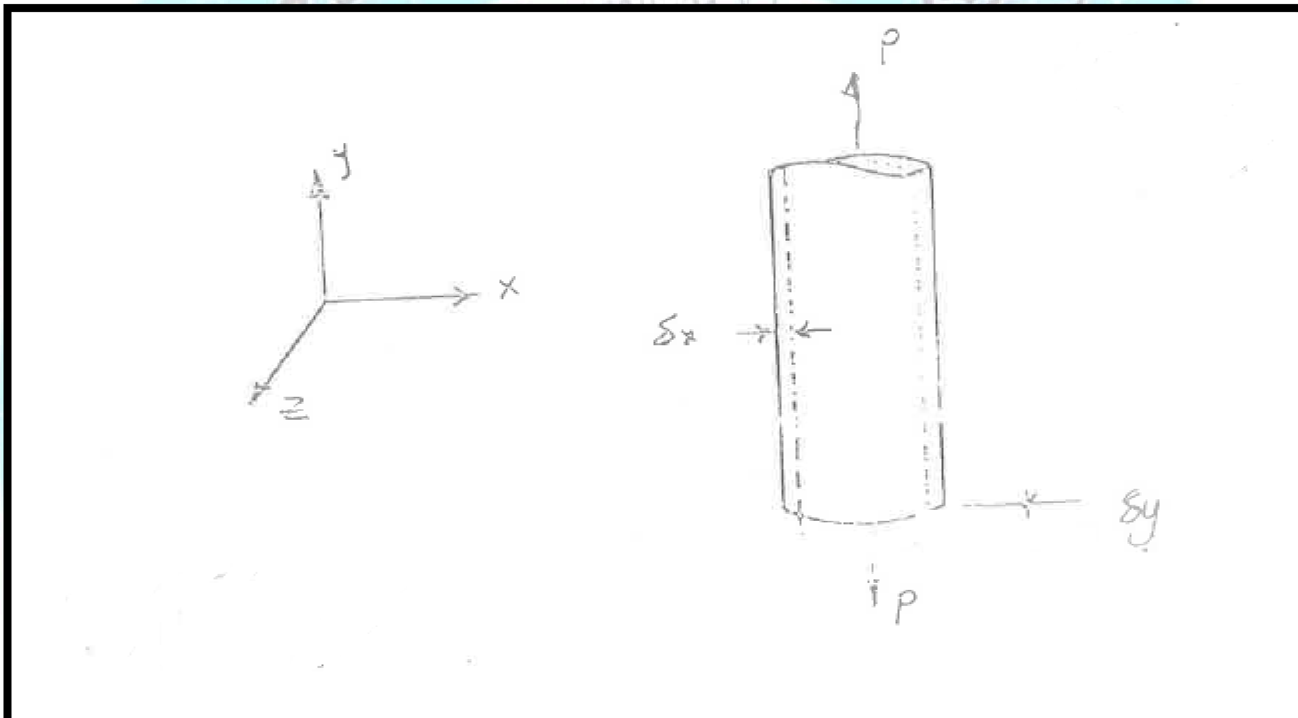
$$\rightarrow D = 0.0135904 \text{ m} = 13.59 \text{ mm}$$

$$\delta = \frac{F\,L}{A\,E} = \frac{20 \times 0.609}{206.85 \times 10^6 \times 0.000145} \times \frac{Kn \times m}{\frac{kn}{m^2} \times m^2}$$

$$\rightarrow \delta = 0.0004061 \text{ m} = 0.4061 \text{ mm}$$

Poisson's Ratio (نسبة بواسون):-

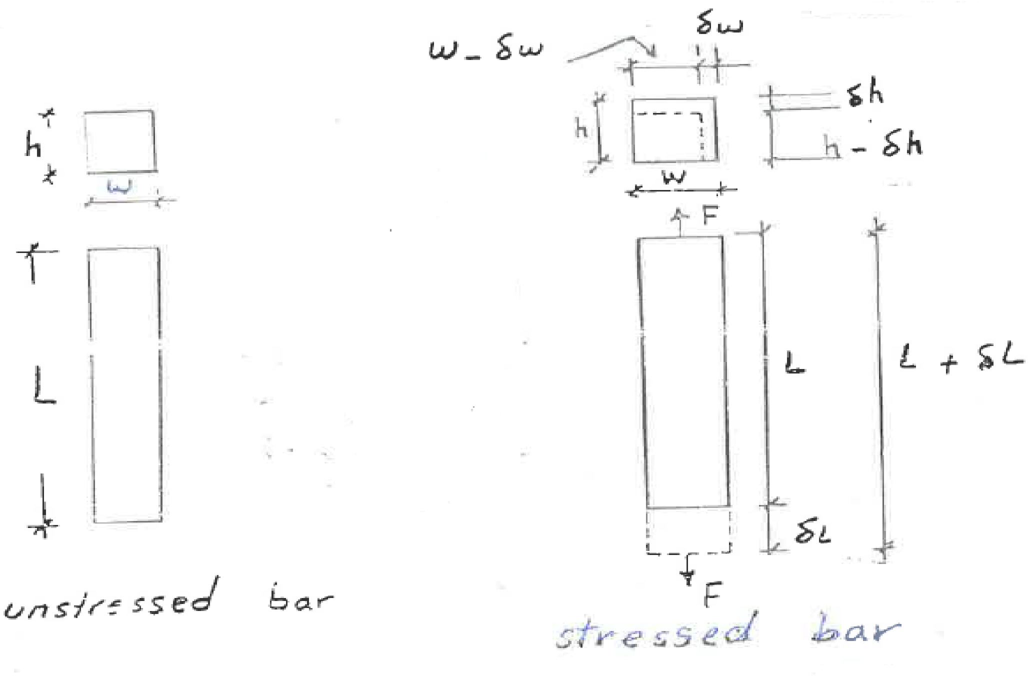
Because of the constancy (ثبات) of volume , when a material is deformed in one direction (تتشوه باتجاه واحد) there is a corresponding displacement (ازاحة مقابلة) or deformation in a direction perpendicular (عمودي) to it.For example , consider the bar in fig. below.If an axial load (P) is applied the bar elongates in the Y-direction .The ratio of the strain in the x-direction to the strain in the Y-direction is termed poisson's ratio (μ) and expressed as follows:-



$$\mu = \frac{\epsilon_x}{\epsilon_y}$$ نسبة بواسون **حفظ**

For symmetry $\epsilon_x = \epsilon_z$ ⇒ μ : is equivalent in X and Z direction.

For a bar of square cross section



$$\mu = \frac{\delta h / h}{\delta L / L} = \frac{\epsilon_h}{\epsilon_L} \rightarrow \text{in } h\text{- direction}$$

$$\mu = \frac{\delta w / w}{\delta L / L} = \frac{\epsilon_w}{\epsilon_L} \rightarrow \text{in } w\text{- direction}$$

Typical values for some materials are given in table below:

Material	μ
Aluminum	0.54
Copper	0.35
Iron	0.28
Carbon steel	0.28

When a body is subjected to stresses in more than one direction , the strain may be found by considering (اعتبار) each stress separately (على حدة) and determining the effect (تاثير) of each stress separately. The total effect is then the algebraic sum of the separate effects with attention (انتباه) to the fact (حقيقة) that by convention (اتفاق) , tension causes positive deformation and compression causes negative deformation.