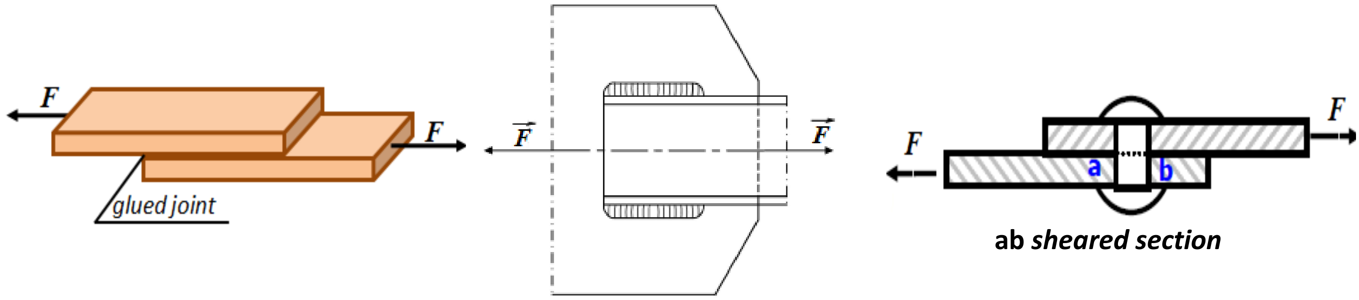
1. Introduction

If a plane is passed through a body, force acting along this plane is called a shear force or shearing force

Figure 1 :

Under the action of these two forces, the two sections 1 and 2 of the bar slide relative to each other in the plane of the straight section (P).
Shear arises in many other practical problems: Figure 2



Gluing assembly **Gluing assembly** **Rivited joint**

Figure 2

2. Stress – Strain Relationship

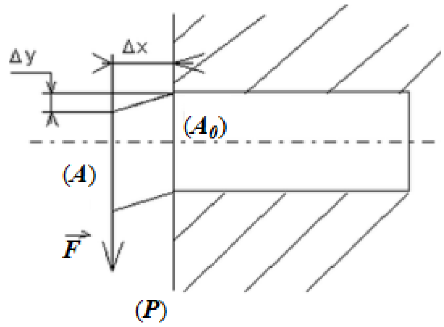
2.1 Shear Stress

The force acting in the plane of the cross section of the bar is called shear force (T). This force is distributed over the section to generate tangential shear stresses (τ). Considering a uniform distribution (τ = constant) (Figure 3), we can define the stress τ in a cross section by the following relationship :

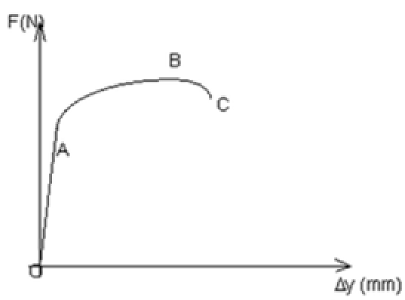
$$\tau = \frac{T}{A} \quad (1) \qquad \begin{cases} T : \text{Shear force en N} \\ A : \text{Shear section mm}^2 \text{ over which } T \text{ acts} \\ \tau : \text{Shera stress or shearing stress N/mm}^2 \end{cases}$$

2.2 Shear test

Under the action of force F, in plane P there is sliding of section A relative to A_0. In zone OA (Figure 3b) the behavior of the material is linear elastic.



(a)



(b)

Figure 3

The deformation γ, called relative slip or deviation (without unit) remains low in the elastic domain; we write: $\gamma = {}^{\Delta y}/_{\Delta x}$.

2.3 Hook's law for shear

In the elastic domain (Figure 3b), the shear stress τ is proportional to the slip angle γ, we then introduce the G modulus shear also known modulus of rigidity such that:

$$\tau = G\gamma \qquad (2) \qquad \begin{cases} \tau : \text{Shear stress N/mm}^2 \\ \gamma : \text{Shear strain in rad} \\ G : \text{Shear modulus in N/mm}^2 \text{or MPa} \end{cases}$$

In reality $\boldsymbol{G}$ is a characteristic of the material which depends on the two elastic constants seen previously, Young's modulus $\boldsymbol{E}$ and Poisson's ratio $\boldsymbol{\nu}$.

$$G = \frac{E}{2(1+\nu)} \qquad (3)$$

Examples of $\boldsymbol{G}$ values

Matrial	Iron	Steel	Copper	Aluminum	Tungsten
E (MPa)	160000	200000	120000	70000	400000
G (Mpa)	64000	80000	48000	28000	160000

3. Shear strength condition

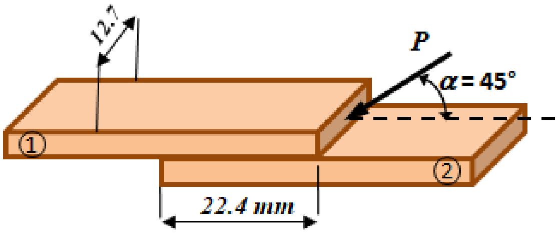
The same reasoning as in tension is used for most constructions. The tangential stress must always remain lower than the admissible shear stress of the material

$$\tau = \frac{T}{A} \leq [\tau] \qquad (4)$$

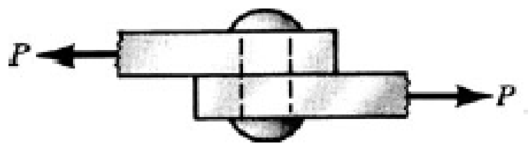
4. Applications

a- Two plates 1 and 2 are glued as shown in Figure 5a. Calculate the average tangential stress due to the force *P = 40kN.*

b- A single rivet is used to join two plates as shown in Figure 5b. If the diameter of the rivet is 20 mm and the load P is 30 kN, what is the average shear stress developed in the rivet?



(a)



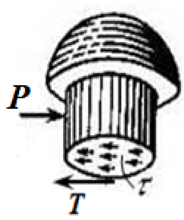
(b)

Figure 5

Solution

a- $\tau = \frac{T}{A} = \frac{P\cos(\propto)}{A} \rightarrow \tau = \frac{2.10^3}{22.4 \times 12.7}$ =**87.88 MPa**

b- $\tau = \frac{T}{A} = \frac{P}{A} \rightarrow \tau = \frac{30000}{(\pi/4)(20mm)^2} = 95\ MPa$



5. Tension – Shear Analogy

Tension		Shear
Normal force : $N = P$	→	Normal force : $T = P$
Normal stress : $\sigma = \frac{P}{A}$ [MPa] *A : Cross section (normal)*	→	Normal stress : $\tau = \frac{T}{A}$ [MPa] *A : Shear section (tangential)*
Normal Strain : $\varepsilon = \frac{\Delta L}{L}$	→	Normal Strain : $\gamma \cong \tan(\gamma)$ *Distortion (sliping)*
Hooke's law : $\sigma = E\,\varepsilon$	→	Hooke's law : $\tau = G\gamma$
Youngs Modulus : E [MPa]	→	Shear Modulus : G [MPa]
Normal strength condition: $\sigma_{\max} \le [\sigma]$	→	Shear strength condition: $\tau_{\max} \le [\tau]$