Mechanics of Materials

OR

Strength of Materials

OR

Mechanics of Solids

OR

Mechanics of structures

OR

Mechanics of Deformable Bodies ie Elastic Bodies.

Topics of Engineering Mechanics wrt Mechanics of Materials →

1) Static Equilibrium equations → Members under static equilibrium.

$$\boxed{\begin{aligned}\Sigma F_x &= 0\\ \Sigma F_y &= 0\\ \Sigma F_z &= 0\end{aligned}}\qquad \boxed{\begin{aligned}\Sigma C_x &= 0\\ \Sigma C_y &= 0\\ \Sigma C_z &= 0\end{aligned}}$$

$$\boxed{\begin{aligned}\Sigma H &= 0\\ \Sigma V &= 0\\ \Sigma M &= 0\end{aligned}}$$

2) Free Body Diagrams (F.B.D.)
3) Resolution of forces
4) Centroid and M.O.I. calculations.
5) Types of supports and calculation of support Reactions.
6) Friction
7) Principle of virtual work
8) Trusses.

* AIM of strength of Material subject is to derive expression for deformation, strain and stress which are develop under different loading conditions by using experimentally obtained elastic properties like young's Modulus and poisson's ratio.

* Ultimate aim of design is to develop a drawing or a plan (ie selection of an appropriate shape, selection of an appropriate material, calculation of appropriate dimensions by using strength of materials equation, selection of manufacturing process details like type of manufacturing, surface finish, limits and fits] in such a way that the resulting component should satisfy, perform its functionality satisfactorily (ie without any failure).

→ A component is said to be failure when it is unable to perform its given functionality satisfactorily.

Assumptions made while deriving Mechanics of Material equations :-

1) Material is assumed to be homogeneous & Isotropic.
2) Material obeys Hooke's law (that is induced deformations, strains, stresses are assumed to be within the elastic region.
3) Member is assumed to be prismatic. (ie cross sectional dimensions remains same throughout the length of the member.
4) Load is assumed to be as static load ie direction and magnitude of the load remains constant with respect to time.
5) Self weight of the components is neglected
6) Member is assumed to be under static equilibrium condition.

Homogeneous & Isotropic Definitions —

1) A material is said to be homogeneous when it exibits same elastic properties at any point in a given direction ie elastic properties are independent of point.
2) A material is said to be isotropic when it exhibits same elastic properties in any direction at a given point ie elastic properties are independent of direction.
3) A material is said to be both homogeneous and isotropic when it exhibits same elastic properties at any point

and in any direction ie elastic properties are independent of both point and direction.

4) Every homogeneous material need not be an isotropic material and vice-versa.

* Anisotropic Material → A material is said to be anisotropic when it exhibits direction dependent elastic properties.

STRESS

Stress is defined as an intensity or a magnitude of an internal resisting force developed at a point under given loading condition.

Pressure	Stress
→ Magnitude of External force.	→ Magnitude of internal resisting force.
→ Pressure always acts normal to the surface.	→ Stress may either acts normal or parallel to the surface.
→ Magnitude of pressure at a point in all directions remains same.	→ Stress varies from plane to plane.
→ Due to pressure, stress is developed.	→ Due to stress, pressure can't be developed.
→ measured by pressure gauges.	→ Stress can't measure.
→ Pressure is scalar quantity.	→ Stress & strain are second order tensor.

Comparison b/w Bending Stress and Shear Stress

Bending stress (σ_b)	Shear stress τ
1) Bending stress (σ_b) acts $\perp$r to the X-s/c of a beam.	1) Shear stress (τ) acts parallel to the X-S/C of a beam.
2) Bending stress varies linearily over the depth of the beam.	2) Shear stress varies parabolically over the depth of the beam.
3) At extreme fibres, bending stress is maximum.	3) At extreme fibres, shear stress is zero.
4) At neutral axis bending stress is zero.	4) At neutral axis, shear stress is non-zero but becomes maximum in circular, square, rectangle, I-sections & T sections.
5) Bending stress distribution consists of two similar triangles for any cross-section of the beam.	5) Shape of shear stress variation varies from X-s/c to X-s/c.

Mohr's circle

→ A graphical representation of normal and shear stresses on any plane inclined to the principal plane.

→ The transformation equations for plane stress can be represented in graphical form by a plot known as Mohr's Circle.

→ This graphical representation is extremely useful because it enables you to vizualize the relationship between the normal and shear stresses acting on various inclined planes at a point in a stressed body.

→ Using Mohr's Circle we can also calculate principal stresses, maximum shear stresses & stresses on inclined planes.

→ In Mohr's circle,
Normal stresses → Abscissa (X-Axis)
Shear stresses → Ordinate (Y-Axis)

→ STEPS TO FOLLOW

1) With the given problem draw the state of stress at a point.
2) Write point A & point B on x & y face respectively in the form of (σ, τ).
3) On the graph paper represent x-axis as normal stress & y axis as shear stress.
4) Locate point A & point B on the graph paper & join them with a straight line.
5) With centre formula – $C\left(\frac{\sigma_x + \sigma_y}{2}, 0\right)$ determine centre & locate it on x-axis.

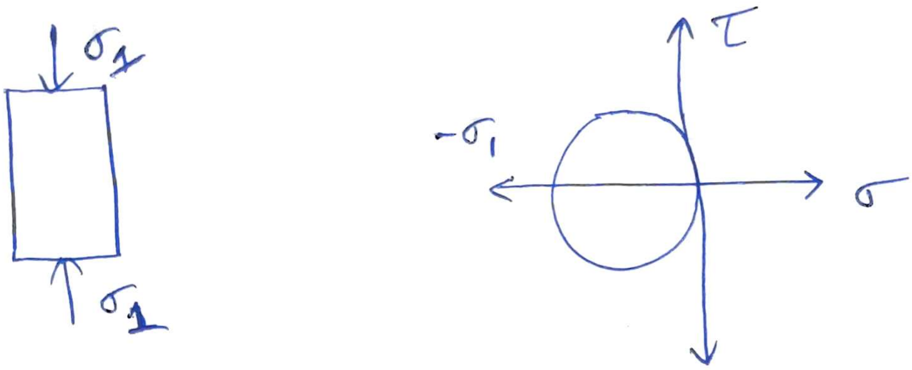
→ With CA line as radius draw the Mohr's circle.

→ Major & Minor principal stress will be obtained on X-axis.

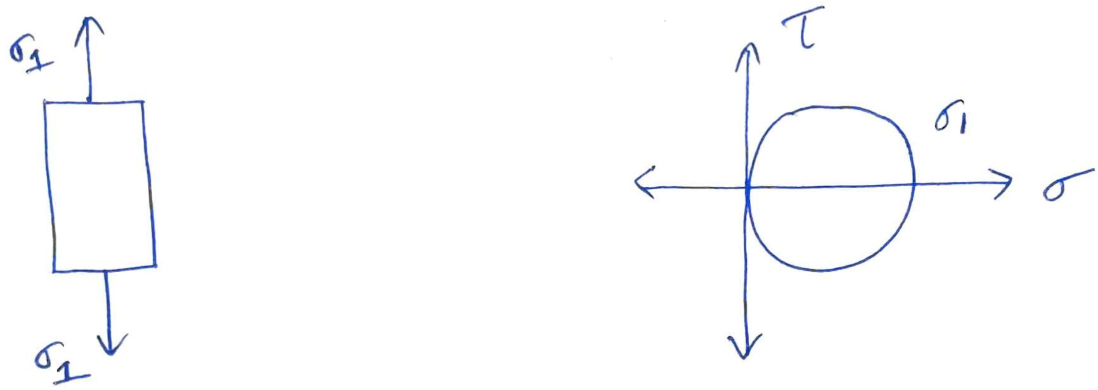
→ Maximum shear stress will be obtained on vertical line from the centre.

MOHR'S CIRCLE FOR SPECIAL STRESS CONDITIONS

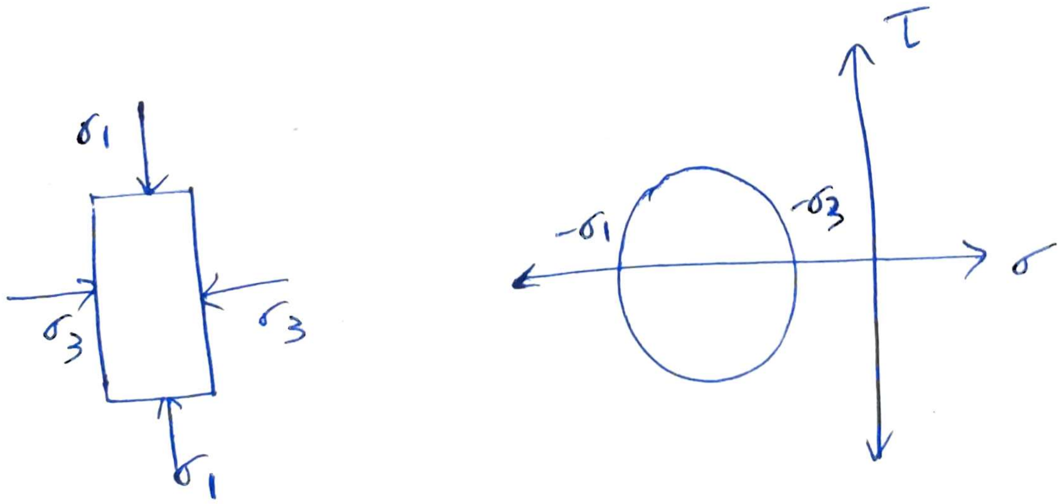
1) Uniaxial compression



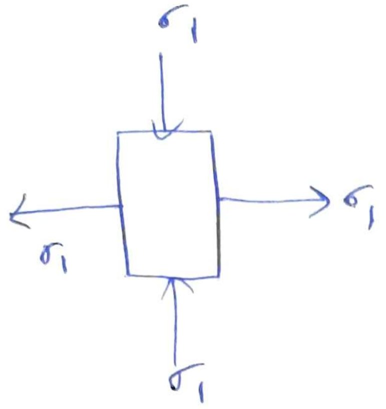
2) Uniaxial Tension

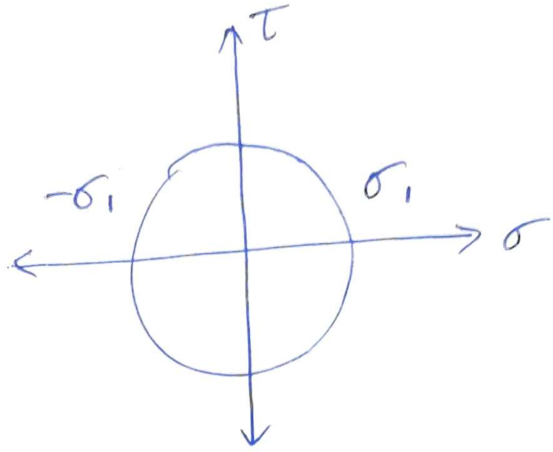


3) Triaxial compression

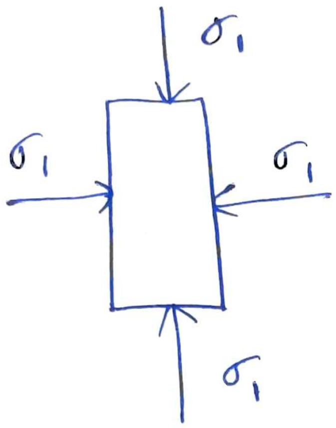


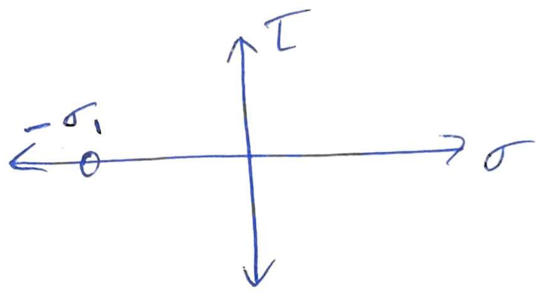
4) Pure shear





5) Hydrostatic condition



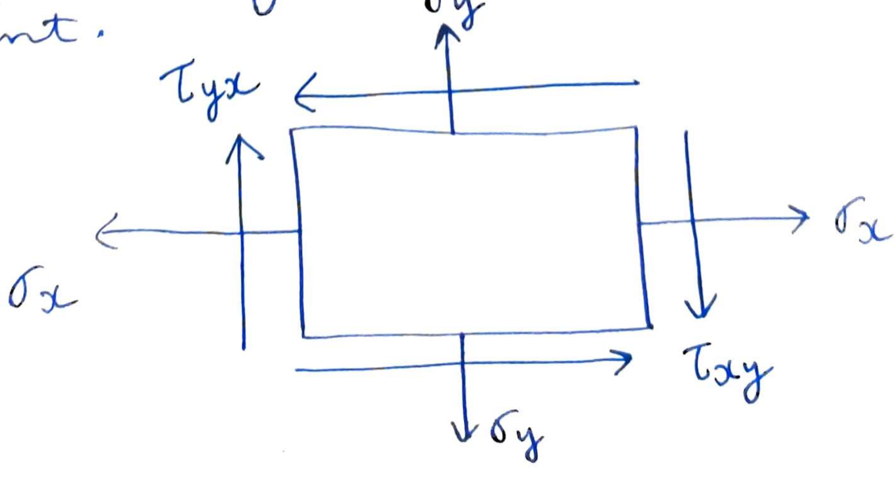


☆ Mohr's circle is named after the famous German civil engineer Otto Christian Mohr (1835–1918), who developed the circle in 1882.

Note → General state of stress at a point is characterized by six independent normal and shear stress components; σ_x, σ_y, σ_z, τ_{xy}, τ_{yz} & τ_{zx}

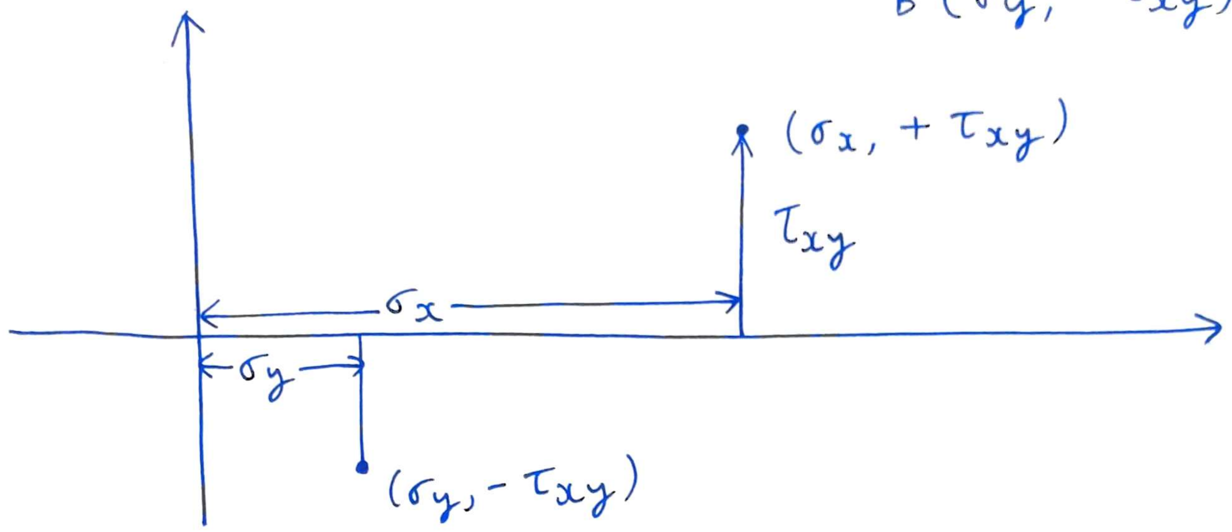
→ General plane stress at a point is represented by σ_x, σ_y and τ_{xy} which act on four faces of the element.

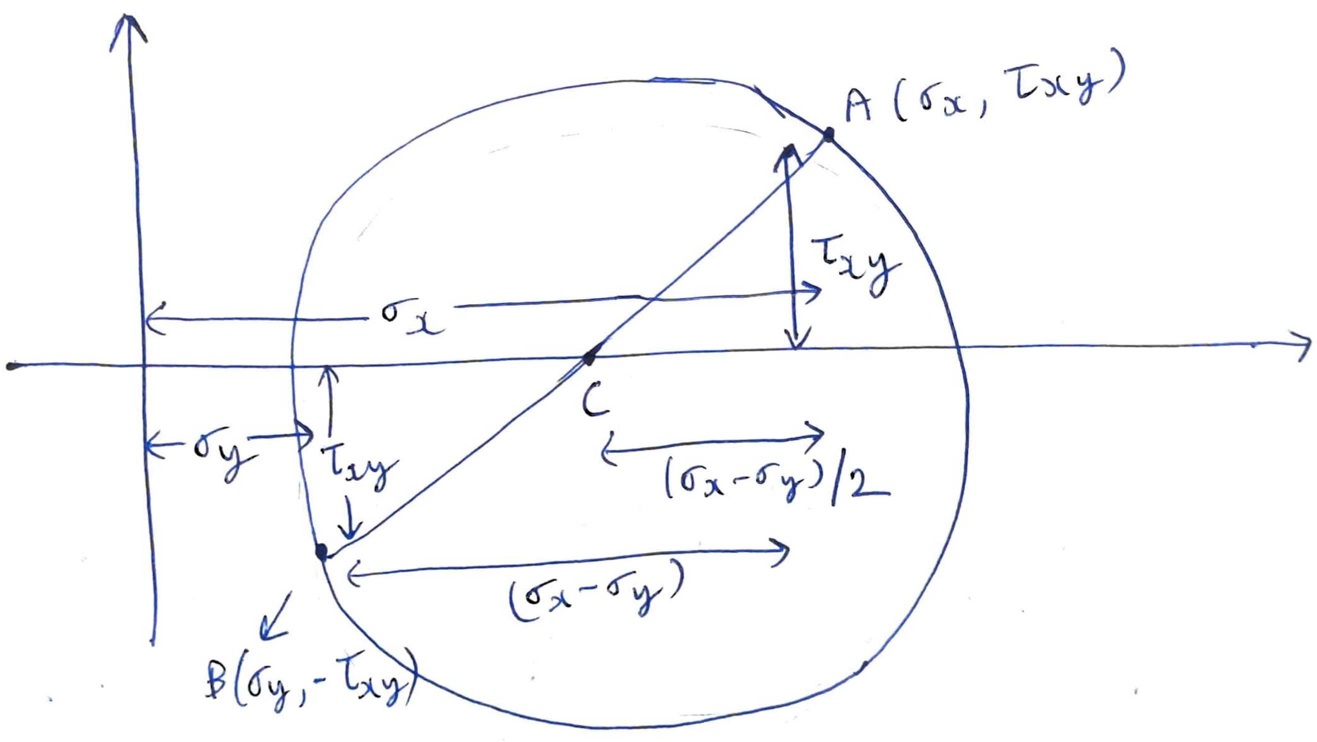
☆



$A(\sigma_x, +\tau_{xy})$

$B(\sigma_y, -\tau_{xy})$





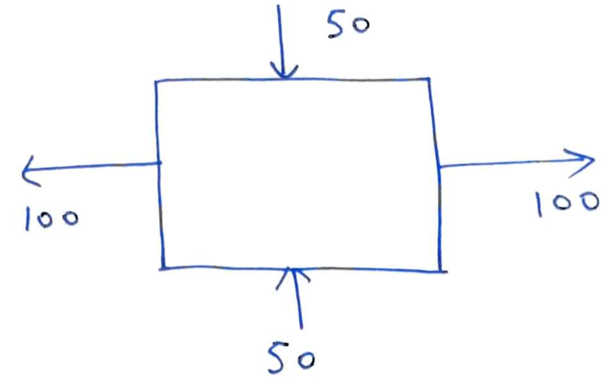
A → vertical plane stresses

CA → shows vertical plane

B → horizontal plane stresses

CB → shows horizontal plane.

Q →



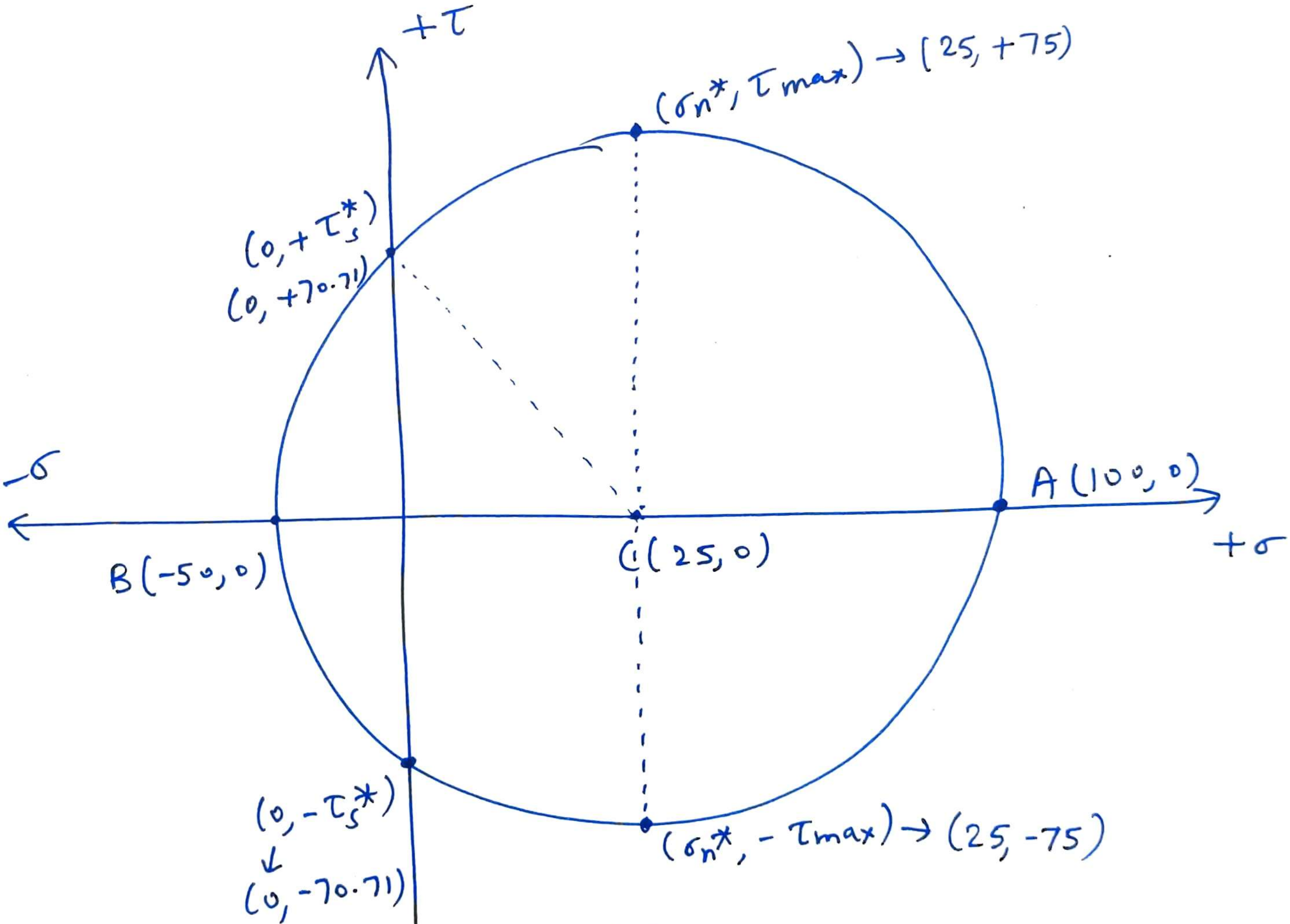
$\sigma_x = 100\ MPa$

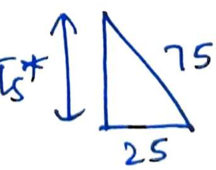
$\sigma_y = -50\ MPa$

$A(\sigma, \tau) = A(100, 0)$

$B(\sigma, \tau) = B(-50, 0)$

$C\left(\frac{\sigma_x + \sigma_y}{2}, 0\right) = C(25, 0)$





$\boxed{\tau_s^* = \pm 70.71}$

* σ_n^* = Normal stress on Maximum shear stress plane.
* τ_s^* = Pure shear stress
* τ_{max} = Maximum shear stress.
* $\sigma_{1,2}$ = Major & Minor principal stress or Maximum & Minimum Normal stress.