جامعة أبو بكر بلقايد
معـهـد العلـوم و الـتـقـنـيـات الـتـطـبـيـقـيـة
UNIVERSITÉ DE TLEMCEN
Institut des Sciences et Techniques Appliquées

BASICS OF STRUCTURAL CALCULATION

BASES DE CALCUL DE STRUCTURES

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DEUXIEME ANNÉE LICENCE GÉOMÈTRE TOPOGRAPHE

Chapter 1

Fundamental of statics

Intitulé	***Bases de calcul des structures***		*Coefficient :* ***3***	**36 heures**		
				CM	*TD*	*TP*
Unité d'enseignement	***Méthodologique 31 (UEM31)***	*Semestre* ***3***	*Crédits :* ***3***	15	12	9
Objectifs	Acquérir les concepts de base de la statique nécessaires à la résolution de systèmes plans isostatiques.					
Compétences visées	• Analyser l'équilibre d'une structure plane ; • Calculer les actions de liaison ; • Déterminer les efforts et de tracer les diagrammes correspondants des structures isostatiques ; • Déterminer les caractéristiques géométriques des sections planes ; • Calculer les contraintes normales.					

Contenu		*Niveau d'acquisition*
	• Calcul et analyse du degré d'hyperstaticité d'une structure plane ;	3
	• Schéma mécanique d'une structure plane ;	3
	• Application du principe fondamental de la statique (PFS) pour le calcul des actions de liaison ;	2
	• Isolation d'un tronçon de poutre et lui appliquer le PFS pour déterminer les efforts internes ;	2
	• Tracé des diagrammes des efforts internes ;	2
	• Détermination de la position du centre de gravité d'une section plane ;	2
	• Détermination du moment quadratique d'une section plane ;	2
	• Calcul des contraintes normales dans une section plane.	2

Introduction to Strength of Materials

- Strength of materials, also known as mechanics of materials, focuses on analyzing the strength, stiffness, and stability of solid materials.

- It deals with the behavior of materials under various forces and moments.

- The subject is crucial in engineering for designing and evaluating structures, machines, and tools.

Introduction to Strength of Materials

- **Strength of materials**, also referred to as **mechanics of materials**, is a field of engineering that focuses on understanding how solid materials respond to various forces. This discipline involves analyzing the **strength**, **stiffness**, and **stability** of materials when subjected to different loads, such as tension, compression, bending, and torsion.

Key aspects include:

- **Strength**: The ability of a material to resist breaking or deformation under applied loads.
- **Stiffness**: A measure of how much a material resists deformation when subjected to a force.
- **Stability**: Ensures that structures maintain their form and do not collapse under load.
- This study is crucial for the design and safety of structures like bridges, buildings, machinery, and vehicles, ensuring they can withstand the forces they encounter in use.

Introduction to Strength of Materials

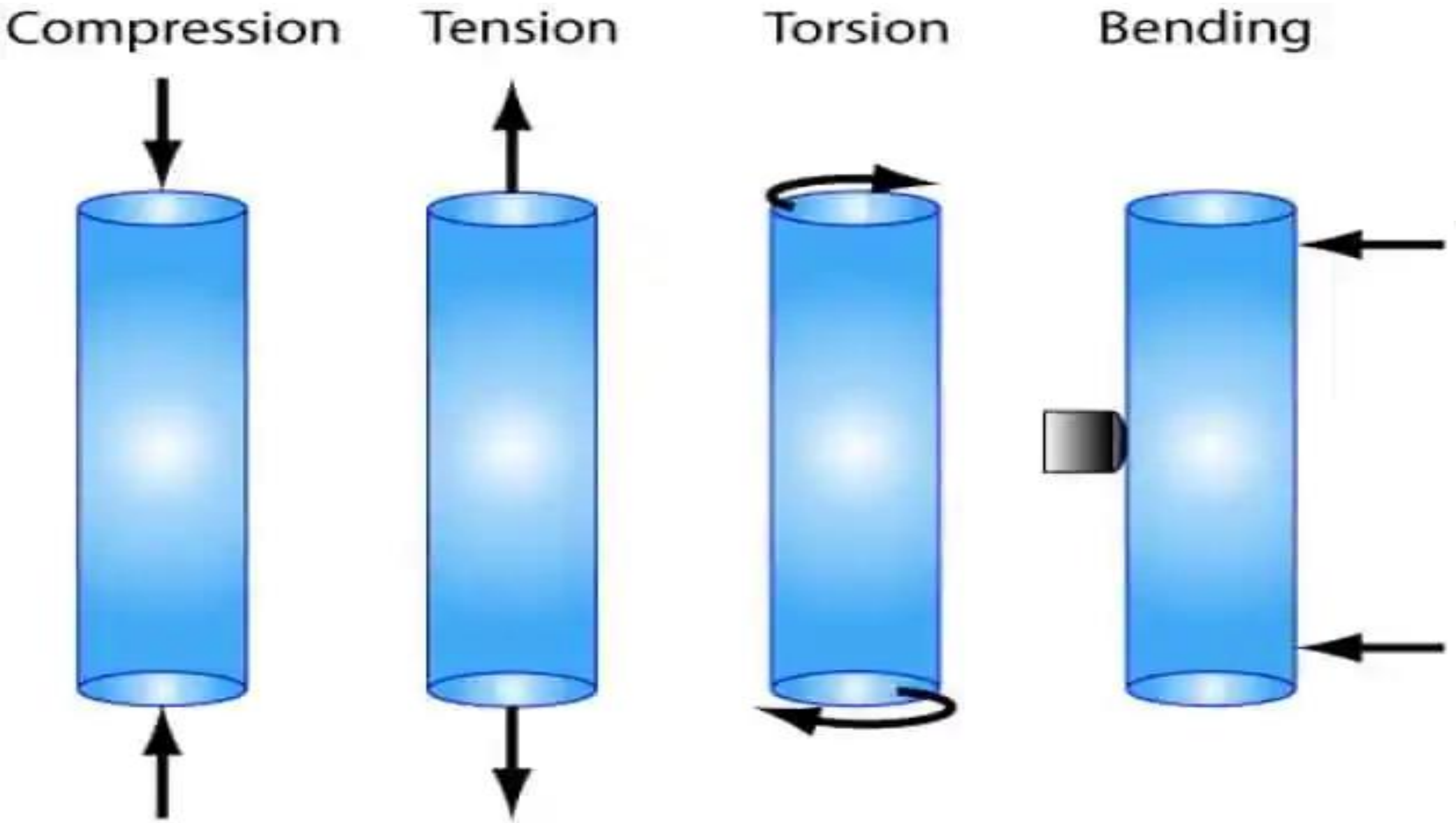
The study of **strength of materials** involves understanding how materials behave when subjected to different **forces** (such as tension, compression, and shear) and **moments** (rotational forces that cause bending or twisting). These external forces and moments create **internal stresses** and **strains** within the material, which can lead to deformation or even failure if the material's limits are exceeded.

Introduction to Strength of Materials

Key aspects include:

- **Tension**: When a material is pulled apart, creating a stretching effect.
- **Compression**: When a material is pushed together, causing it to shorten or compact.
- **Shear**: When forces are applied parallel to a material's surface, causing sliding between layers.
- **Bending moments**: These arise when external forces cause a structure to bend, leading to tensile and compressive stresses on different sides of the material.
- **Torsion**: A twisting moment that produces shear stress, particularly in circular shafts or beams.

Understanding these behaviors allows engineers to predict how materials will perform under different conditions and design structures that can safely support various loads without failure.


Compression
Tension
Torsion
Bending

Introduction to Strength of Materials

The study of **strength of materials** is critical in engineering because it provides the foundation for designing and evaluating the safety and performance of **structures**, **machines**, and **tools**. Engineers rely on this knowledge to ensure that materials can withstand the forces they will encounter in real-world applications without failing or deforming excessively.

Introduction to Strength of Materials

In the context of:

Structures (such as bridges, buildings, and dams), engineers must ensure that materials can support both static and dynamic loads, including the weight of the structure itself and external forces like wind, earthquakes, or traffic.

Machines (such as engines, turbines, or gears) require materials that can handle high stresses and repetitive motion without wearing out or breaking.

Tools and equipment need to be durable and capable of performing under different mechanical stresses to remain functional and safe over time.

By understanding material properties, engineers can optimize designs to improve reliability, efficiency, and cost-effectiveness, ensuring that products and infrastructure perform safely under operational conditions.

Stress and Strain

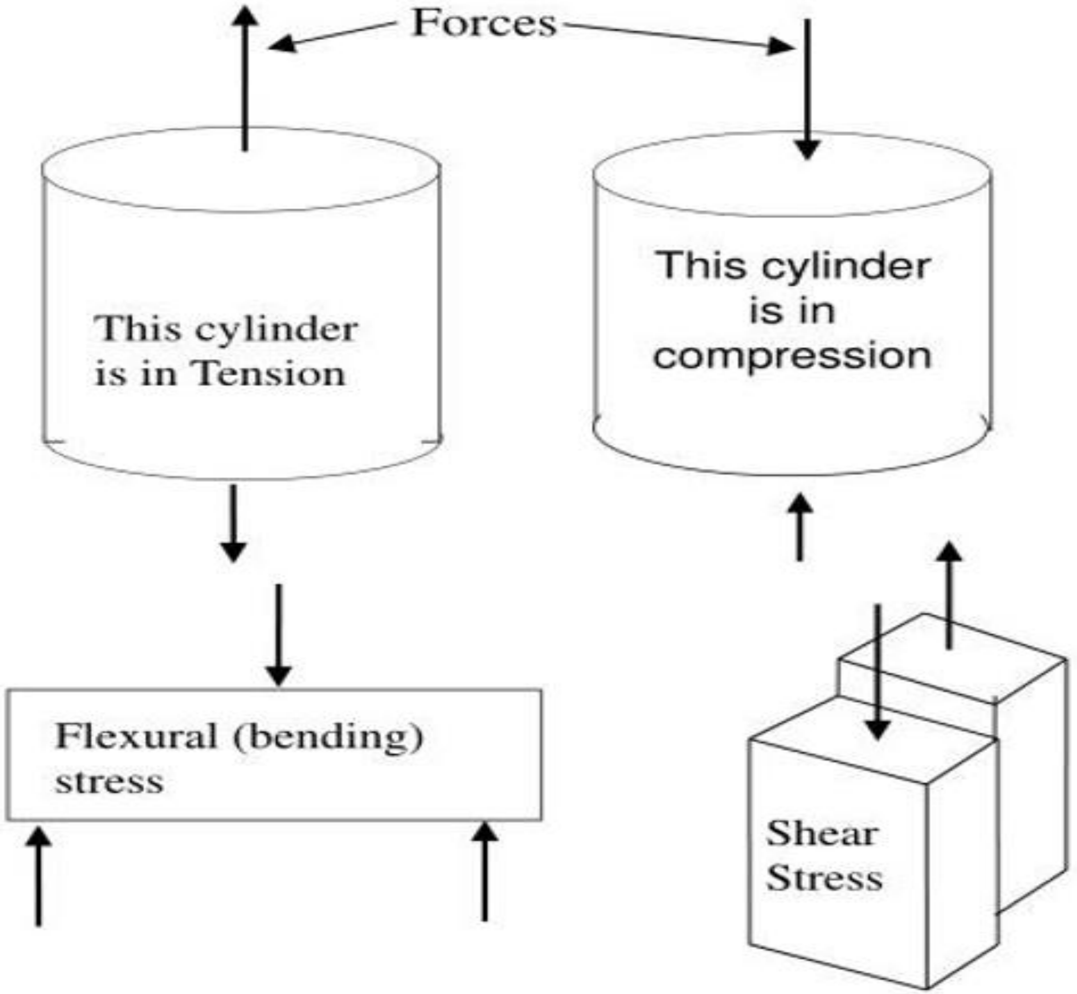
- Stress is the internal force per unit area within materials.

- Strain is the deformation or displacement a material undergoes due to applied forces.

- The relationship between stress and strain determines a material's elasticity and plasticity.

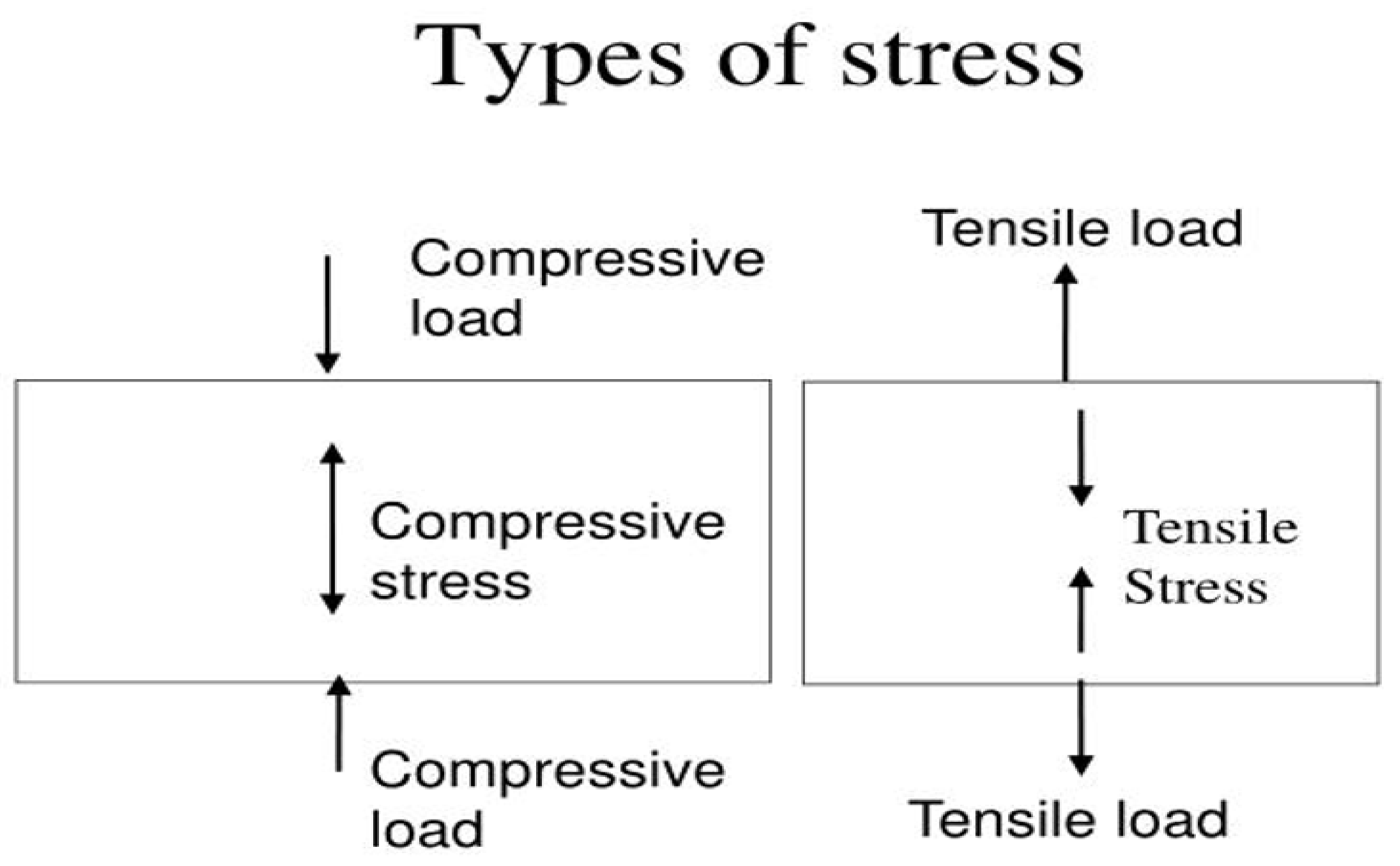
- Stress can be tensile, compressive, or shear.

Stress and Strain



Compression, tension, bending and shear

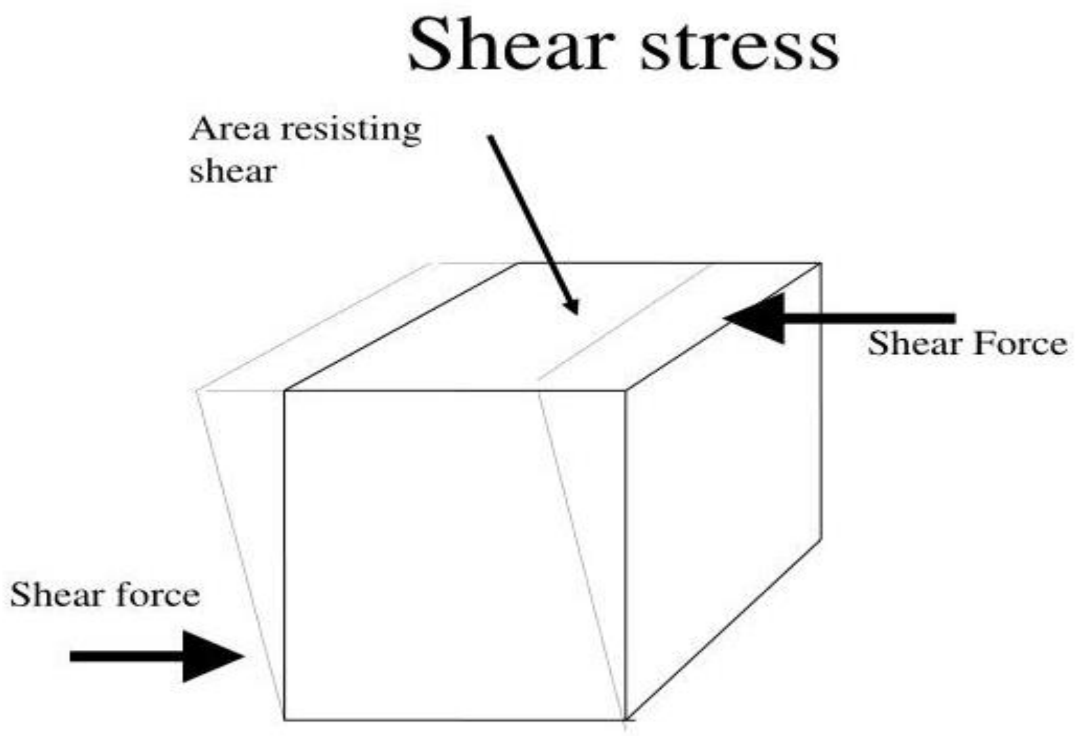
Tensile and compressive Strenght



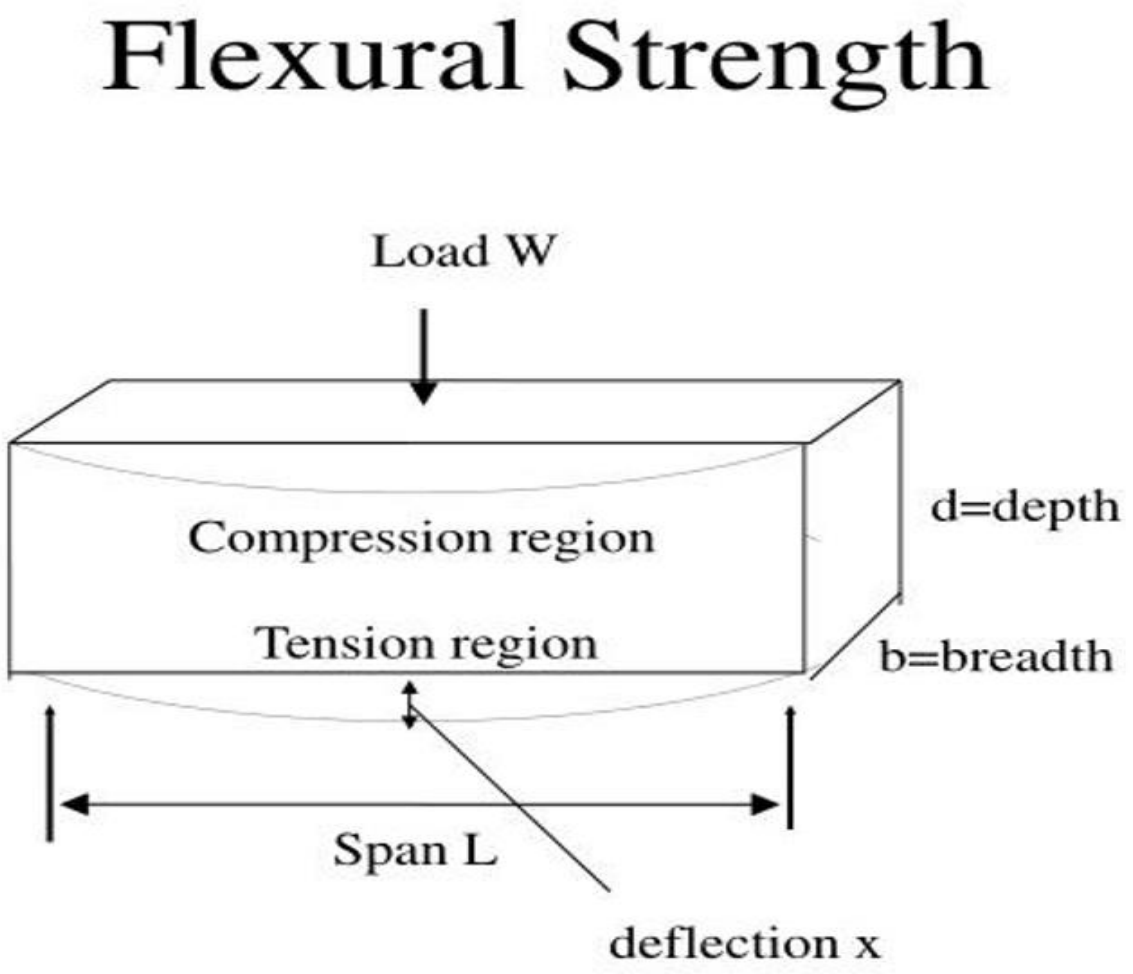
Shear Force and Bending Moment

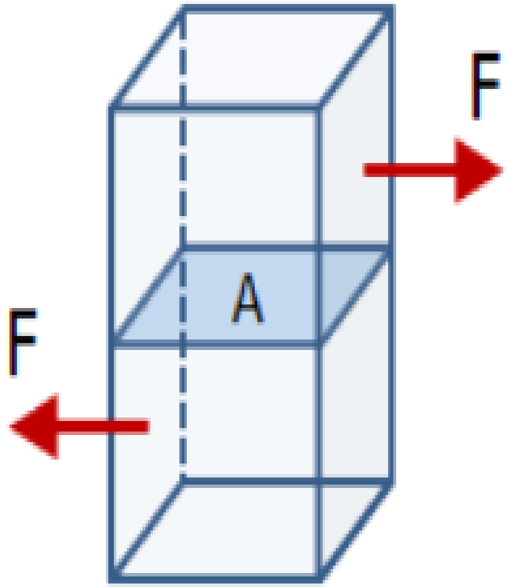
- Shear force refers to the force that acts along a material's cross-section.
- Bending moment is the internal moment that causes a beam or other object to bend.
- Understanding shear force and bending moments is vital for analyzing beams and other structural elements.

Shear Force and Bending Moment

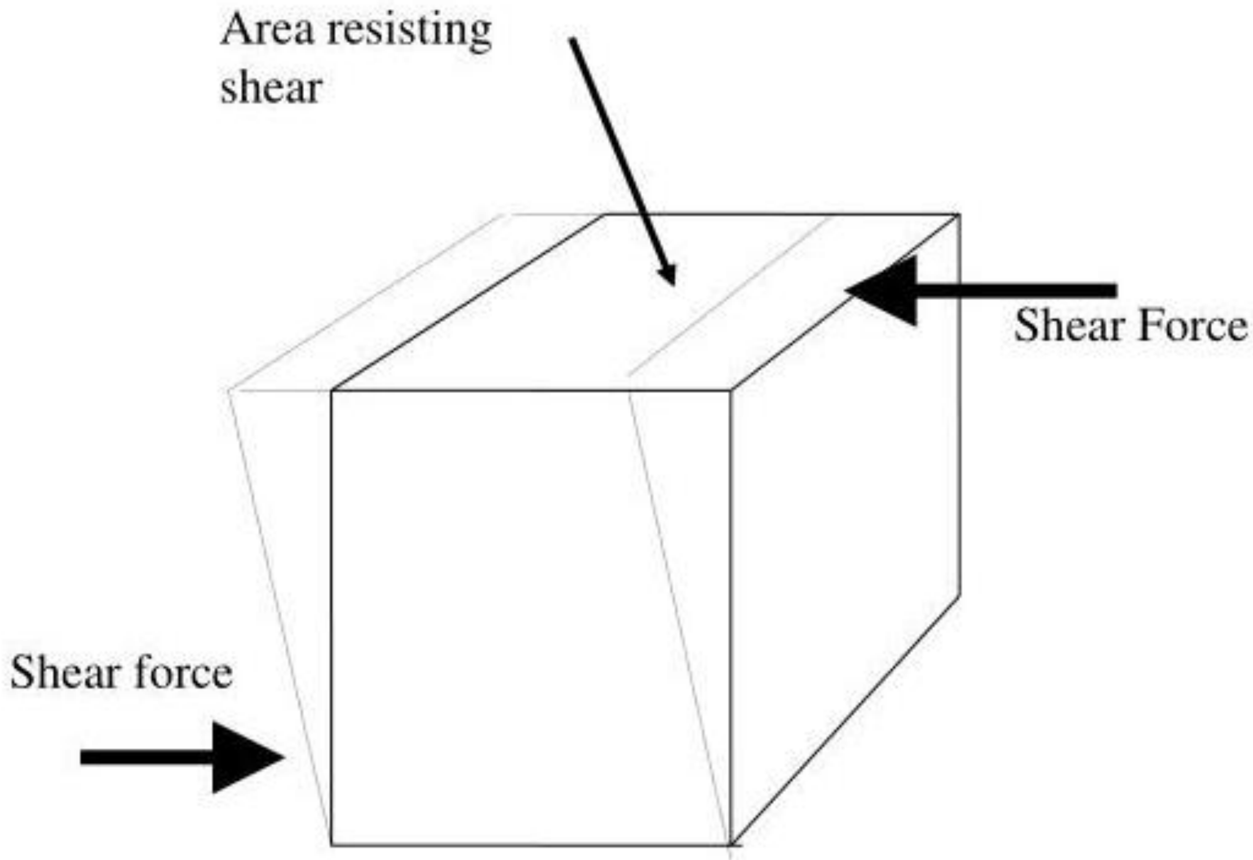


Shear Force and Bending Moment



Shear Force	Transverse Shear Stress	

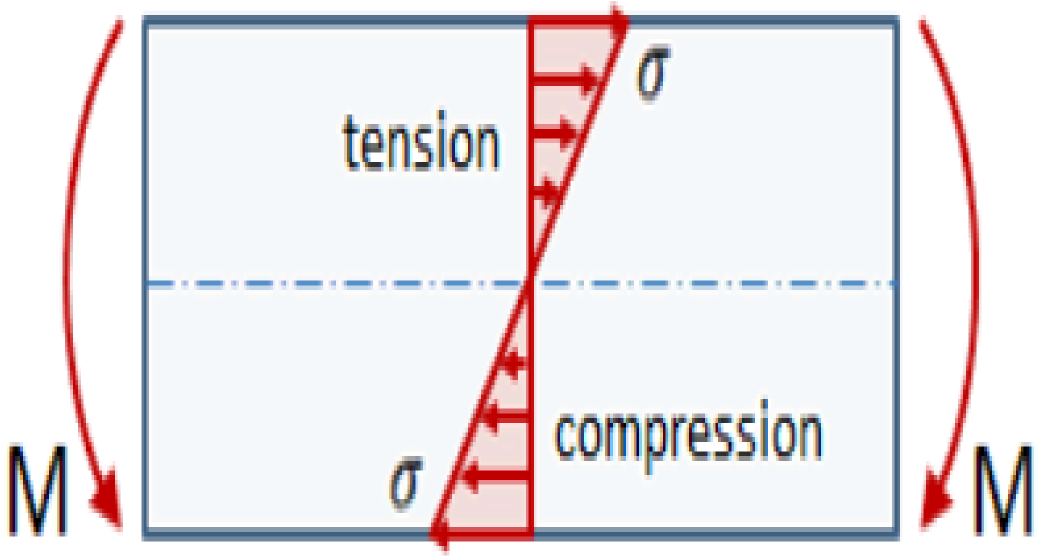
Shear stress



Shear Stress

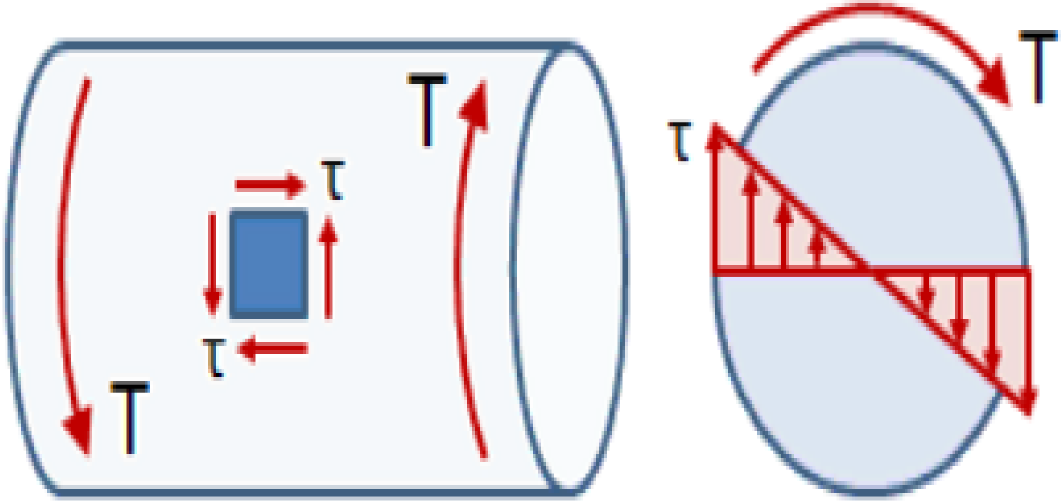
Similarly in shear the shear stress τ is a measure of the internal resistance of a material to an externally applied shear load. The shear stress is defined as:

$$\textit{shear stress} \qquad \tau = \frac{\textit{load } W}{\textit{area resisting shear } A}$$

Bending Moment	Bending Stress	

Torsion in Materials

- Torsion refers to the twisting of a structural member when subjected to torque.
- It produces shear stress over the material's cross-section.
- The torsional stiffness and angle of twist are important factors in torsional analysis.

Torsion	Torsional Stress	

Strain

We must also define **strain**. In engineering this is not a measure of force but is a measure of the deformation produced by the influence of stress. For tensile and compressive loads:

$$\textit{strain} \quad \varepsilon = \frac{\textit{increase in length } x}{\textit{original length } L}$$

Strain is dimensionless, i.e. it is not measured in metres, killogrammes etc.

$$\textit{shear strain} \quad \gamma \approx \frac{\textit{shear displacement } x}{\textit{width } L}$$

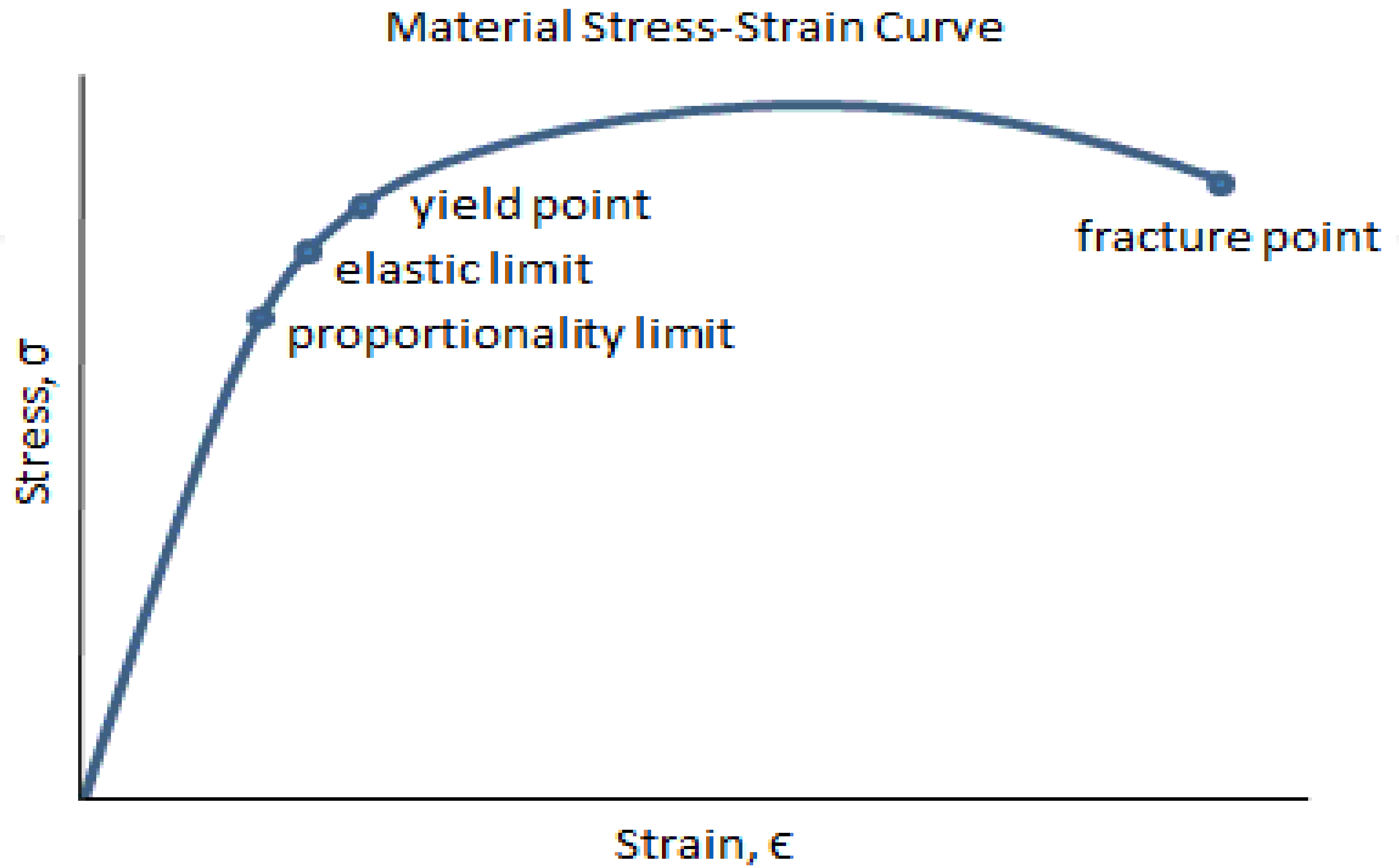
For shear loads the strain is defined as the angle γ This is measured in radians

Elasticity and Plasticity

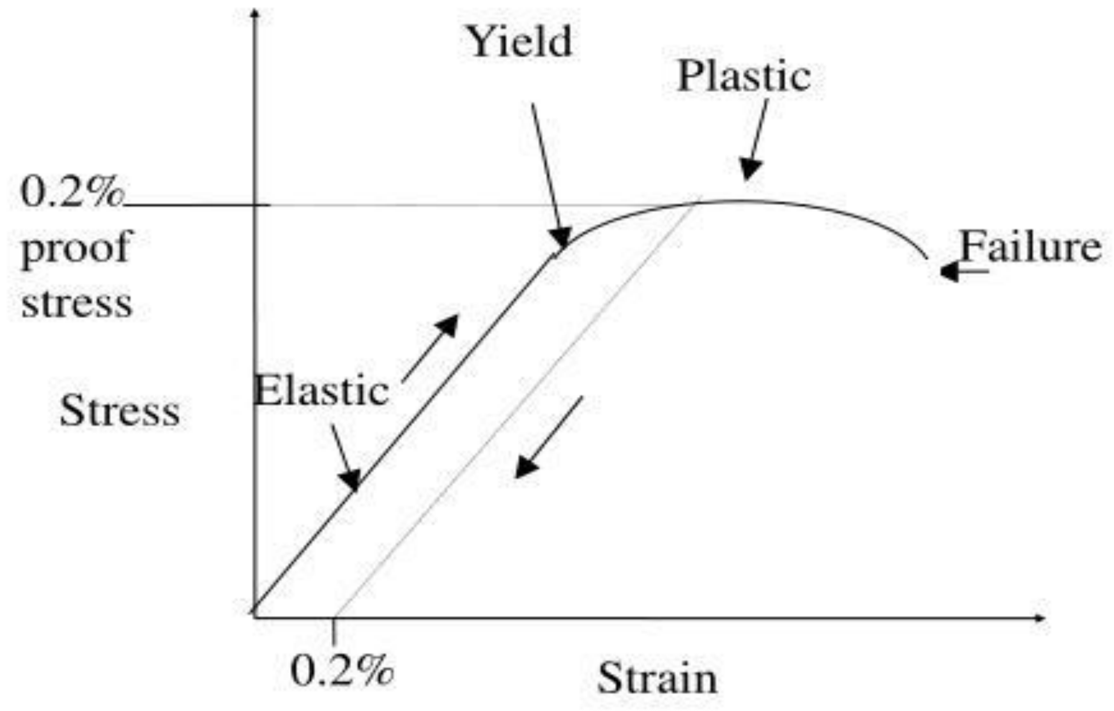
- Elasticity is the property of materials to return to their original shape after deformation when the load is removed.

- Plasticity refers to a material's ability to undergo permanent deformation without breaking.

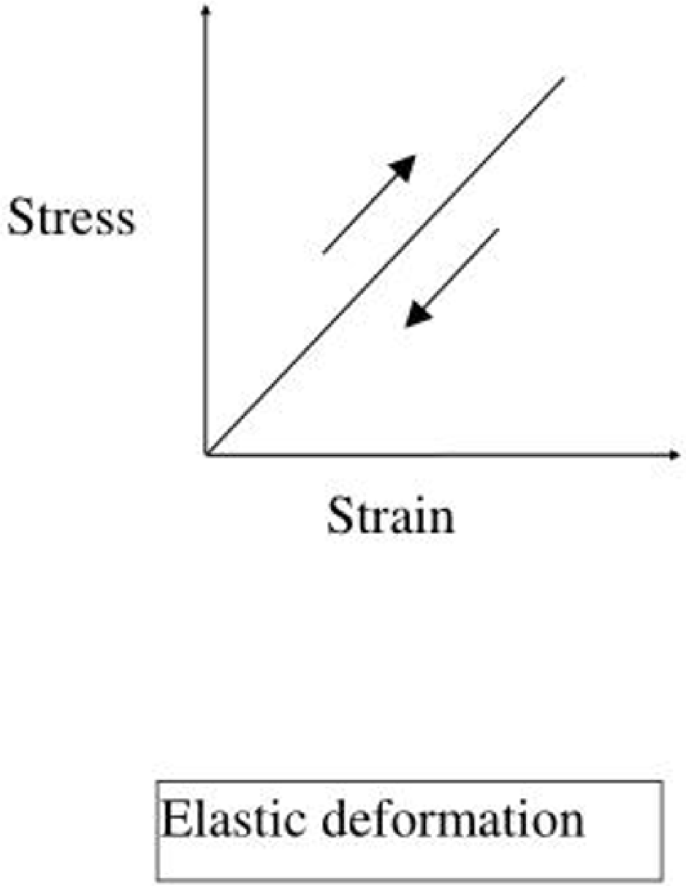
- The elastic limit is the maximum stress a material can endure without permanent deformation.

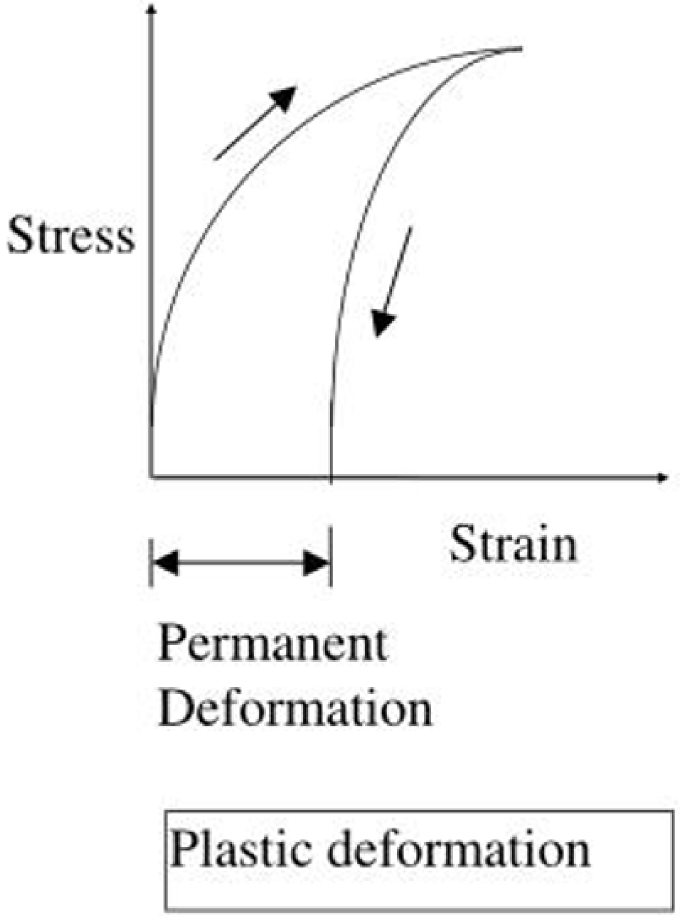

Material Stress-Strain Curve
yield point
elastic limit
proportionality limit
fracture point
Stress, σ
Strain, ϵ

Stress-Strain curve for steel



Elastic and Plastic deformation





Young’s Modulus and Poisson’s Ratio

- Young’s Modulus is a measure of a material’s stiffness and is the ratio of tensile stress to tensile strain.
- Poisson’s Ratio is the ratio of transverse strain to axial strain in a material subjected to axial stress.
- These properties help engineers understand the mechanical behavior of materials.

Young’s Modulus and Poisson’s Ratio

Modulus of Elasticity

If the strain is "elastic" Hooke's law may be used to define

$$\text{Youngs Modulus}\quad E = \frac{\text{Stress}}{\text{Strain}} = \frac{W}{x} \times \frac{L}{A}$$

Young's modulus is also called the modulus of elasticity or stiffness and is a measure of how much strain occurs due to a given stress. Because strain is dimensionless Young's modulus has the units of stress or pressure

Beam Deflection

- Beam deflection refers to the displacement of a beam under a load.

- It is influenced by the beam's material, shape, and the type of load applied.

- Deflection must be controlled to ensure structural integrity and serviceability.

Fatigue and Fracture

- Fatigue occurs when a material is subjected to repeated cycles of stress, leading to weakening and failure.

- Fracture mechanics studies the propagation of cracks in materials.

- Both fatigue and fracture are critical considerations in the design of durable structures.

Applications in Engineering

- Strength of materials is used in designing bridges, buildings, automotive parts, aircraft structures, and machinery.
- Engineers rely on material properties to ensure safety, reliability, and cost-effectiveness in construction.
- Advances in material science continue to enhance the field of strength of materials.

Français	Anglais
Résistance des matériaux	Strength of Materials (SOM)
Contrainte	Stress
Déformation	Strain
Loi de Hooke	Hooke's Law
Module d'Young	Young's modulus
Traction	Tension
Compression	Compression
Flexion	Bending
Cisaillement	Shear
Torsion	Torsion

Structures lab

Testing for strength

Tension and Compression