Strength of Materials

Introduction

- Strength of Materials can be simply defined as the ability of a material to resist the application of force. The effects of dynamic loading are probably the most important practical part of the strength of materials, especially the problem of fatigue.
- The study of Strength of Materials is concerned specifically with the following issues:

Introduction

- **1.** The internal forces of a member caused by the external forces acting on the system.
- **2.** The changes in dimension of a member caused by these forces.
- **3.** The physical properties of the material the member is made of.
- **Static** is the study of the behavior of rigid bodies at rest as external forces act upon them.

Introduction

- Although most of these bodies are not absolutely rigid, **the assumption of rigidity** is valid for the purpose of determining the reactions of the system. Actually, every material will get deformed under a load. Even concrete slabs get microscopically deformed when a person walks on it.
- **External loads** on a structural system create resisting forces within all of the members that form the load path from the load's point of application to the ground beneath the foundation.

Definitions

- The following are basic definitions and equations used to calculate the strength of materials:
- **Stress** is the ratio of applied load to the cross-sectional area of an element in tension or compression and is expressed in pounds per square inch (psi) or N/m2

$$Stress\ (\sigma) = \frac{Load}{Area} = \frac{P}{A}$$

- **Strain (normal):** A measure of the deformation of the material and is dimensionless.

$$Strain\ (\varepsilon) = \frac{Change\ in\ length}{Original\ length} = \frac{\Delta L}{L}$$

- **Modulus of elasticity:** Since stress is proportional to load, and strain is proportional to deformation, this implies that stress is proportional to strain.

$$E = \frac{\sigma}{\varepsilon} = \frac{Stress}{Strain}$$

Definitions

- Hooke's law is the statement of that proportionality. The constant is the modulus of elasticity, Young's or the tensile modulus and is the material's stiffness, If a material obeys Hooke's law, it is elastic.
- **Proportional Limit:** the greatest stress at which a material is capable of sustaining the applied load without deviating from the proportionality of stress to strain

Definitions

- **Ultimate Strength (tensile):** maximum stress a material stands when subjected to an applied load; dividing the load at failure by the original cross-section area determines the value.
- **Elastic Limit:** The point on the stress-strain curve beyond which the material permanently stays deformed after removing the load.
- **Yield Strength:** point at which material exceeds the elastic limit and will not return to its original shape or length if the stress is removed.

Definitions

- **Poisson's ratio:** is the ratio of the lateral to longitudinal strain, a dimensionless constant used for stress and deflection analysis of structures such as beams, plates and rotating discs.

$$\nu = \frac{\textit{lateral strain}}{\textit{longitudinal strain}}$$

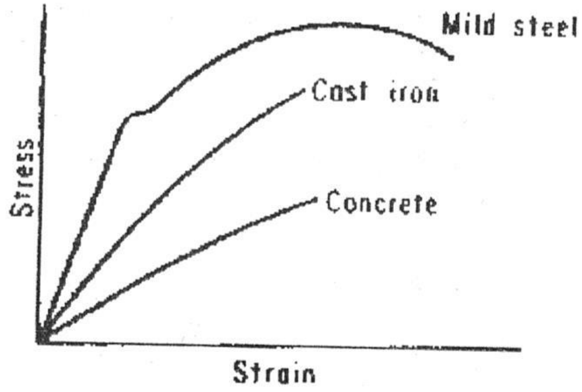
- **Bending stress:** When bending a piece of metal, one surface of the material stretches in tension, while the opposite surface compresses. There is a line or region of zero stress between the two sides of the beam, called neutral axis, where the beam doesn't get compressed neither tensed.

Definitions

- **Yielding:** It occurs when the design stress exceeds the material yield strength. The yield point of a material is defined in engineering as the stress at which a material begins to plastically deform.
- **Fatigue** is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. It is also the maximum stress limit of the material.

Stress-strain curve

- The relationship between the stress and the strain that a material shows is known as a **Stress-Strain Curve**. It is unique for each material and is given by plotting the amount or deformation (strain) at distinct intervals of tensile or compressive loading.



Beams

- A **beam** is a structural member which carries loads; these loads are applied generally perpendicular to its longitudinal axis (the longest side), often they have a rectangular cross-sectional shape, but they can be of any geometry.
- **Beam types** are determined by method of supports, not by method of loading. The beam types: **simple and cantilever**, are statically determinable, meaning that the reactions in the supports, shears and moments can be calculated

Beams

- Continuous beams are statically indeterminate; the internal forces of these beams cannot be found by using the laws of static alone. A number of formulas have been derived to simplify their analysis.
- Two beam loading conditions that either occur independently, or combined are: Concentrated, either a force or a moment can be applied as a concentrated load. Both are applied at a single point along the beam axis; these loads are shown as a “jump” in the shear or moment diagrams. Distributed, these loads can be uniformly or non-uniformly distributed.