Topics for Simulation

1. What is Stress in Engineering?

When designing a structure like a bridge, engineers must make many decisions about which materials to use. One important factor is the **stress** in the different parts of the structure, but what is stress in engineering? Whenever forces are applied to an object, it creates stress within it. This stress results from internal forces within that resist deformation. To visualize these internal forces, imagine making a hypothetical cut that would cut the object in half. Doing so will reveal the internal forces that keep the object together.

Because forces can be applied in different ways, several types of stress can exist within a material. Some of the most common types of stress include tensile stress, compressive stress, shear stress, and torsional stress.

Stress Equation

The stress definition in engineering says that stress is the force applied to an object divided by its cross-section area. Therefore, the applied force must be known to determine the stress within an object. In addition, the cross-sectional area of the object is also important. The cross-sectional area is simply the area of the object that would be measured if it were cut in half.

To calculate engineering stress using the stress equation, divide the applied force (F) by the cross-sectional area (A) of the object.

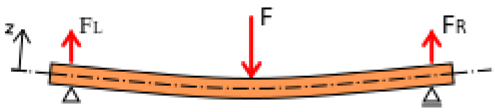
According to the stress equation, stress (σσ) is calculated by dividing the applied force (*F*) by the cross-sectional area (*A*) of the object:

stress=forceareastress=forcearea

σ=FA

Types of Mechanical Stress

Force is typically applied to an object in one of two directions. Axial forces are applied parallel to the major axis of the object and perpendicular to the cross-sectional area. This type of loading can create compressive or tensile stress. Longitudinal forces are applied perpendicularly to the major axis of the object and parallel to the cross-sectional area. Longitudinal forces can create bending or shear stress depending on how the forces are applied.



Three longitudinally applied forces that act on a beam

Axial and longitudinal forces can create six major types of mechanical stress, which are described in more detail below:

- **Compressive stress** results when axially applied forces push inward toward the center of an object. This pushes the molecules that make up the object closer, creating internal stress. Compressive stress typically causes objects to get shorter, although this change in length is minimal for some materials. Compressive stress can also cause buckling, which occurs when an object subjected to a compressive load bends and can, therefore, no longer support the applied load.
- **Tensile stress** results when axially applied forces pull outward on both ends of an object. Tensile stress can cause objects to get longer, such as when a rubber band is stretched. However, some materials, like concrete and ceramic, will not stretch very much but will instead crack when subjected to tensile stress, even though they can withstand a large amount of compressive stress.
- **Shear stress** results when forces are applied longitudinally. The forces on each end must be in opposite directions to create shear stress. Shear stress can cause objects to change their shape or to break. Many things that can withstand a large amount of tensile or compressive stress without breaking cannot withstand the same level of shear stress. For example, bones are very strong in tension and compression but much easier to break when subjected to shear forces.

2. What Does Engineering Strain Mean?

Strain is a deformation measurement that represents the displacement of particles in the body in relation to a reference length. Strain is defined as a change in the shape or size of a body caused by a deforming force.

The strain equation is represented by the Greek letter epsilon (ε).

$$\varepsilon = \text{Change in dimension}/\text{Originaldimension} = \Delta x/x$$

Since strain is a ratio of two similar quantities, it is dimensionless.

Strain Example:

When a body is subjected to a tension force along its length then there develops stress due to which the body experiences a longitudinal strain along the length. Similarly when the same body is subjected to loading in all directions then the body will experience a volumetric strain. If the body is loaded parallel to the axis then shearing occurs which results in shearing strain.

Types of Strain

There are three types of strain:

- Longitudinal strain
- Volumetric strain
- Shearing strain

Longitudinal Strain

The strain produced by a deforming force that only changes length is known as longitudinal strain. The ratio of the change in length to the initial length is used to calculate the longitudinal strain formula.

The longitudinal strain formula physics is given as follows:

$\varepsilon_L L = \text{Change in length}/\text{Original length} = \Delta L/L$

Volumetric Strain

The strain is called volume strain when the deforming force changes volume. The ratio of change in volume to the original volume is used to calculate the volumetric strain formula.

The volumetric strain formula physics is given as follows:

$\varepsilon_v V = \text{Change in volume}/\text{Original volume} = \Delta v/v$

Shearing Strain

Shearing strain occurs when a deforming force causes a change in the shape of the body. It's calculated as the difference between the original location and the displacement of the surface in direct contact with the applied shear stress. Shear strain is represented by the lowercase Greek letter gamma (γ) or Greek letter epsilon (ε).

The shear strain formula physics is given as follows:

$\gamma = \varepsilon_{s}s = \text{Change in volume}/\text{Originalvolume} = \Delta v/v$

3. Deformation

In engineering, deformation refers to the change in size or shape of an object. Displacements are the absolute change in position of a point on the object. Deflection is the relative change in external displacements on an object. Strain is the relative internal change in shape of an infinitesimally small cube of material and can be expressed as a non-dimensional change in length or angle of distortion of the cube. Strains are related to the forces acting on the cube, which are known as stress, by a stress-strain curve. The relationship between stress and strain is generally linear and reversible up until the yield point and the deformation is elastic

Poisson's Ratio - Longitudinal Strain and Lateral Strain

In mechanics, Poisson’s ratio is the negative of the ratio of transverse strain to lateral or axial strain. It is named after Siméon Poisson and denoted by the Greek letter ‘nu’, It is the ratio of the amount of transversal expansion to the amount of axial compression for small values of these changes.

What is Poisson’s Ratio?

Poisson’s ratio is **“the ratio of transverse contraction strain to longitudinal extension strain in the direction of the stretching force.”** Here,

- Compressive deformation is considered negative
- Tensile deformation is considered positive.

Symbol	Greek letter ‘nu’,ν
Formula	Poisson’s ratio = – Lateral strain / Longitudinal strain
Range	-1.0 to +0.5
Units	Unitless quantity
Scalar / Vector	Scalar quantity

Poisson’s Ratio Formula

It will compress in the middle. If the original length and breadth of the rubber are taken as L and B respectively, then when pulled longitudinally, it tends to get compressed laterally. In simple words, length has increased by an amount dL and the breadth has increased by an amount dB.

In this case,

$$\varepsilon_t = -\frac{dB}{B}$$
$$\varepsilon_l = -\frac{dL}{L}$$

The formula for Poisson's ratio is,

$$Poisson's\ ratio = \frac{Transverse\ strain}{Longitudinal\ strain}$$
$$\Rightarrow \nu = -\frac{\varepsilon_t}{\varepsilon_l}$$

where,

ε_t is the Lateral or Transverse Strain

ε_l is the Longitudinal or Axial Strain

ν is the Poisson's Ratio

Poisson's ratio values for different material

It is the ratio of transverse contraction strain to longitudinal extension strain, in the direction of the stretching force. There can be a stress and strain relation that is generated with the application of force on a body.

- For tensile deformation, Poisson's ratio is positive.
- For compressive deformation, it is negative.

Here, the negative Poisson ratio suggests that the material will exhibit a positive strain in the transverse direction, even though the longitudinal strain is positive as well.

For most materials, the value of Poisson's ratio lies in the range, **0 to 0.5.**

A few examples of poisson's ratio are given below for different materials.

Material	**Values**
Concrete	0.1 – 0.2
Cast iron	0.21 – 0.26
Steel	0.27 – 0.30
Rubber	0.4999
Gold	0.42 – 0.44
Glass	0.18 – 0.3

Cork	0.0
Copper	0.33
Clay	0.30 – 0.45
Stainless steel	0.30 – 0.31
Foam	0.10 – 0.50