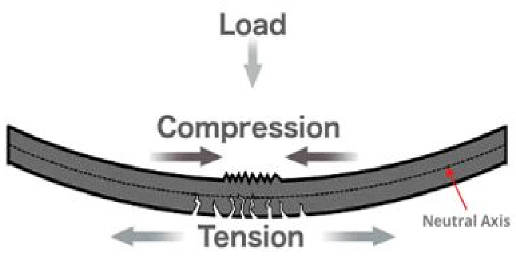
Basic knowledge

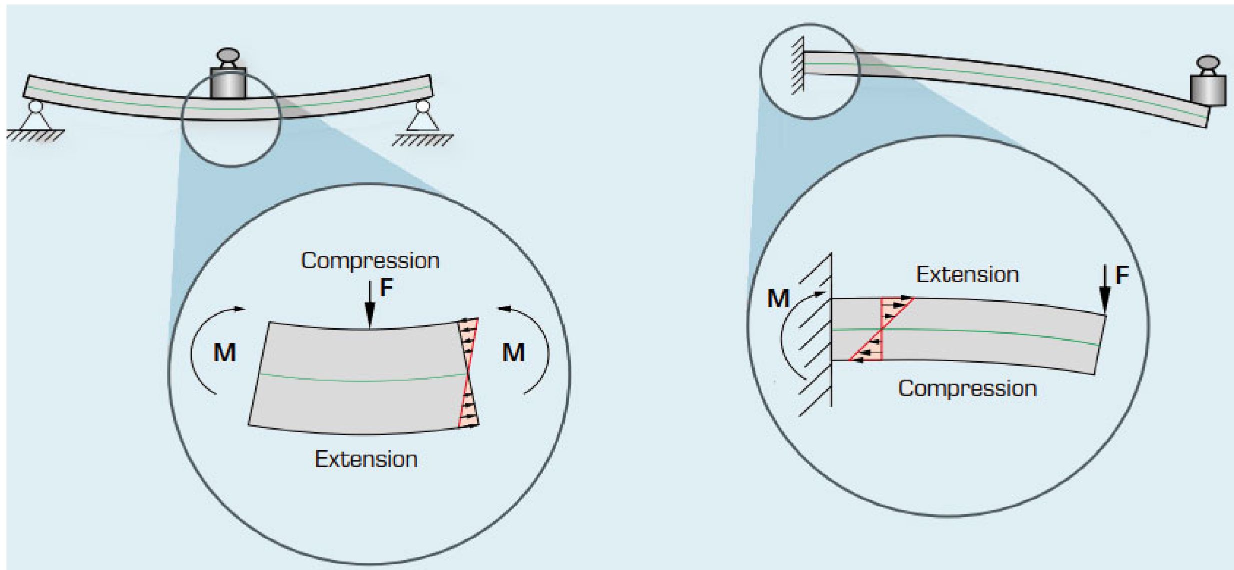
ELASTIC DEFORMATION

Components are differently stressed when subjected to load from external forces. Load causes stresses in the components.
The mesh of the material is deformed under force action, e.g. compressed and stretched. This load leads to volume or shape deformation. Unlike plastic deformation, elastic deformation means that all atoms return to their original position once the force action ends. Different loads lead to typical component deformations.

Deformation of beams

Deflection and load-bearing capacity of beams are extremely important in practice, in structural engineering and bridge building as well as in mechanical and automotive engineering. Deflection depends on the dimensions, material properties and especially on how the beams are mounted at the ends.

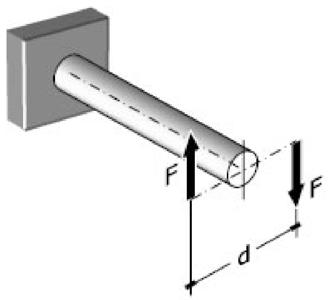


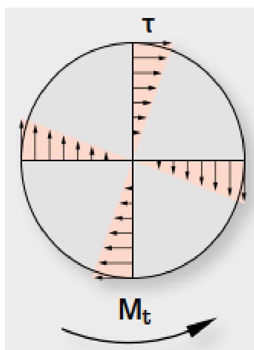


Tensile stress results in the extension of the outer strands, whereas compressive stress results in compression of the outer strands.
The neutral strand (green) passes through the centroid and is neither compressed nor extended.
M moment, F force

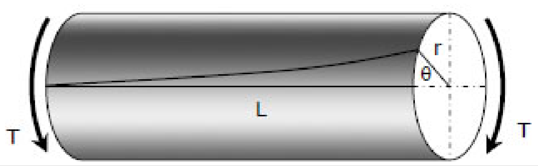
Deformation of bars due to a twisting moment

When subject to a load due to a twisting moment, bars are twisted about their bar axis. The torsional deformation is described by the twisting angle φ. Hooke's law states that the twisting angle φ is proportional to the externally acting twisting moment.





Torsional stress leads to deformation of the bar.



M_t twisting moment, F force, θ twisting angle, τ shear stress

Basic knowledge

ELASTIC DEFORMATION

Determination elastic behaviour

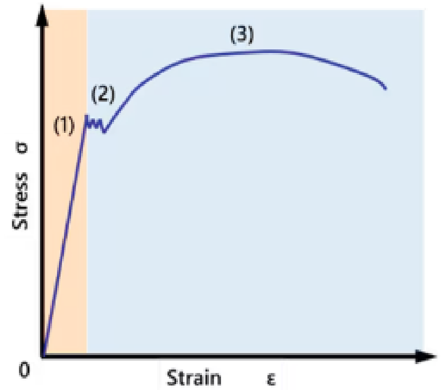
There is direct proportionality between deformation and applied force. Therefore, it is necessary to know the material properties as well as the stress to determine the strain or elastic deformation. These material properties, known as the modulus of elasticity, describe the relation between stress and strain in the deformation of a solid body with linear elastic behaviour. The elastic modulus can be calculated from the measured values of the tensile test or determined graphically from the stress-strain diagram.
In strength of materials, we consider the linear-elastic region, since the deformation of the material is reversible in this region. When designing beams or supporting structures, the linear-elastic region should not be exceeded.

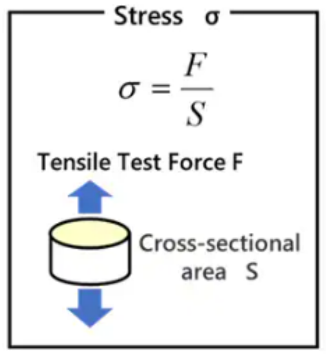
Outline of Stress-Strain Diagrams

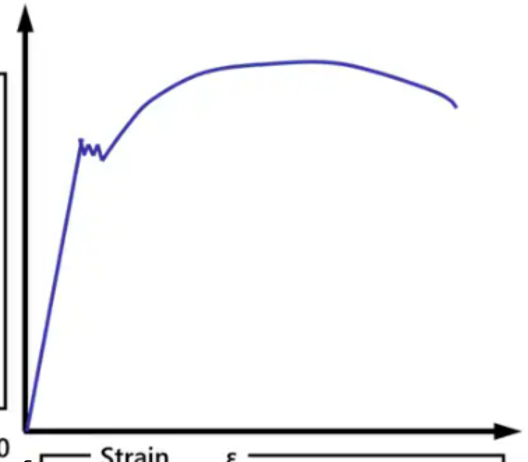
A graph showing the relationship between stress and strain obtained from strength tests is referred to as a stress-strain diagram. The horizontal axis of this diagram shows strain, the ratio of material deformation, and the vertical axis shows stress, the test force per unit area of material.

The diagram below shows a schematic diagram obtained from a tensile test of a steel material. As the test piece is stretched, the relationship between stress and strain is as follows.

1. Linearly increasing at first
2. Yield at a certain point
3. Non-linear curve.

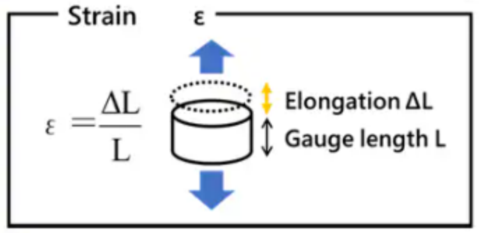






The calculation of deformations under load is described by Hooke's law of elasticity

$$\sigma = E \cdot \varepsilon = \frac{F}{A}$$



σ stress, E elastic modulus, ε strain, F force, A area

Characteristics Indicated from Stress-Strain Diagrams

The individual property values obtained from these stress-strain diagrams are described below.

Elastic Region / Plastic Region

The right diagram describes the elastic and plastic regions. The orange area shows the elastic region, which "returns to its original shape like a spring when the force is removed. The blue area shows the plastic area, which is "the region that does not return to its original shape even if the force is removed. The elastic region provides data used in product design, which assumes that the shape will not deform, while the plastic region provides data for processing and durability.