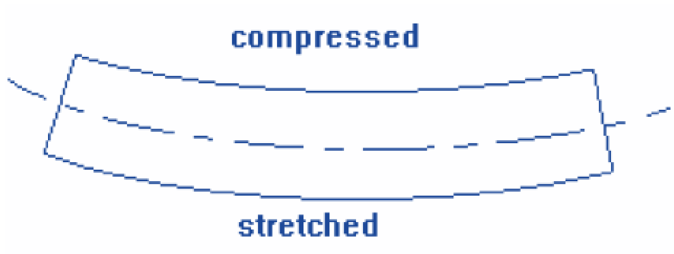
FLEXURAL STRESSES IN BEAMS

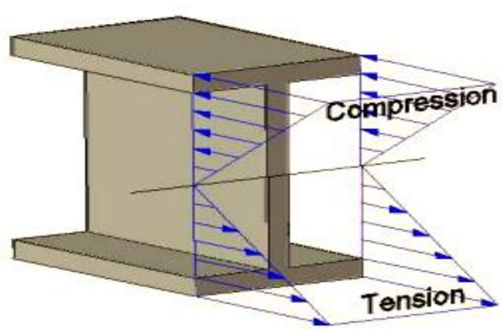
A **beam** is a structural member whose length is large compared to its cross sectional area which is loaded and supported in the direction transverse to its axis. Lateral loads acting on the beam cause the beam to bend or flex, thereby deforming the axis of the beam into a curved line.

Axial Stress (tension and compression) and the **Shear Stress** (vertical and horizontal) which develop in a loaded beam depend on the values of the Bending Moments and the Shear Forces in the beam. Determining the axial stress - which is often known as the **Bending Stress** in a beam; and determining the shear stress - often called the **Horizontal Shear Stress** (for reasons we will discuss) is important in two ways. First, it will enable us to determine if a particular loaded beam is safe under the applied loading. Second, it will enable us to select the best beam (from a table of beams) for a particular loading. Both of these are very important processes for the safety and efficiency of a beam.

Forces and couples acting on the beam cause bending (flexural stresses) and shearing stresses on any cross section of the beam and deflection perpendicular to the longitudinal axis of the beam. Transverse loading causes bending and bending is very severe form of stressing a structure. The bent beam goes into tension (stretched) on one side and compression on the other.



Bending stress is distributed through a beam as seen in the diagram below:



So, in reality, bending stresses are tensile or compressive stresses in the beam! A simply-supported beam always has tensile stresses at the bottom of the beam and compressive stresses at the top of the beam.

If couples are applied to the ends of the beam and no forces act on it, the bending is said to be **pure bending**. If forces produce the bending the bending is called **ordinary bending**.

The complete formula which describes all aspects of bending is, $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$

We will go on to look at the derivation and use of this formula in the next sheet of this chapter.

Pure Bending Assumptions:

1. Beam is straight before loads are applied and has a constant cross-sectional area.

2. Beam has a longitudinal plane of symmetry and the bending moment lies within this plane.

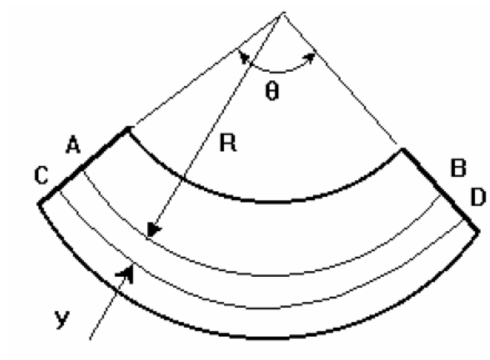
3. Beam is subjected to pure bending (bending moment does not change along the length).

4. Beam material is homogeneous and isotropic and obeys Hook's law.

5. The modulus of elasticity in tension and compression are equal.

Neutral Axis:

This is the axis along the length of the beam which remain unstressed , neither compressed nor stretched when it is bent. Normally the neutral axis passes through the centroid of the cross sectional area. The position of the centroid hence important.



Consider a beam is bent into an arc of a circle through angle Θ radians. AB is on the Neutral Axis and is the same length before and after the bending. The radius of neutral axis is R.

<u>Shearing Stresses in Beams</u>

It is easy to imagine vertical shear on a beam that was made up of concrete blocks:

This type of shear is called "transverse" shear, and occurs if there is no bending stresses present. The transverse shear stress =V/A

However, almost all real beams have bending stresses present. In this case, beams are more like a deck of cards and bending produces sliding along the horizontal planes at the interfaces of the cards as shown below:

This type of shear is called "longitudinal" or horizontal shear. The formula used for determining the maximum longitudinal shear stress, f_v, is as follows: