

Module 2 : Analysis of Statically Determinate Structures

Lecture 3 : Axial Force, Shear Force and Bending Moment

Objectives

In this course you will learn the following

- Three primary types of internal force, based on their orientation.
- Definitions of axial force, shear forces and bending moments.

2.3 Axial Force, Shear Force and Bending Moment

We will restrict our discussions to primarily one-dimensional members (in reality these are three-dimensional structural members, but the other two dimensions are relatively much smaller). When the loading on such a member is on a plane same as the member itself, we call it a two-dimensional (planar) case (see Figure 2.3a for example). In such cases, the internal forces also lie on the same plane. The internal forces on any cross-section can be expressed with two orthogonal force components and one moment in the plane of loading (F_1 , F_2 , M in Figure 2.3b). We can align x -axis along the centroidal axis of the member and we can also align one of the forces, let's say F_1 , along this centroidal axis (along the primary dimension). Then this internal force will be known as the *axial force* (Figure 2.3c). In general, we consider an internal surface perpendicular to the centroidal axis (transverse cross-section, also called the *yz-plane* or *x-plane*). Then the other force component F_2 acts tangentially to this surface and it is known as the *shear force*. The internal moment, which is acting on the transverse cross-section, is known as the *bending moment*.

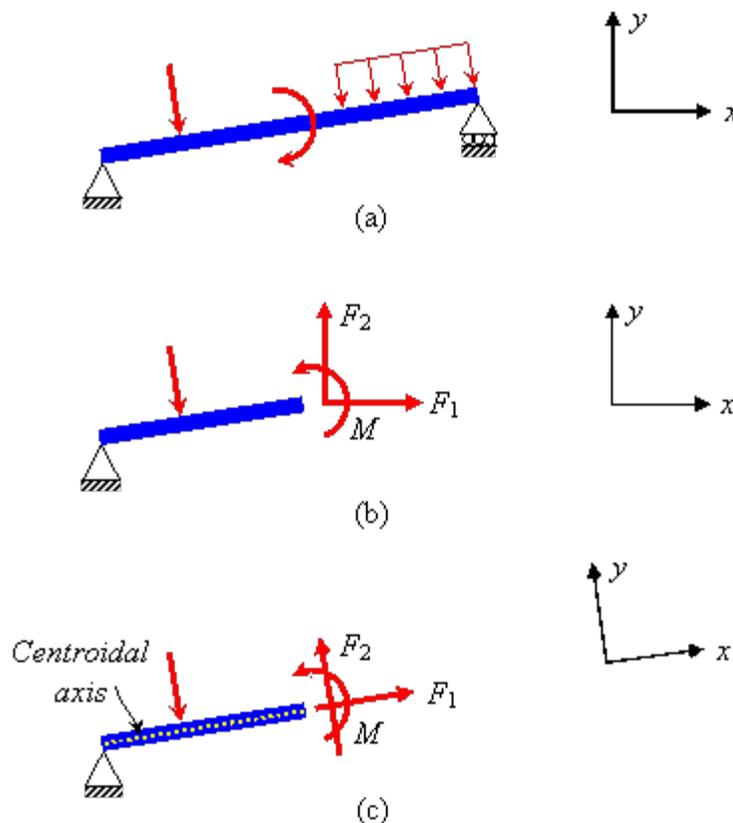


Figure 2.3 Axial force, shear force and bending moment on a cross-section of a two-dimensional (planar) system

For a three-dimensional case, that is when the loading is not restricted to one plane, we have three orthogonal force components and three orthogonal moment components on an internal surface (Figures 2.4 a & b).

We align the centroidal axis of the member along, say, x -axis, and consider an internal surface perpendicular to it (Figures 2.4c). Then F_x is the *axial force* and F_y and F_z are the two *shear forces*. Moments M_x and M_y are the two *bending moments*. The moment M_x is known as *torsion*. This set of forces is the most generic case of internal forces for such structural members.

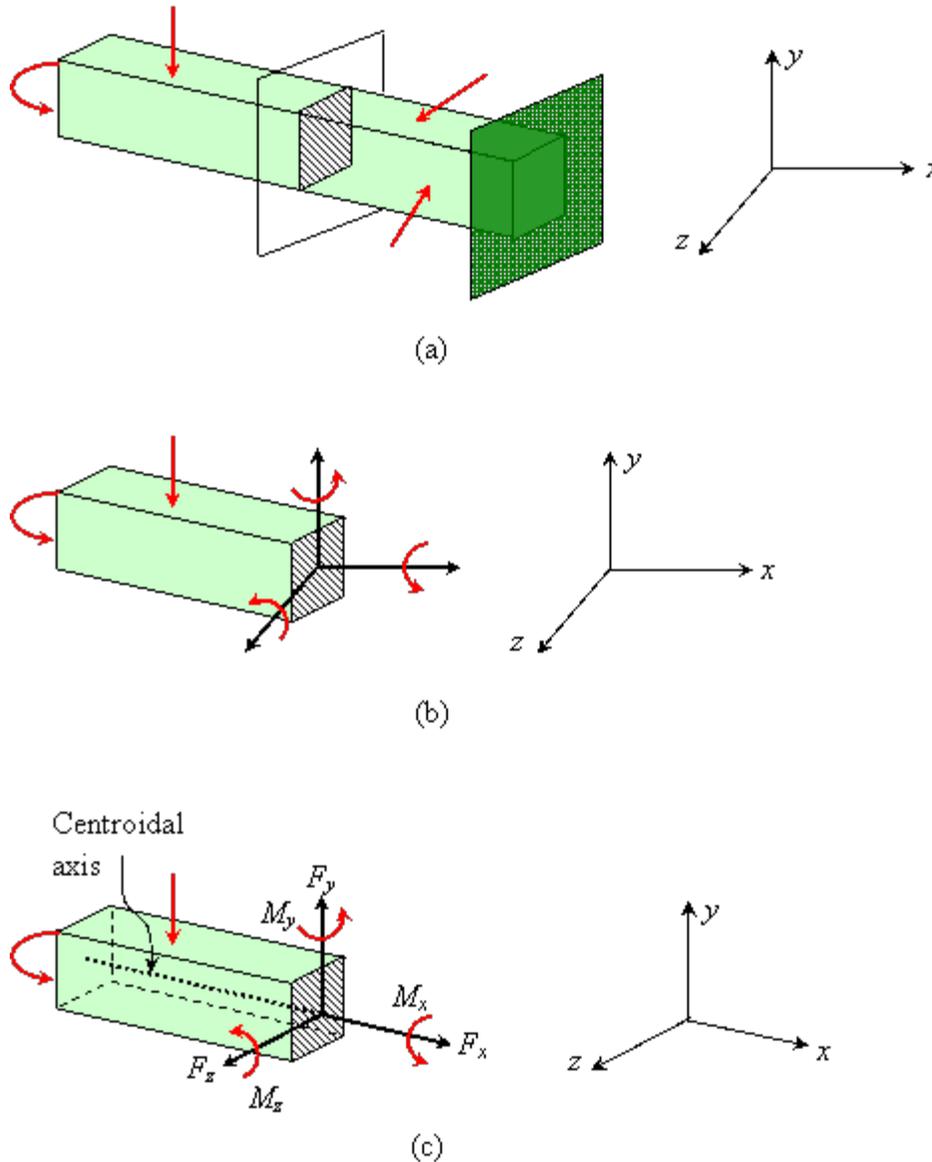


Figure 2.4 Axial force, two shear forces and two bending moments for three-dimensional systems

Note that these internal forces are defined according to their orientation respective to the structural member. The axial force acts along the centroidal axis of the member. The shear forces act in a plane which is perpendicular to this centroidal axis and the bending moments act along directions perpendicular to this axis as well. The torsion acts along the centroidal axis.

Recap

In this course you have learnt the following

- Three primary types of internal force, based on their orientation.
- Definitions of axial force, shear forces and bending moments.