# Federal University, Oye-Ekiti, Ekiti State Nigeria. Department of Civil Engineering CVE 204 – Strength of Materials

## Shear Force and Bending Moment Diagram of Beams

## 1.0 General Background

1.1 Beam – structural member loaded perpendicular to its longitudinal axis



Figure 1

Beams transmit loads by the development of BM and SF at different sections. Beams can be classified in many ways

- i. Classification based on Support system
  - Simply supported



## 1.2 Types of Support in Beams Structure

The supports in beams (framed structure) supply the necessary reactive forces to maintain the structure in equilibrium as a result of applied load. There are many types of supports from which a system of supports can result. Some of these supports are:

a) Fixed End /Bulk-In/EnCastre/Rigid



Figure 1.2.1: Fixed Support

Three supports are capable of supplying three reactive forces: horizontal, vertical, and a fixing moment. This type of support is fixed so that it cannot move or rotate under the action of superimposes load.

b) Pin/Hinged Support



Figure 1.2.2: Pinned Support

This is assumed to be free to rotate under the applied load, but cannot move either vertically or horizontally. This type of support can produce two support reactions. These are: horizontal and vertical forces.

c) The Roller Bearing

This can only supply one reaction. This is the case when a beam simply rests on a support. The bean can rotate. It can move horizontally. But it is restrained in the vertical direction only. When we sit down on a chair, this is the type of support that develop



1.2.3: Roller Bearing Support

#### **1.3** Determinate and Indeterminate Beams

On the basis of support systems of the beam, beam can be classified as either determinate or indeterminate beam

## **Determinate Beams**

It is a determinate beam when the reactions formed by the support systems are such that the static equilibrium equations are sufficient to solve it

The static equilibrium equations are:

$$\sum Fx = 0$$
  

$$\sum Fy = 0$$
  

$$\sum Mo = 0$$

The equations of static equilibrium assume that there are three unknowns. In order words, the support reactions resulting from the support system must not be more than 3 for a beam to be **Determinate.** For example

#### 1.4 Types of Loads on Beams Structure

Many forms of loads are dealt with in structural analysis. They include:

- 1. Static Load
  - i) Point Static. Also known as concentrated load



ii) Distributed Load (udl)

This is when a load is applied in such a way that it spread over the entire or part of the length.

a. When the loading rate is uniform, it is called **uniformly distributed load**.



Uniformly distributed load (constant rate of loading)

b. Triangular Load (varying rate of loading). For example, soil pressure on wall, etc.



c. Trapezoidal loaded (Varying rate of loading). For example, soil pressure + permanent load



Kn/m or Kn/m<sup>2</sup>

d. Irregularly loaded



2. Dynamic Loads

These are moving loads. It usually occurs in highway/bridge analysis and design.



#### 1.5 SHEAR FORCE AND BENDING MOMENTS

The forces acting in a structural beam member may include some or all the following:

- a. Forces normal to elemental axis e.g. shear force.
- b. Forces parallel to elemental axis e.g. Axial or normal forces
- c. Bending Actions. For example, bending moment and twisting moment

#### **Beans subjected to Bending Actions**

In the beam type of structure, analysis involves the determination of the magnitude of the Shear force (SF) and the Bending moment (BM) at all points of the beam.

#### The Shearing Force (SF)

The shearing Force at any section of a beam is defined as the unbalanced vertical force to the right or left of the section.



The Shearing force at any section is the algebraic sum of all the lateral components of the forces acting on either side of the section.

Shearing force is +ve when the resultant to the left is upward, and –ve when resultant to the right is downward.

The shear force varies along the length of the beam; and this variation is represented by a diagram. The **shearing force diagram** is the one which shows the variation of shearing force along the length of the beam

#### The Bending Moment (BM)

The bending moment about any section is the algebraic sum of all the moments about that section of all the forces acting on either side of the section

The Bending moment diagram is the one which shows the variation of bending moment along the length of the beam

Bending moment can be of two types:



a. Sagging moment  $\rightarrow$  +ve



b.) Hogging moment  $\rightarrow$  -ve

Also, bending moment at a section is described in terms of clockwise and anticlockwise. It is taking to be POSITIVE when clockwise and NEGATIVE when anticlockwise





a) Positive Moment

b) Negative Moment

## Note:

- 1. The beam is assumed to be weightless when calculating SF and BM in a section
- 2. When drawing the SF and BM diagrams, all positive values are plotted above the base line and the negatives are plotted below the base line.

## Example 1

Draw the shear force and bending moment diagram for a simply supported beam with a point load as shown



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