BEAM DEFORMATION

Book 6

Designer's Den

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Definition

In structural mechanics, beam deformation refers to the bending and deflection of a beam under the action of applied loads. When a beam is subjected to external forces, it undergoes elastic deformation, causing it to bend and change shape. Understanding and analyzing beam deformation is essential for designing structures that can withstand the anticipated loads without excessive deflection or failure.

Beam deformation occurs due to the internal stresses induced by external loads. When a load is applied to a beam, it causes bending moments and shear forces within the beam. The beam's material properties, cross-sectional shape, and support conditions influence the magnitude and distribution of these internal forces, resulting in beam deformation.

The beam’s material properties are described by the elastic modulus (E). This modulus, also known as Young’s modulus, measures the material's ability to deform elastically when subjected to stress. The beam’s cross-sectional shape affects its second moment of area (I) which is a geometrical property of an area which reflects how its points are distributed about an arbitrary axis. These two concepts together determine a beam’s stiffness. Stiffness refers to the resistance of a material or a structure to deformation.

Criterion

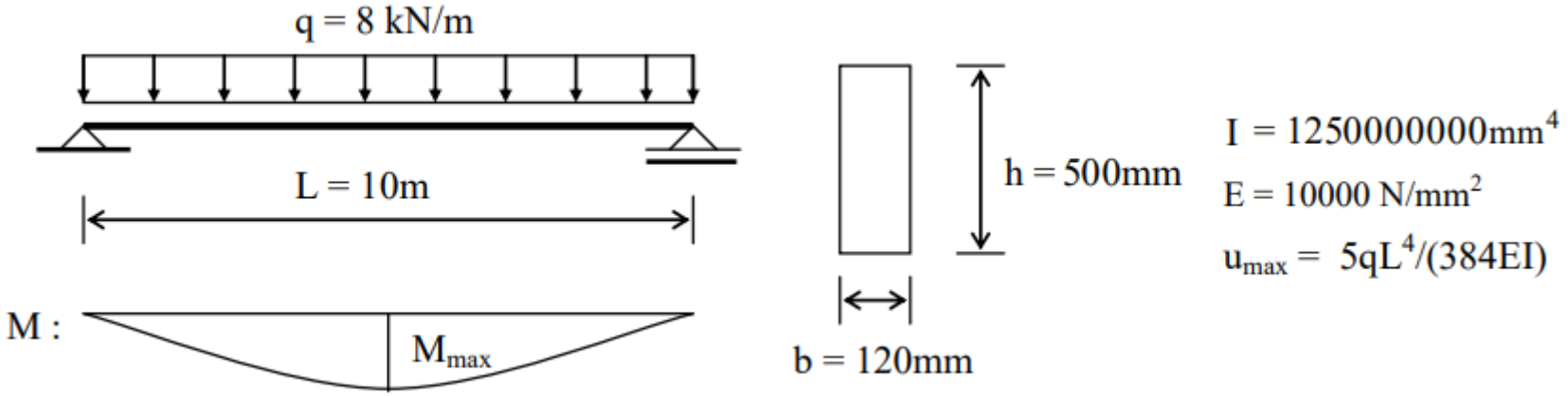
The criterion of L/200 is a common deflection limit used in structural design for beams. It specifies that the maximum deflection of a beam should not exceed L/200, where L represents the span length of the beam. This criterion is based on the assumption that smaller deflections generally result in more visually acceptable and structurally sound designs.

The L/200 deflection criterion is typically applied to beams in order to ensure adequate serviceability and user comfort. By limiting the deflection to a fraction of the beam's span, it helps maintain the appearance, functionality, and stability of the structure. Excessive deflection can lead to aesthetic concerns, cracking of finishes, discomfort to occupants, and potential damage to nonstructural elements.

It's important to note that the L/200 criterion is not a strict requirement in all cases and can vary based on the specific design requirements, codes, standards, and engineering practices. Different applications and building codes may specify different deflection limits, such as L/240 or L/360. Specialized structures or unique cases may have their own specific deflection criteria based on specific considerations.

Examples

Example: Calculate the beam's deformation and ensure it is within the deflection criterion



Solution:

$$u_{max} = \frac{5 \cdot 8 \cdot 10\,000^4}{384 \cdot 10\,000 \cdot 1\,250\,000\,000} = \frac{250}{3}$$

L/200 = 10000/200 = 50

Since the deformation u_{max} is greater than the criterion this beam needs to be adjusted such that it is more stiff and deflects lesser. A good idea is to increase the cross-section height.