CEG 221 - MECHANICS OF MATERIALS II (2 UNITS)

- Tension, compression, torsion and hardness.

- Fracture mechanics, fatigue, creep and viscoelasticity.

- Elementary plasticity, thin plates and shells, yield criteria and stress concentration.

- Buckling instability, stress-strain transformation.

- Bending moment and shearing forces in beams.

- Bending: stress, slope and deflection, energy methods.

- Statically determinate and indeterminate stress systems.

NOTES:

1. SIMPLE BENDING THEORY AND BENDING STRESS

Suppose we have beam and load is applied, a bending moment is developed (sagging bending moment) upper layer is compressed, lower layer is in tension. This is a pure bending (or simple bending) which means there is no shear force in the length of the beam and there is a constant bending moment in the beam.

It is practically not possible to have no shear stress when a load is applied. Or it could be said to be possible in only certain parts of the beam.

Given an overhang beam and we apply a loads at the ends, when you draw the shear force and bending moment diagram, the place in the diagram where the shear force is 0 and the BM is constant, then the theory of simple bending moment is applicable for the specific length where the SF and BM is constant.

Bending also known as flexure is a characteristic behaviour of slender structural members subjected to tranversely applied loads. Bending is common in beams, slabs and columns.

A beam will deform as shown above(like lagging) when a transverse load is applied creating internal stresses within it. Thus at a typical cross-section of a beam, there will be two types of stresses defined.

I. Above the neutral axis – Compression

II. Below the neutral axis – Tension

While the neutral axis is assumed to be an axis of zero stress.

Also, for a cantilever beam, the nature of beding is reversed i.e. a convex bening and also,

DEFINITIONS

1. The beam axis: This is aline passing through the centroid of all cross-sections of the beam.

2. Axis of Symmetry: This is a line about which the area of th cross-section is symmetrical

3. Plane of Bending/Bending Axis: An axis in which bending takes plae, it usually coincides with the axis of symmetry

4. Neutral Axis: This is a line in which the bending stress is zero, usually the centroidal axis

If there’s no pure bending, there will be different shear stresses when a load is applied. There will be bending stresses and shear stress. When bending stress is maximum, shear stress is maximum.

At outer fibres of a beam, the bending stresses are max an shear forces are zero. So theory of simple bending can be applied safely for outer fibres.

CALCULATIONS

To make calculations in these, some assumptions have to be made

1. The material is homogeneous and isotropic (E is constant at all sections)

2. E is constant is Compression and Tension

3. Transverse sections which are plain before bending are plane and undistorted after beding

4. The beam is initially straight and all the longitudinal filaments bend into circular axis parallel to the bending axis

5. Radius of curvature is large compared to the dimensions of the beam’s cross section

6. The internal stress is withing the elastic limit

Note that the neutral axis has no stress

AB > A’B’ (Compression)

CD < C’D’ (Tension)

NL = N’L’ (No stress) (Neutral Layer)

There are infinite neutrall layers in the beam

Also, note that:

The length of the neutral axis remains constant during bending

N’N’ = R{%theta} = NN

while B’B’ = R(y+{%theta})

Similarly,

BB = NN = N’N’

From Hooke’s law

A beam cross section, the stress is:

…

Consider an elementary area dA at a distance, y from the centroidal axis, the force acting of dA (dF).

Moment of Force acting on dA about the neutral axis

{dM} = {%sigma}y{dA}

I => Moment of inertia

For planar rectangular,

Characteristics of I

1. I is defined about a reference axis using the centroidal axis

2. For rectangular objects, this reference axes are the x and y axes.

3. For circular cross-section, the reference axis is the dimension

4. For Several objects on the same axis

I obeys the commutative additive law provided the centroids line on the same axis

5. Complex objects having different centroidal axis are resolved into a single common axis of reference. Hence I can be determined using the “parallel axis theorem”.

Parallel Axis Theorem =>

This theorem states that the moment of an object about a centroidal axis equals the I about the centroida

QUESTIONS

1. The cross-section and … beam is shown below and the bending moment of the section is 20kN. Determine and plot two bening stress distributions at that cross-section.

TOPIC 2: TORSION