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Section - 5

Q1

Ans. **Bending Equation :-**

Bending theory is also known as flexure theory is defined as the axial deformation of the beam due to external load that is applied perpendicular to a longitudinal axis which finds application in applied mechanics.

- For a material, flexural strength is defined as the stress that is obtained from the yield just before the flexure test.
- It represents the highest stress that is experienced within the material at the moment of its yield.
- "σ" is used as the symbolic representation of flexural strength.

* **Bending Equation Derivation :-**

Following are the assumptions made before the derivation of bending equation :-

- The beam used is straight with constant cross - section.

- The beam used is of homogeneous material with a symmetrical longitudinal plane.

- The plane of symmetry has all the resultant of applied loads.

- The primary cause of failure is bending.

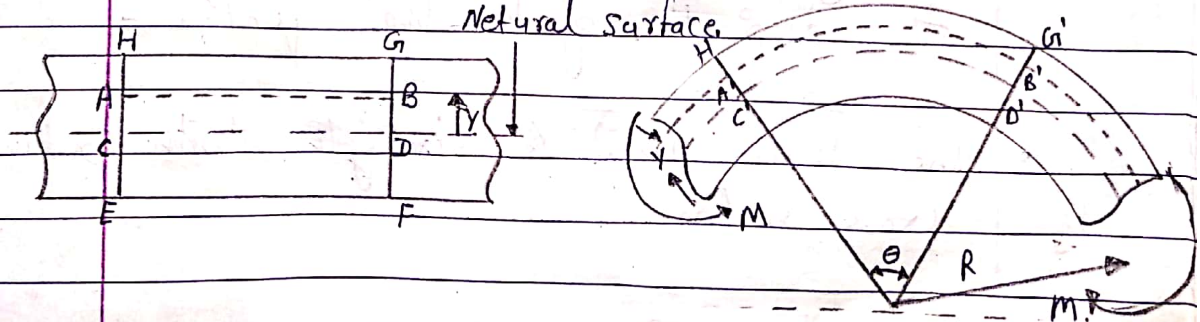
- E remain same for tension and compression.

- Cross section remains the same before and after bending.

⇒ Consider an unstressed beam, which is subjected to a const. bending moment such that the beam bends up to radius R.

- The top fibres are subjected to tension whereas the bottom fibres are subjected to compression.

- The locus of points with 'Zero' stress is known as "neutral axis".



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- With the help of the above fig., the following are the steps involved in the derivation of the bending equation:-

- Strain in fibre AB is the ratio of change in length to original length.

- Strain in fibre, AB = $\frac{A'B' - AB}{AB}$

$\therefore$ Strain = $\frac{A'B' - C'D'}{C'D'}$ (as AB = CD and CD = C'D')

- CD & C'D' are on the neutral axis and stress is assumed to be zero, therefore strain is also zero on the neutral axis.

$$= \frac{(R+y)\theta - R\theta}{R\theta}$$

$$= \frac{R\theta + y\theta - R\theta}{R\theta}$$

$$= \frac{y}{R}$$

$$\boxed{\frac{\sigma}{E} = \frac{y}{R}}$$

where :- (E → Young's Modulus of Elasticity)

or

$$\boxed{\frac{\sigma}{y} = \frac{E}{R}}$$

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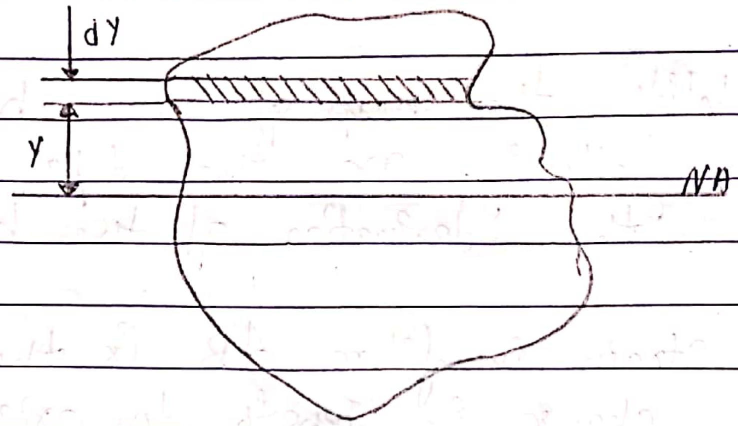

- $$\sigma = \frac{E}{R} y \quad \text{--- (1)}$$
- $F = \sigma \delta A = \frac{E}{R} y \delta A$ (force acting on the strip with area dA)
- $Fy = \frac{E}{R} y^2 \delta A$ (momentum about neutral axis)
- $M = \Sigma \frac{E}{R} y^2$ (total momentum for entire cross-section area)
- $\delta A = \frac{E}{R} \Sigma y^2 \delta A$

"$\Sigma y^2 \delta A$" is known as second moment of area and is represented as "I".

$\therefore$

$$M = \frac{E}{R} I \quad \text{--- (2)}$$

from eq^n (1) & eq^n (2), we get

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- $$\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$$ Ans

- Therefore, the above is the bending theory equation.