CLASS 17 - UNSYMMETRIC & COMPOSITE BEAMS

OBJECTIVES:
1. DEFINE UNSYMMETRIC BEAMS
2. CONSIDER MOMENT IN AN ARBITRARY ORIENTATION

READ:
CH 8.5 - 8.9 PHILPOT

O UNSYMMETRIC BENDING

CONSIDER ARBITRARY CROSS-SECTIONS THAT ARE NOT SYMMETRIC

BEAM MUST BE IN EQUILIBRIUM:
$$\sum F_x = 0 \quad \sum M_y = 0 \quad \sum M_z = M$$

$$\sum F_x = 0 = \int_A \sigma \, dA$$ \(\rightarrow\) AXIS Passes Through N.S.

$$\sum M_y = 0 = \int_A z \sigma \, dA$$ \(\rightarrow\) 0 = \(\int_A z \left(-\frac{y}{C}\right) \sigma_{\text{max}} \, dA\)

$$\sum M_z = M = \int_A -y \sigma \, dA$$

(i): \(\int_A yz \, dA = 0\) \(\quad \frac{\text{PRODUCT of INERTIA}}{C}\)
Indeed $\int yz \, dA = 0$ (product of inertia) if $z$ & $y$ are based on principal axes of inertia.

For symmetric elements, axis of symmetry

$\Sigma M_z = M = \int_A -y \sigma \, dA \quad \rightarrow \quad \sigma = \frac{M y}{I_z}$

**Flexural Formula**

2: **Moment in Arbitrary Plane**

$M_y = M \sin \theta$

$M_z = M \cos \theta$

**Theory of Superposition - Sum Response Due to Individual Loads**

$\sigma = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}$

(c) Jerome P. Lynch, 2015
WHERE IS NEUTRAL SURFACE?

\[ \sigma = 0 = - \frac{M_x y}{I_x} + \frac{M_y z}{I_y} \quad \Rightarrow \quad \frac{M_x y}{I_x} = \frac{M_y z}{I_y} \]

\[ y = \frac{M_y I_x}{M_x I_y} \ z \]

\[ y = \frac{I_x}{I_y} (\tan \theta) \ z \]

\[ \therefore \tan \alpha = \frac{I_x}{I_y} (\tan \theta) \]

N.C.