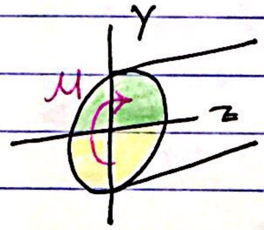
6.3 + 6.4 :- Bending Deformation and Flexure Formula

- When a member is suspended to a moment, a region called Neutral Surface appears which is a region with no change in length

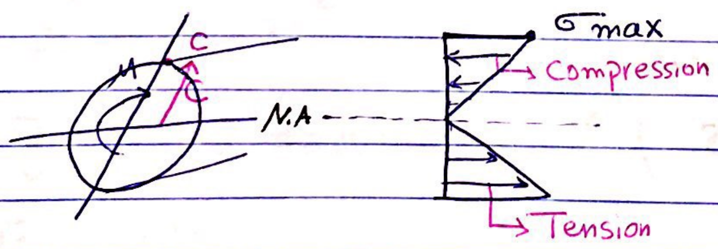
Yellow region → Tension
Green region → Compression



← ملاحظة : المنطقة الي فيها ال Moment
داخل عليها بتكون compression

- The stress That forms in Green region is Called Compression.
〃 〃 〃 〃 〃 Yellow 〃 〃
〃 Tension.

- We Can Draw the stress like:



ε & σ At neutral axis = 0

$$\sigma_{max} = \frac{Mc}{I}$$

where : c : perpendicular distance between N.A and farthest point
I : moment of cross section about N.A

▶ How to find $\bar{y}$ (centroid) or N.A :-

1- Divide your section into Areas
2- find a ref ($y=0$)
3- find y between ref and centroid of each Area
4- Calculate $\bar{y} = \frac{\Sigma yA}{A}$

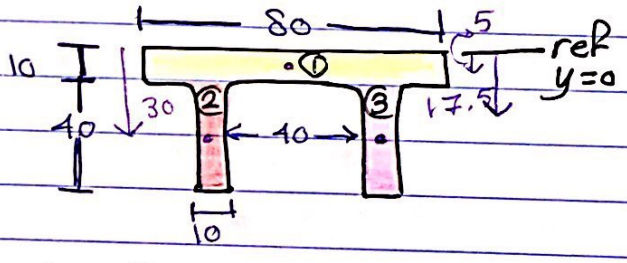
▶ How to find I :-

1- Divide your Sections Into Areas
2- find I for each Area (Square , triangle ....)
3- find I about N.A using Parallel axis Theorem.

$\Sigma\left(I_{N.A} = I + Ad^2\right)$ (d: distance between NA & centroid)

Example:

To find $\bar{y}$



1 ✓

2 ✓

3 Area 2 is similar to 3

$y_1 = \frac{10}{2} = 5$

$y_2 = 10 + \frac{40}{2} = 30$

$y_3 = y_2 = 30$

4 $\bar{y} = \frac{(5)(80)(10) + 2(30 \times (10)(40))}{2\times(10)(40) + (80)(10)}$ (since ② = ③)

$\bar{y} = 17.5$

To find I :

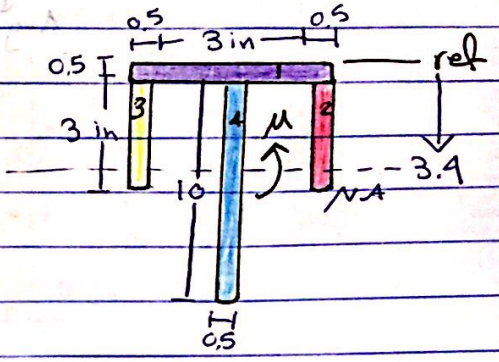
1 ✓

2 $I_1 = \left(\frac{1}{12}\right)(80)(10)^3$

$I_2 = I_3 = \left(\frac{1}{12}\right)(10)(40)^3 =$

3 $I = I_1 + A_1(17.5-5)^2 + 2\left(I_2 + A_2(30-17.5)^2\right)$

Example: 6-19



1- Find N.A ($\bar{y}$)

$A_1 = (4)(0.5) = 2$

$A_2 = A_3 = (0.5)(3) = 1.5$

$A_4 = (10)(0.5) = 5$

$y_1 = \frac{0.5}{2} = 0.25$

$y_2 = y_3 = 1.5 + 0.5 = 2$

$y_4 = 5 + 0.5 = 5.5$

$\bar{y} = (2)(0.25) + 2[1.5 \times 2] + (5.5)(5) \;/\; 2+2*1.5+5$

$= 3.4$

2- Find $\bar{I}$

$\bar{I} = \bar{I}_{A_1} + 2\bar{I}_{A_2} + \bar{I}_{A_4}$

$= \left(\frac{1}{12}\right)(4)(0.5)^3 + (2)(3.15)^2 + 2\left[\left(\frac{1}{12}\right)(0.5)(3)^3 + (0.5)(3)(1.4)^2\right] + \left(\frac{1}{12}\right)(0.5)(10)^3 + (0.5)(10)(2.1)^2$

$= 91.73 \text{ in}^4$

Tension : lower part :

$\sigma_{max} = (4 \times 10^3)(12)\underbrace{(7.1)}_{\text{ft} \to \text{in}} \;/\; 91.73 = 3.72 \text{ ksi}$

$10.5 - 3.4$ يعني بعد نقطة من تحت عن N.A

Compression $\to \sigma_{c\,max} = (4 \times 10^3)(12)\underbrace{(3.4)}_{\text{بعد نقطة من فوق عن N.A}} \;/\; 91.73 = 1.78 \text{ ksi}$

ref عن N.A يعني بعد