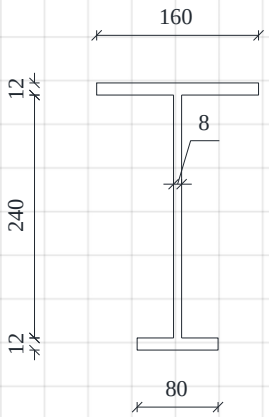
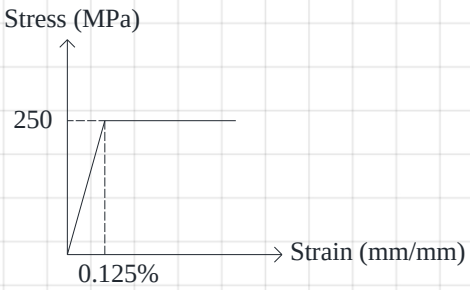
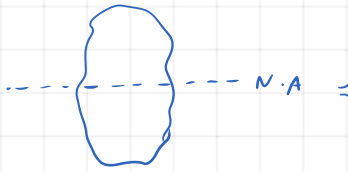
For the given asymmetric cross-section about one axis:

a) Determine the location of the elastic and plastic neutral axis.
b) Based on the location of the neutral axis, determine the elastic and plastic section modulus.
c) If the material is elastic perfectly plastic, determine the elastic and plastic moment of the cross-section.



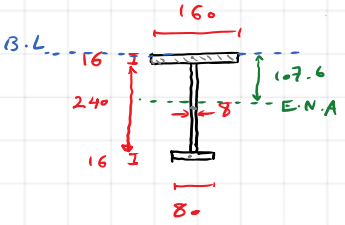
Cross-Section (mm)



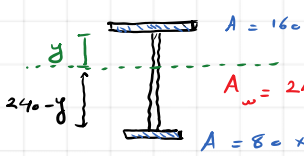


Elastic N.A → $\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i}$, $\Sigma Q_{Top} = \Sigma Q_{Bott}$

plastic N.A → $\Sigma A_{Top} = \Sigma A_{Bott}$



$$\bar{y} = \frac{\Sigma A_i y_i}{\Sigma A_i} = \frac{160\times16\times8 + 240\times8\times(240/2+16) + 80\times16\times(16+240+\frac{16}{2})}{160\times16 + 240\times8 + 80\times16} = 107.6\ mm$$



$A = 160\times16 = 2560\ mm^2$

$A_w = 240\times8 = 1920\ mm^2$

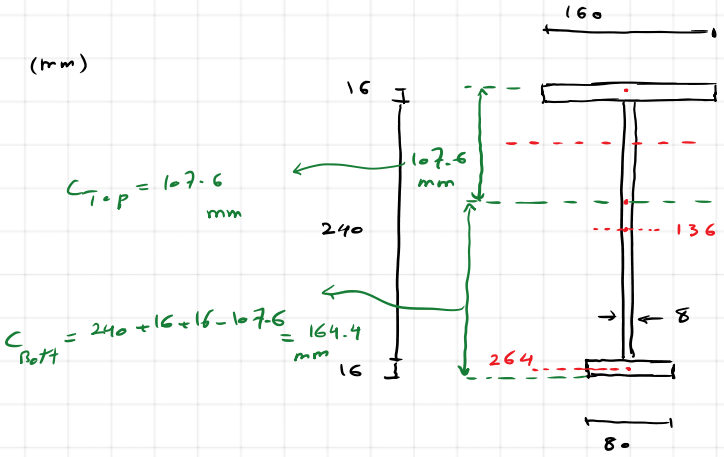
$A = 80\times16 = 1280\ mm^2$

P.N.A → $\Sigma A_{Top} = \Sigma A_{Bott}$

→ $A_{Top} = 2560\ mm^2 + 8\ mm \times y_{mm}$

$A_{Bott} = 1280\ mm^2 + 8\ mm\ (240\ mm - y_{mm})$

$2560\ mm^2 + 8mm \cdot y_{mm} = 1280\ mm^2 + 8_{mm}\ (240\ mm - y_{mm}) \rightarrow \boxed{y = 40\ mm}$



$C_{Top} = 107.6\ mm$

$C_{Bott} = 240+16+16-107.6 = 164.4\ mm$

$$I = \frac{160\times16^3}{12} + 160\times16\,(107.6-8)^2 \quad (mm^4)$$

$$\frac{8\times240^3}{12} + 8\times240\,(136-107.6)^2 \quad (mm^4)$$

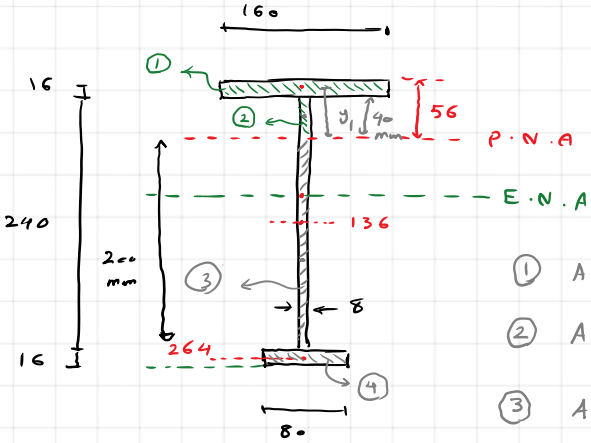
$$+ \frac{80\times16^3}{12} + 80\times16\,(264-107.6)^2 \quad (mm^4)$$

$I = 6.75\times10^7\ mm^4$

Elastic section modulus: $W_{el} = \frac{I}{c}$

Plastic section modulus: $W_{pl} = \Sigma A_i \cdot y_i$

$$(W_{el})_{min} = \frac{I}{c_{max}} = \frac{6.75\times10^7\ mm^4}{164.4\ mm} = 4.1\times10^5\ mm^3$$



$W_{pl} = \Sigma A \cdot y$

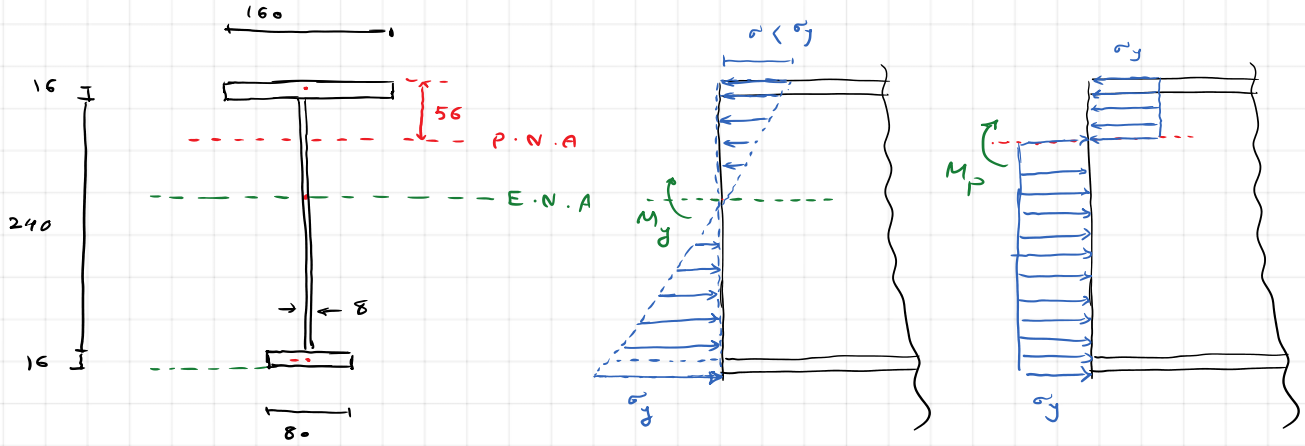
① $A = 160 \times 16 = 2560\ mm^2$ $\quad y_{①} = 56 - 8 = 48\ mm$

② $A = 40 \times 8 = 320\ mm^2$ $\quad y_{②} = 20\ mm$

③ $A = 200 \times 8 = 1600\ mm^2$ $\quad y_{③} = 100\ mm$

④ $A = 80 \times 16 = 1280\ mm^2$ $\quad y_{④} = 208\ mm$

$$W_{pl} = \Sigma A_i y_i = A_1 \cdot y_1 + A_2 y_2 + A_3 y_3 + A_4 y_4 = 5.55 \times 10^5\ mm^3$$



$$\begin{cases} M_y = W_{el} \cdot \sigma_y = 4.1 \times 10^5\ mm^3 \times 250\ MPa \approx 102\ kN \cdot m \\ M_p = W_{pl} \cdot \sigma_y = 5.55 \times 10^5\ mm^3 \times 250\ MPa = 137.5\ kN \cdot m \end{cases} \qquad (\sigma_y = 250\ MPa)$$