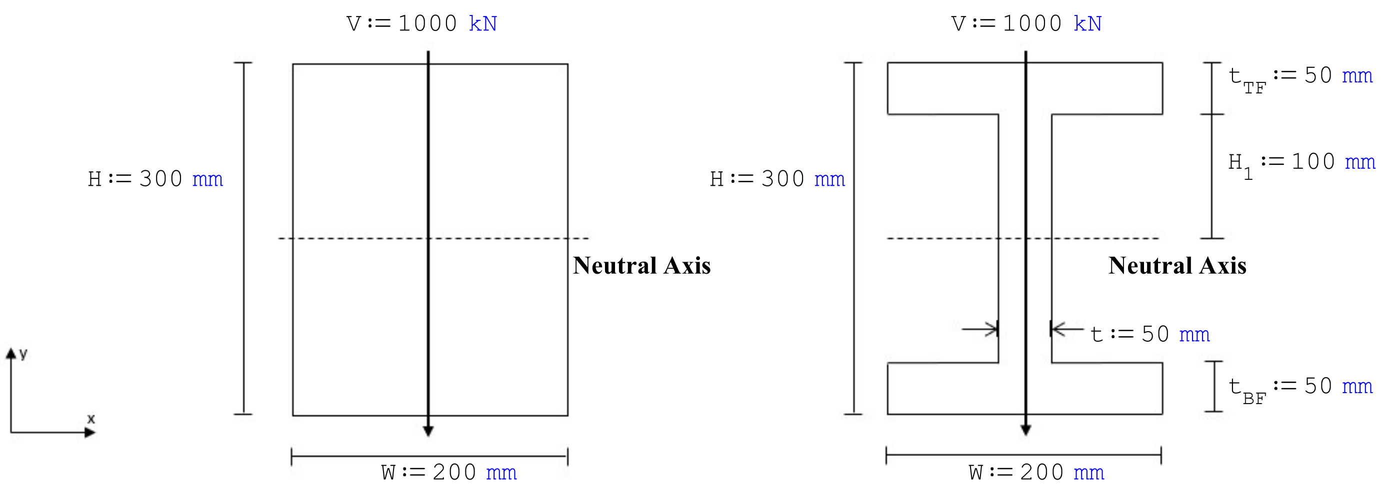
1) **Question**: How is shear distributed in different cross-sections?

In this document, we will plot stress distributions for both beam cross-sections using the transverse shear formula.

2) **Cross-section of a Rectangular Beam vs an I-beam**:



3) **Assumptions**:

- Stress is applied uniformly across the beams thickness.

- This method does not give accurate values at the junction between the flange and the web. Instead, this method expresses the average shear stress value.

- The beam is made of a homogenous material.

- This method does not work well with irregularly shaped cross-sections. The cross-section must be short and flat.

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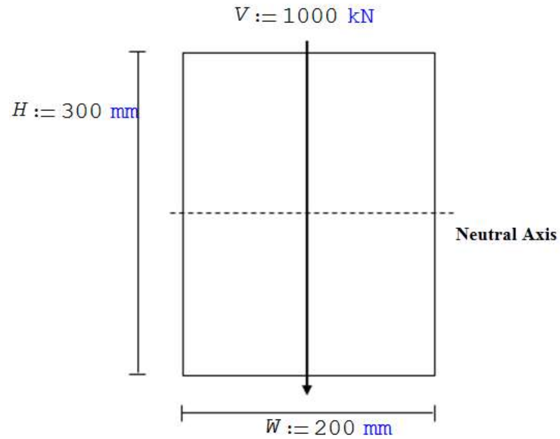
4) **Creating shear distribution equations for both beams**:

a) Rectangular Beam



Shear flow formula:	Known Variables:	Unknown Variables:
$\tau_R := \frac{V \cdot Q_R}{I_R \cdot t}$	$V = 1.00 \cdot 10^{6}\ N$ $W = 0.2\ m$ $H = 0.3\ m$ $t = 0.05\ m$	I_R Q_R

Calculating the Area Moment of Inertia of cross-section $\left(I_R\right)$

$I_R =$ *(Outer Rectangle Moment of Inertia)*

$$I_R := \frac{W \cdot H^3}{12} = 4.5 \cdot 10^{-4}\ m^4$$

Calculating the First Moment of Area about centroid $\left(Q_R\right)$

$Q_R = \Sigma\, \bar{y} \cdot A$

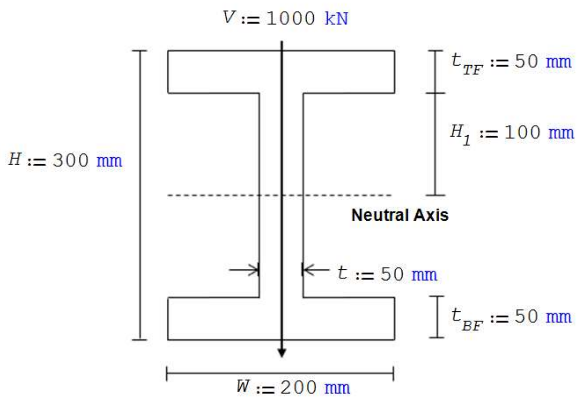
$$Q_R := \left(\left(\frac{H}{2} - y\right) \cdot W\right) \cdot \left(\frac{H}{2} - \frac{\frac{H}{2} + y}{2}\right) = 0.00225 - 0.03 \cdot y + 0.1 \cdot y^2$$

Shear Distribution Formula

$$\boxed{\tau_R := \frac{V \cdot Q_R}{I_R \cdot W} = 2.5 \cdot 10^{7} - 3.33 \cdot 10^{8} \cdot y + 1.11 \cdot 10^{9} \cdot y^2}$$

b) I-beam

<u>Note</u>: To avoid a lengthy calculation, we will only create a function describing the shear flow along the web of the beam. As a result of this, the shear stresses on the flanges are somewhat ignored.



Shear flow formula:	Known Variables:	Unknown Variables:
$\tau_I := \dfrac{V \cdot Q_I}{I_I \cdot t}$	$V = 1.00 \cdot 10^{6}\ N$ $W = 0.2\ m$ $H = 0.3\ m$ $t = 0.05\ m$	I_I Q_I

Calculating the Area Moment of Inertia of cross-section $\left(I_I\right)$

I_I = *(Outer Rectangle Moment of Inertia) - (Inner Rectangle Moment of Interia)*

$$I_I := \frac{W \cdot H^3}{12} - \frac{(W - t) \cdot \left(H - t_{TF} - t_{BF}\right)^3}{12} = 3.5 \cdot 10^{-4}\ m^4$$

Calculating the First Moment of Area about centroid $\left(Q_I\right)$

$Q_I = \Sigma\, \bar{y} \cdot A$

$$Q_I := \left(H_1 + \frac{t_{TF}}{2}\right) \cdot \left(t_{TF} \cdot W\right) + \left(y + \left(\frac{H_1 - y}{2}\right)\right) \cdot \left(t_{TF} \cdot \left(H_1 - y\right)\right) = (-0.025) \cdot y^2 + 0.0015$$

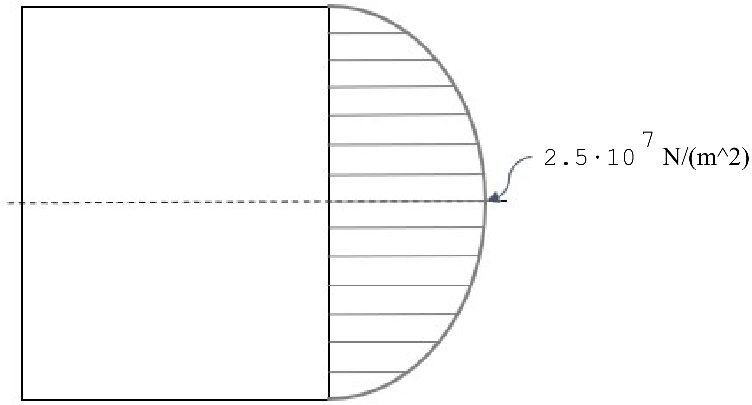
*Note: y is the distance from the point at which we want the shear and the neutral axis of the beam. The maximum shear value occurs at the neutral axis, so the value of y is zero.

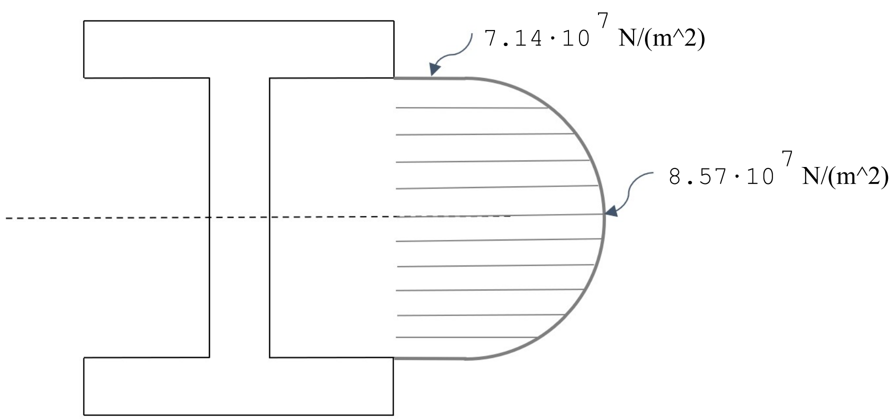
Shear Distribution Formula

$$\boxed{\tau_I := \frac{V \cdot Q_I}{I_I \cdot t} = -1.43 \cdot 10^{9} \cdot y^2 + 8.57 \cdot 10^{7}}$$

5) **Plotting Stress Distribution**

Now that we've described the τ values as a function of y, we can now plot it onto the beam cross-sections.





6) **Conclusion**:

We observe that when the cross-section decreases in size the shear stress increases. This can be seen by the formula for stress, which is force/area. As the cross-sectional area decreases, it can be predicted that the stress increases. We will test the validity of this claim by comparing it to our SOLIDWORKS Simulation results.