University of Nottingham
UK | CHINA | MALAYSIA

Mechanics of Solids

MMME2053

Shear Centre

Lecture 1

Learning Objectives

4. Understand that in an I-section, in addition to the transverse vertical shear stresses in the flange and web, more dominant horizontal shear stresses also occur in the flange (comprehension);
5. Recognise that the resultant of the shear stresses always act through one point, known as the 'shear centre' (comprehension);
6. Calculate the position of the shear centre (application);
7. Understand that if the applied loads do not act through the shear centre, then there is a resultant torsional load, which can result in twisting of the section if the torsional rigidity of the section is low e.g. thin walled sections (comprehension).

Objectives

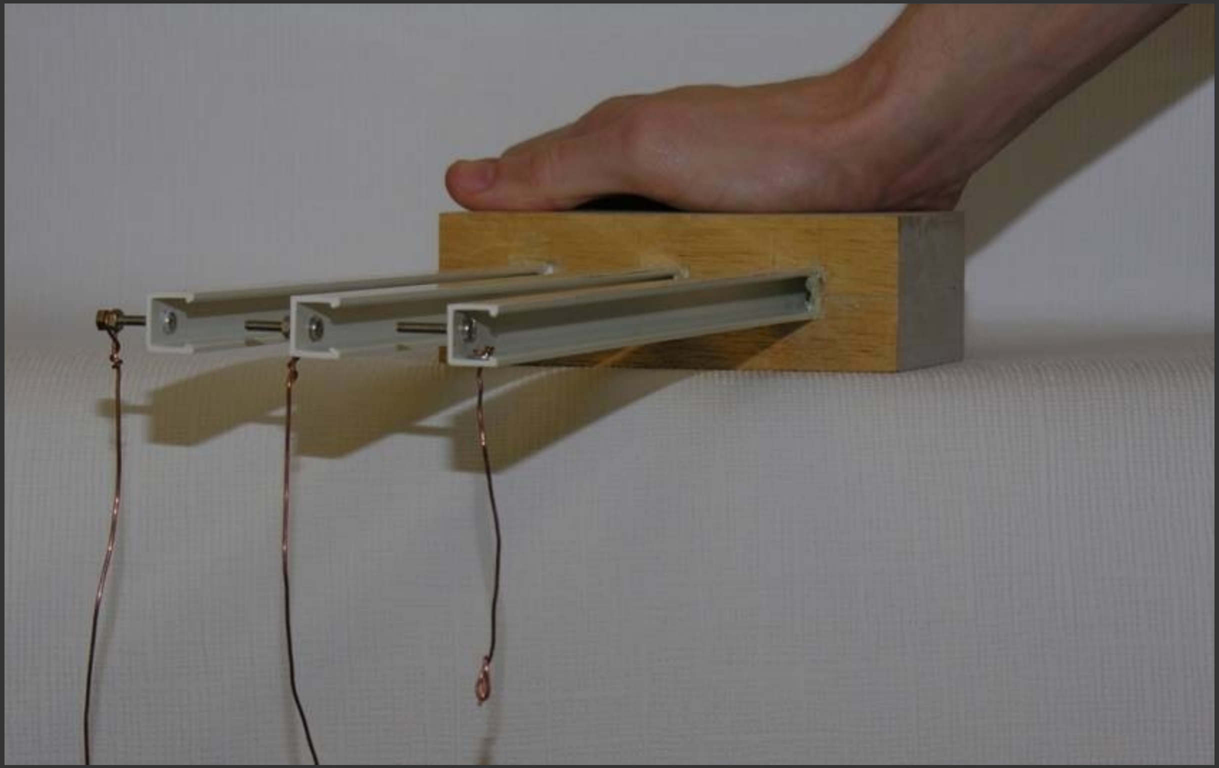
- Recognise the importance of shear centre in beams
- Recognise that the resultant of the shear stresses for a section act through the shear centre
- Recognise that if applied loads do not act through the shear centre then twisting of thin walled sections can occur
- Apply theory to calculate the position of the shear centre

Introduction

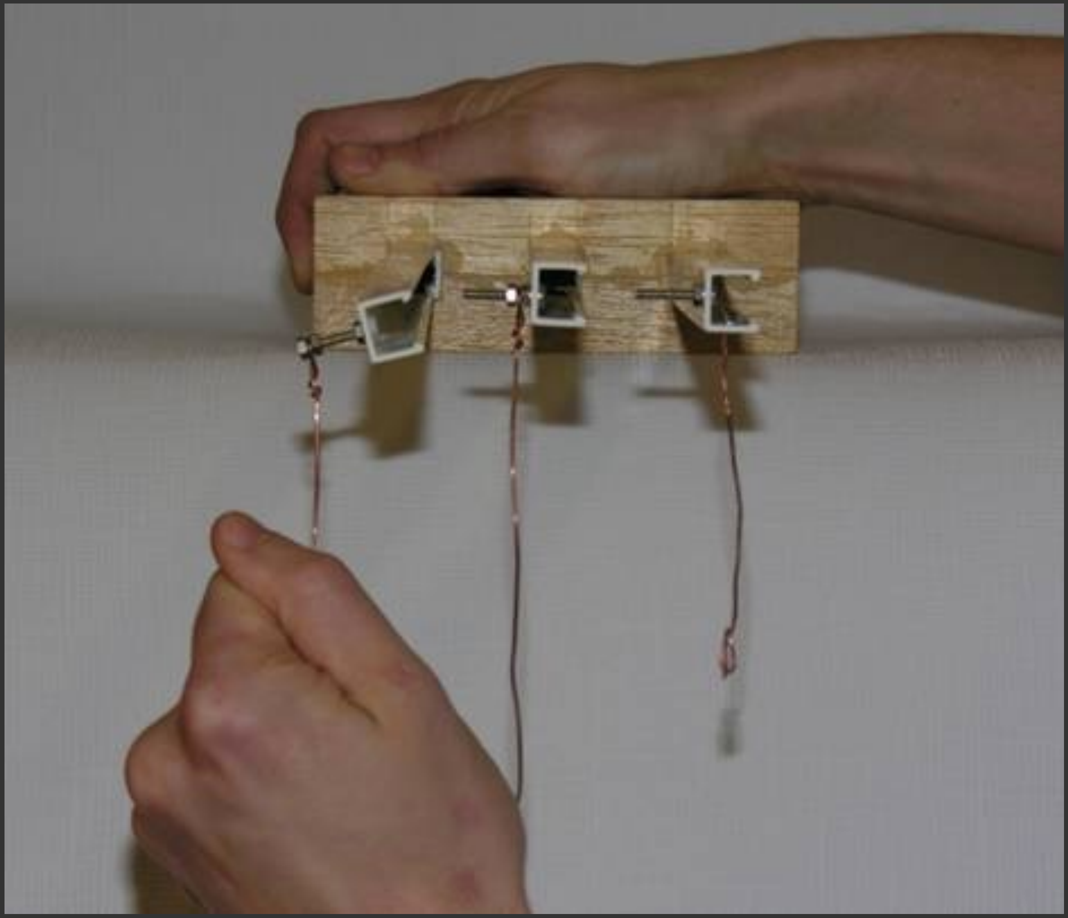
- What is the Shear Centre?
- The shear centre is the point through which the resultant of the shear stresses act
- The shear centre is important for beam sections which have low torsional rigidity, i.e. can twist easily, such as thin-walled sections. For such beams, if the resultant of the applied transverse loads do not act through the shear centre, they can cause twisting of the beam

Introduction

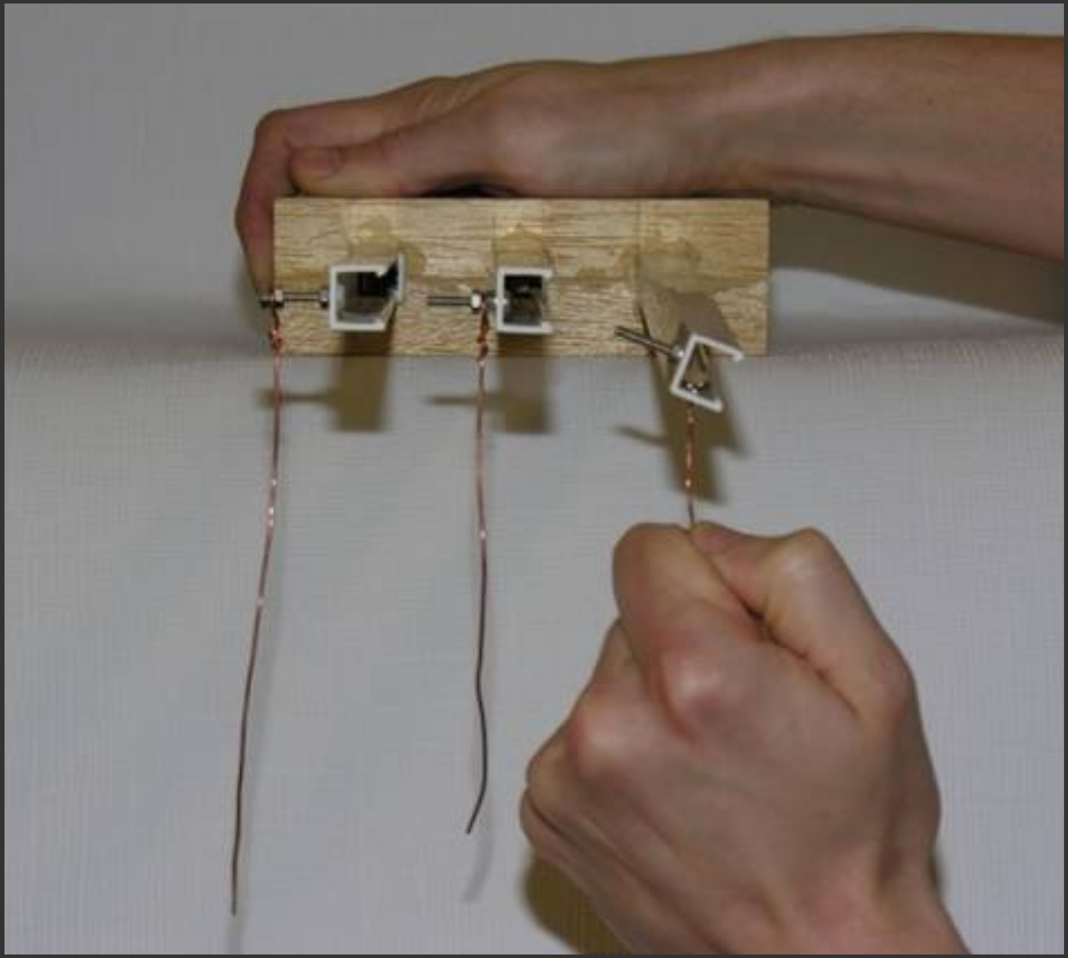
- Example



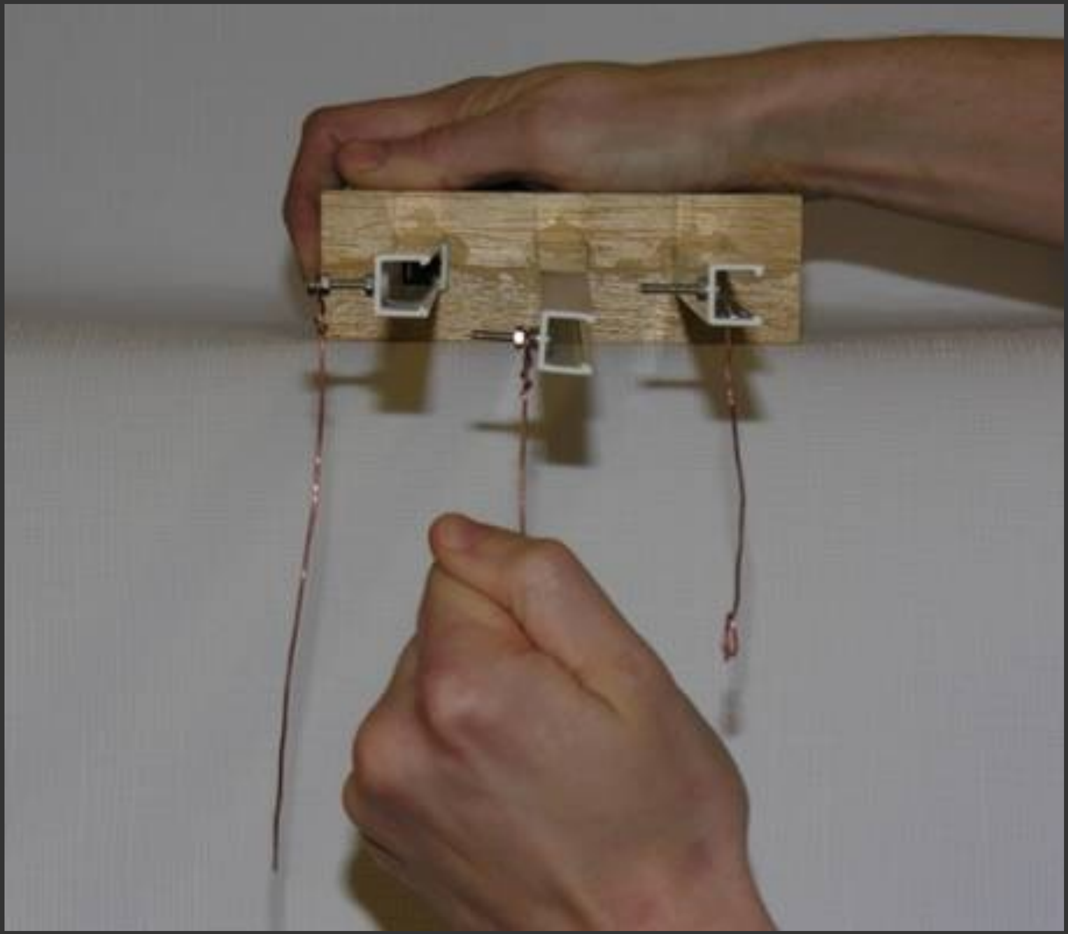
Introduction



Introduction

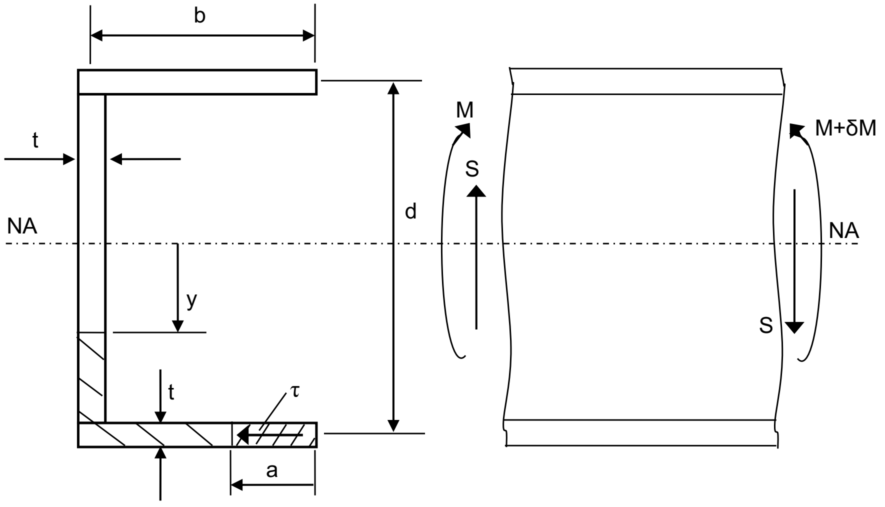


Introduction



Thin Walled Channel Section

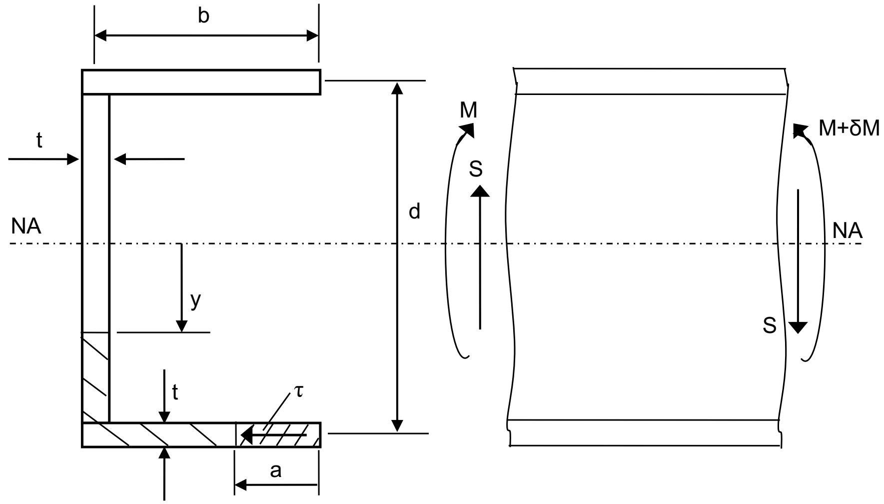
- Consider the shear stress distribution in a symmetric, thin walled channel section bending in the plane of the web:



Thin Walled Channel Section

- For the flange at distance *a* from the edge, the horizontal shear stresses are:

$$\tau = \frac{S}{Iz}A\bar{y} = \frac{S}{It}(at)\cdot\left(\frac{d}{2}\right) = \frac{S.d.a}{2I}$$

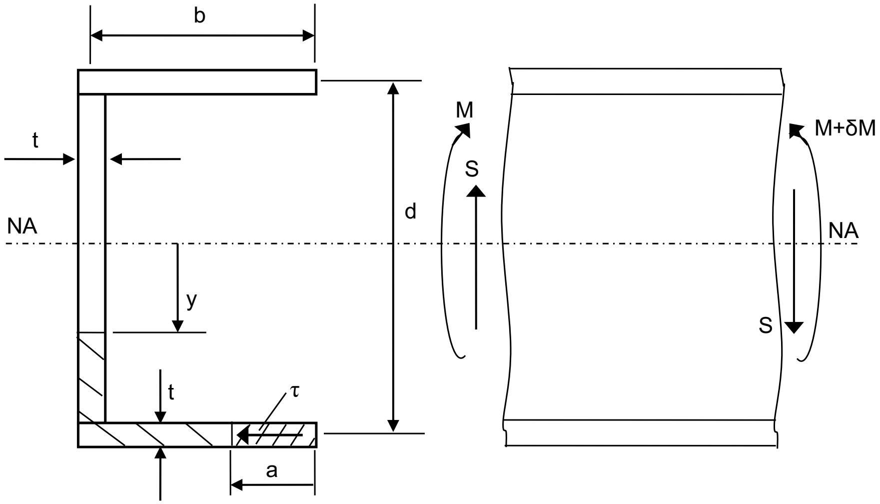


As analysed as previously for the flange in an I-section

Thin Walled Channel Section

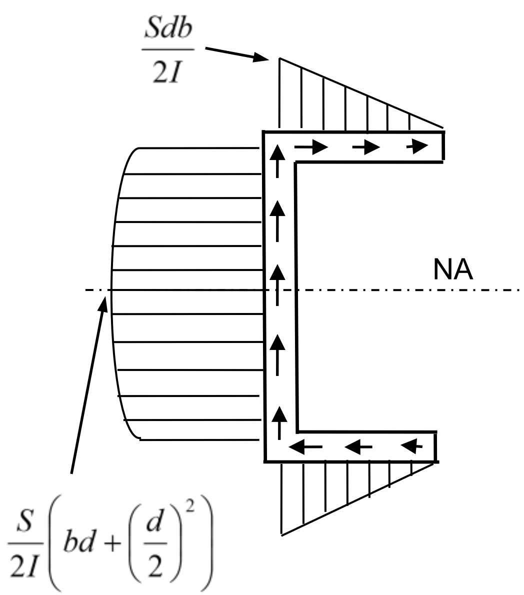
- For the web at distance *y* from the N.A., the transverse shear stresses are:

$$\tau = \frac{S}{I\,z} A\bar{y} = \frac{S}{I\,t}\left[bt\frac{d}{2} + \left(\frac{d}{2} - y\right)t\left(\frac{d}{2} + y\right)\frac{1}{2}\right] = \frac{S}{2I}\left(bd + \left(\frac{d}{2}\right)^2 - y^2\right)$$



Thin Walled Channel Section

- We can now draw the shear stress distribution in the web and flanges, as shown below:

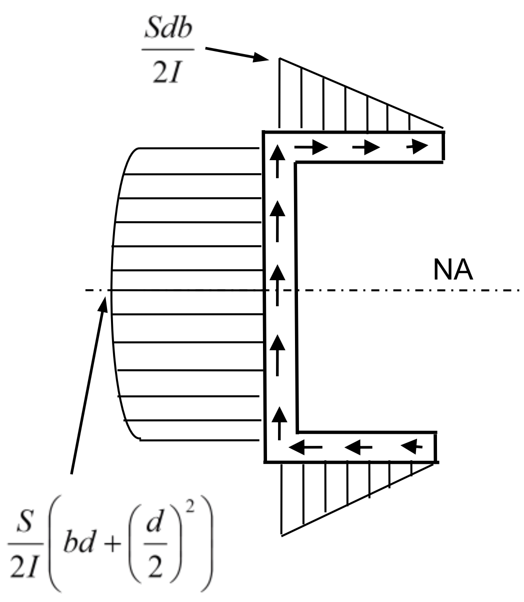


(a)

- The shear stress in the upper flange is in the opposite sense to that in the lower flange i.e. there is no horizontal resultant.

Thin Walled Channel Section

- We can now draw the shear stress distribution in the web and flanges, as shown below:

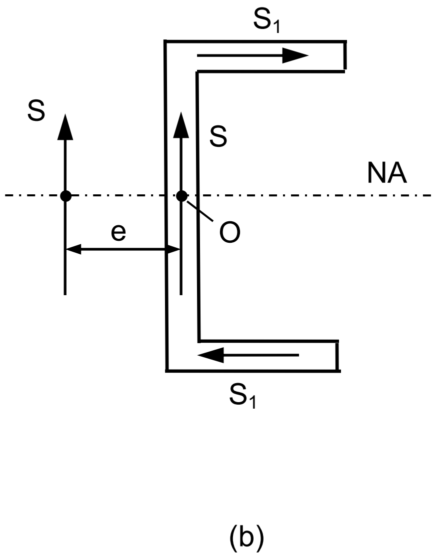


(a)

- There are no shear stresses on the free surfaces, the shear stresses act along the walls i.e. horizontal in the flanges and vertical in the web.

Thin Walled Channel Section

- The resultant forces arising from this shear stress distribution are:



- The total shear force in the lower flange, S_1, is the integral of the shear stresses in this flange:

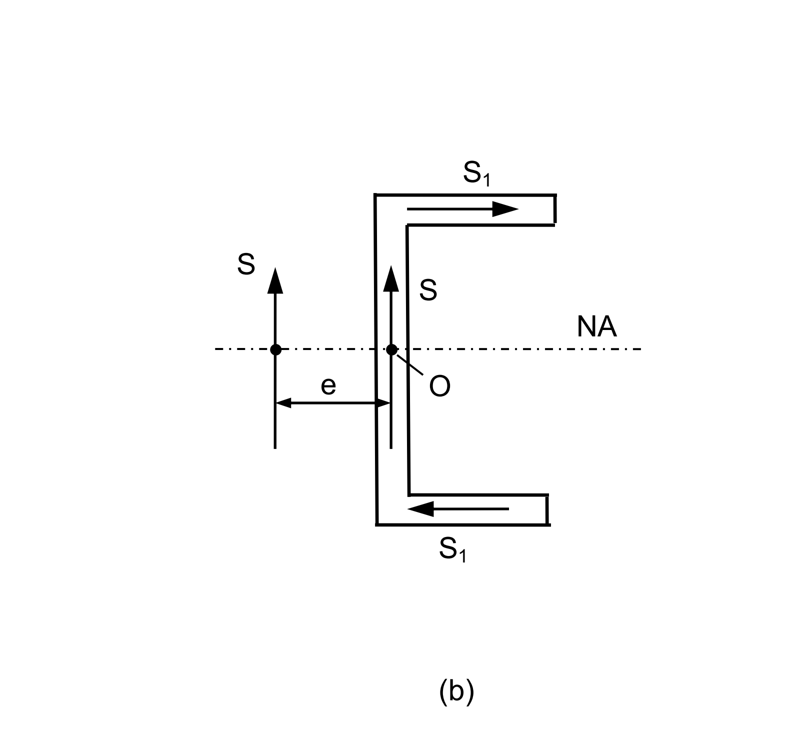
$$S_1 = \int_0^b \tau \, t \, da = \int_0^b \frac{S\,d\,a}{2I} t \, da$$

$$= \frac{Sdtb^2}{4I}$$

- An equal and opposite shear force acts in the upper flange

Thin Walled Channel Section

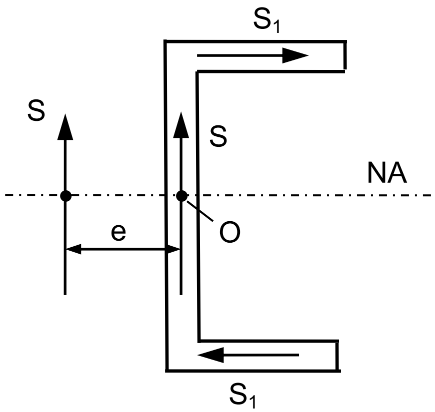
- The resultant forces arising from this shear stress distribution are:



- The shear force in the web is approximately *S* i.e. the total vertical shear load [assuming thin flanges carry negligible vertical shear load].

Thin Walled Channel Section

- The resultant of all the shear stresses must be the vertical shear force *S*, and its line of action is distance *e* outside the web.



(b)

- If we take moments about *O* in the web:

$$S.e = 2S_1\frac{d}{2}$$

$$\therefore e = \frac{S_1 d}{S} = \frac{d^2tb^2}{4I}$$

Learning Summary

4. Understand that in an I-section, in addition to the transverse vertical shear stresses in the flange and web, more dominant horizontal shear stresses also occur in the flange (comprehension);
5. Recognise that the resultant of the shear stresses always act through one point, known as the 'shear centre' (comprehension);
6. Calculate the position of the shear centre (application);
7. Understand that if the applied loads do not act through the shear centre, then there is a resultant torsional load, which can result in twisting of the section if the torsional rigidity of the section is low e.g. thin walled sections (comprehension).