Advanced Bending and Torsion
Shear Flow in Open Thin-Walled Sections

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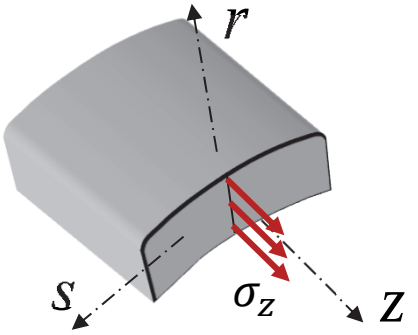
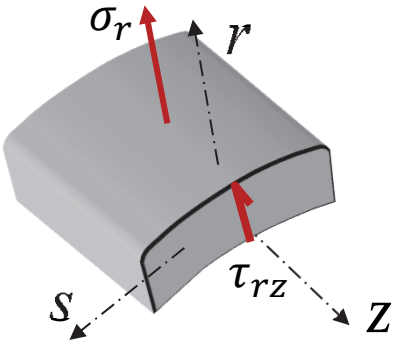
Shearing of Open Thin-Walled Sections - Derivations

- Thin-wall assumptions
  - Direct stresses are constant through the thickness:

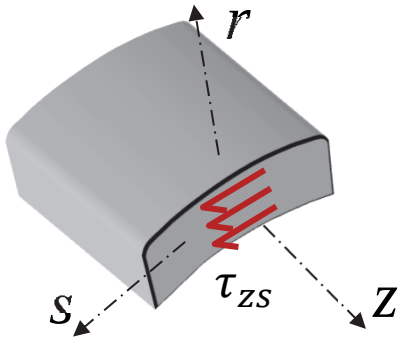


  - Through-thickness direct and shear stresses are negligible:

$$\sigma_r = 0 \qquad \tau_{rz} = 0$$



  - In-plane shear stresses are constant through the thickness:

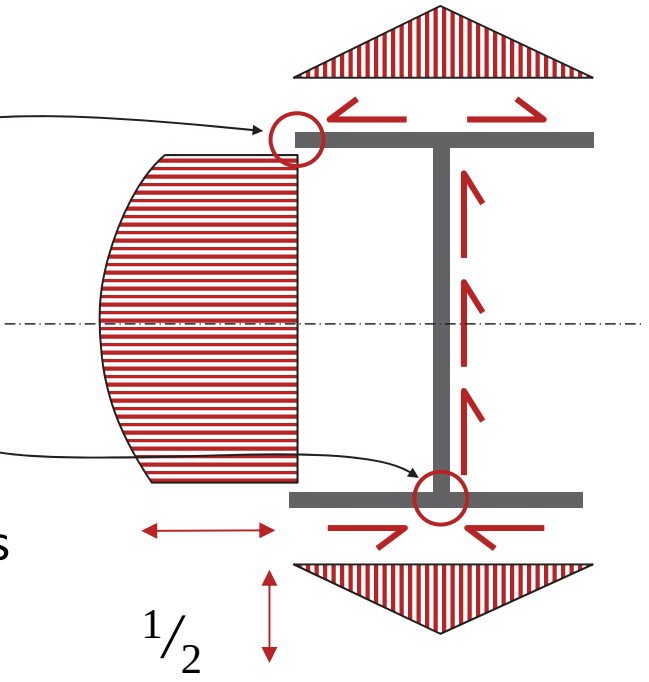


- The **shear flow** (shear force per unit arclength s) is defined as:

$$q_{zs} = t\,\tau_{zs}$$

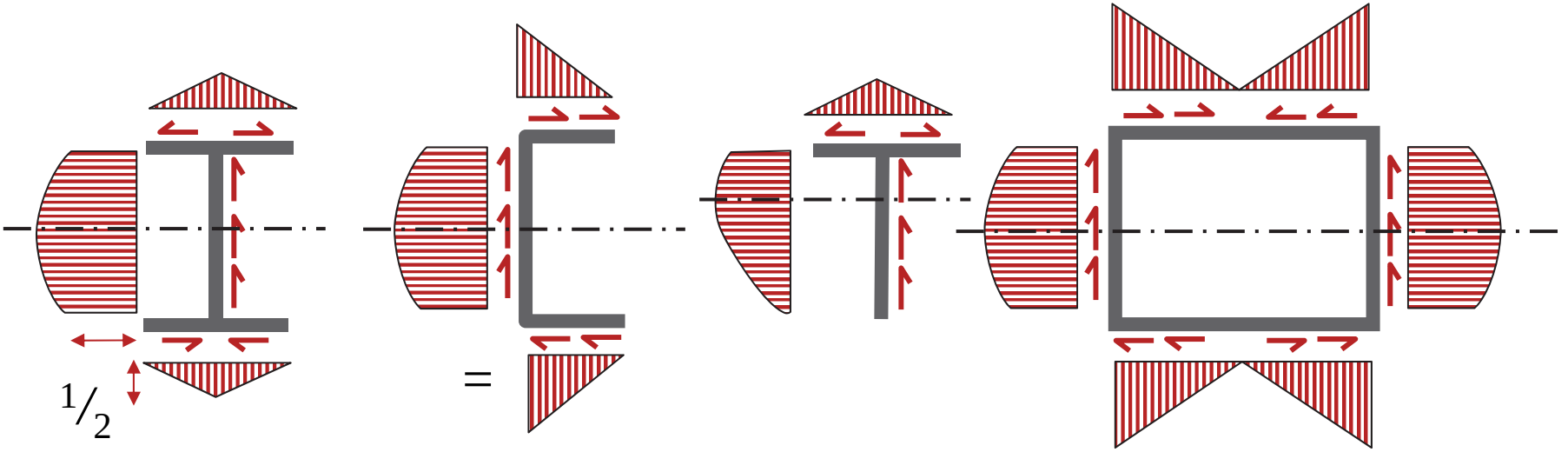
Shear Flow in Thin Walled Sections

- Thin wall approximations mean that:
  - The aspect ratio of each member should be 10 or greater (ideally 20)
  - Forces act along the centre line of each member
  - In-plane stresses are constant along the thickness direction
- Consequently the shear flow is:
  - Zero at free edges
  - Continuous around section
  - Always aligned with the centre line of thin sections



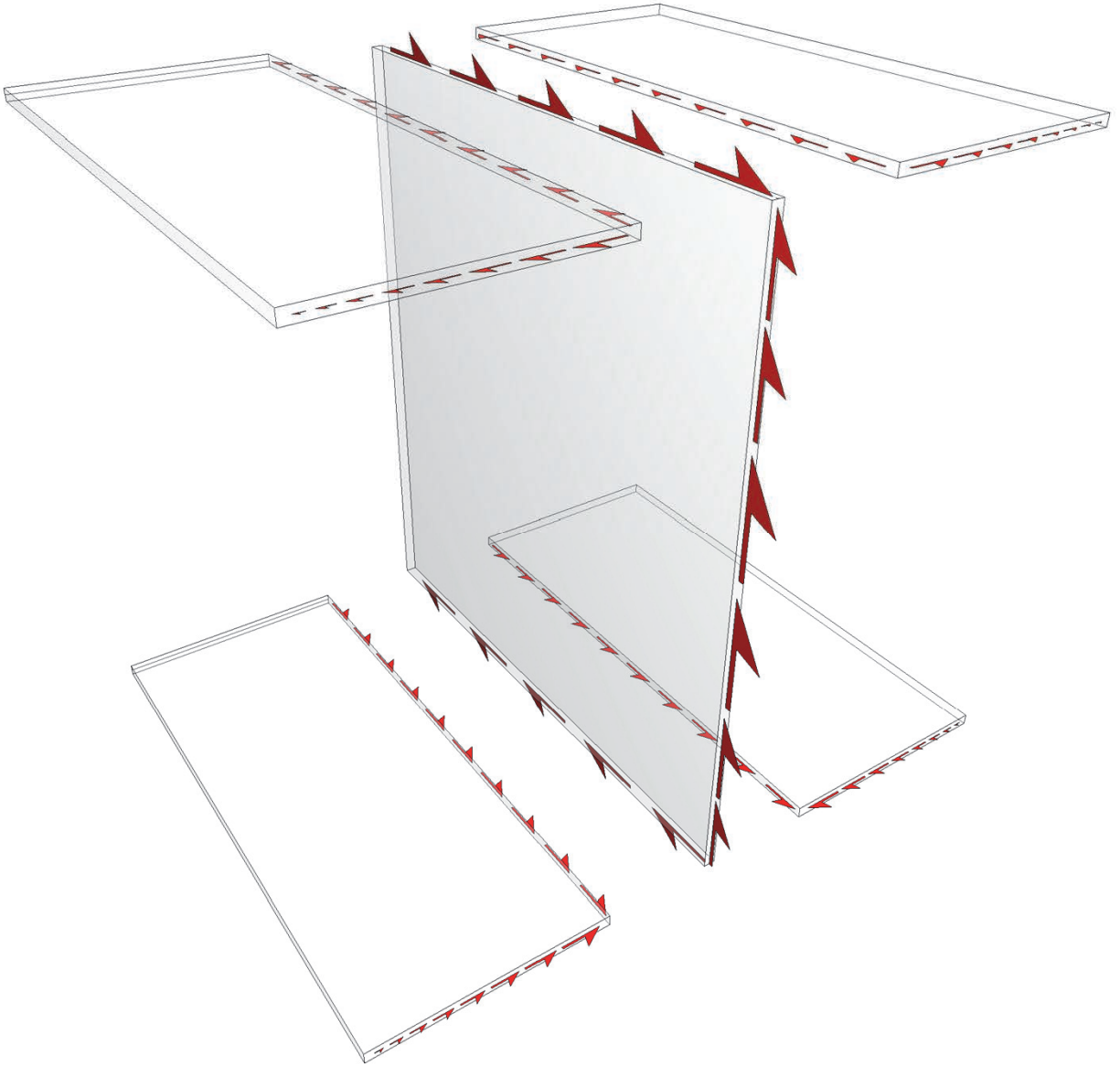
Shear Flow Distribution Examples

- For vertical upward loading S_y:



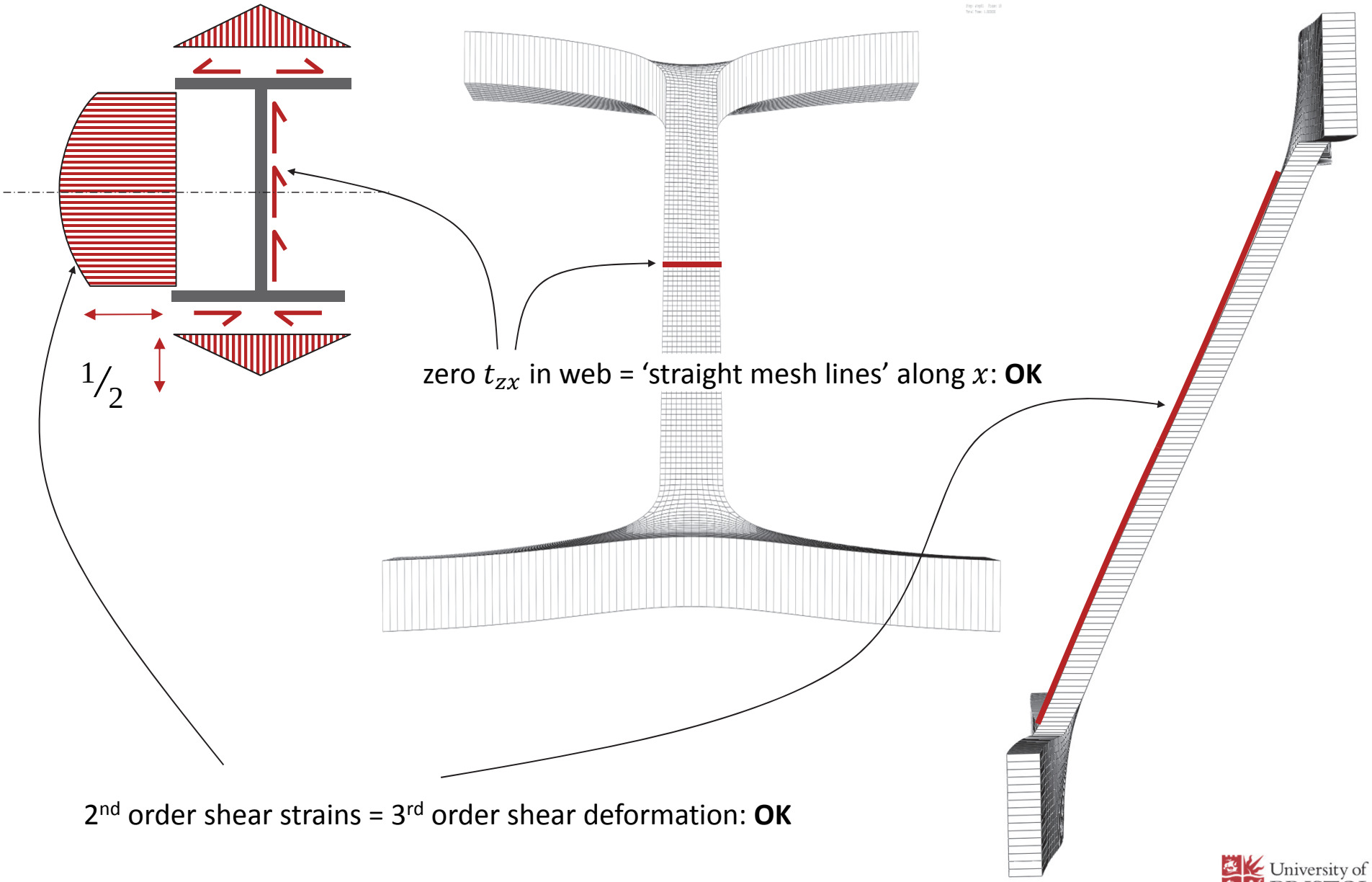
Shear Flow in Thin Walled Sections

- The shear flow is ‘transferred’ between thin walled members, *e.g.* flanges and web:



Shear Flow in an I-Section

- Analytical thin-wall solution *vs.* numerical full 3D solution:



Shear Flow in an I-Section

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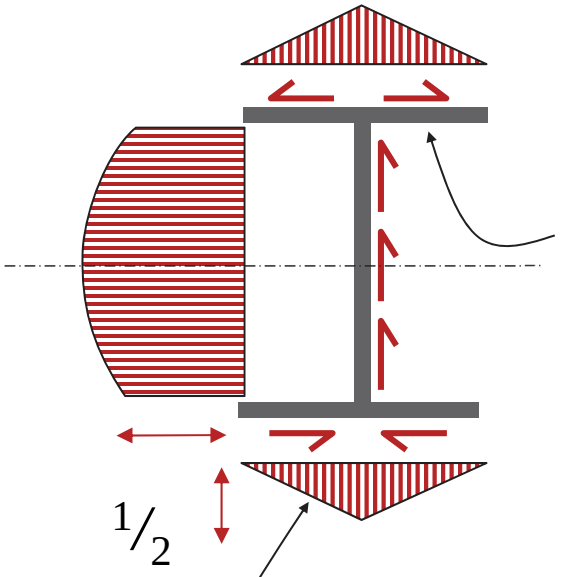
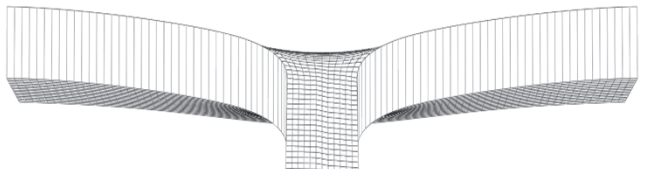
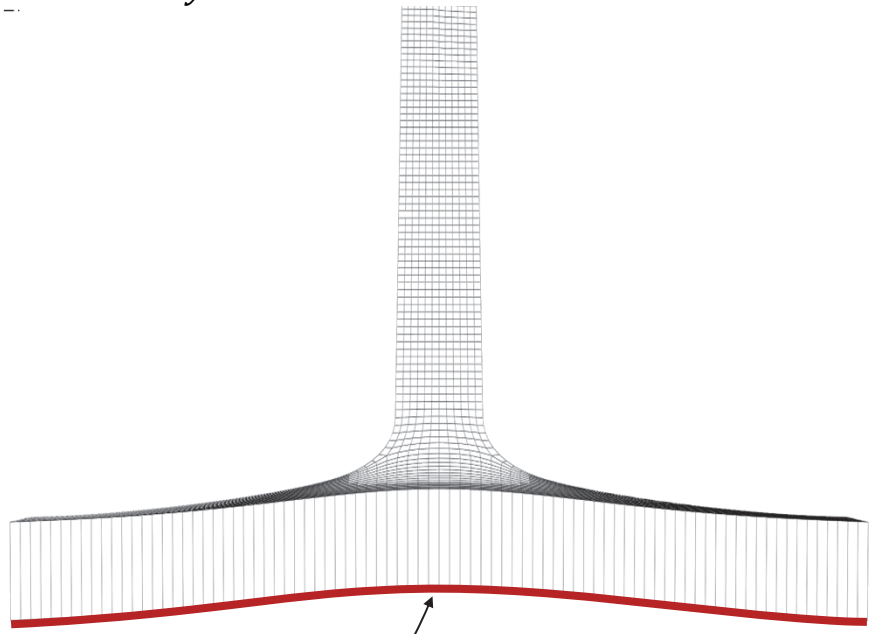
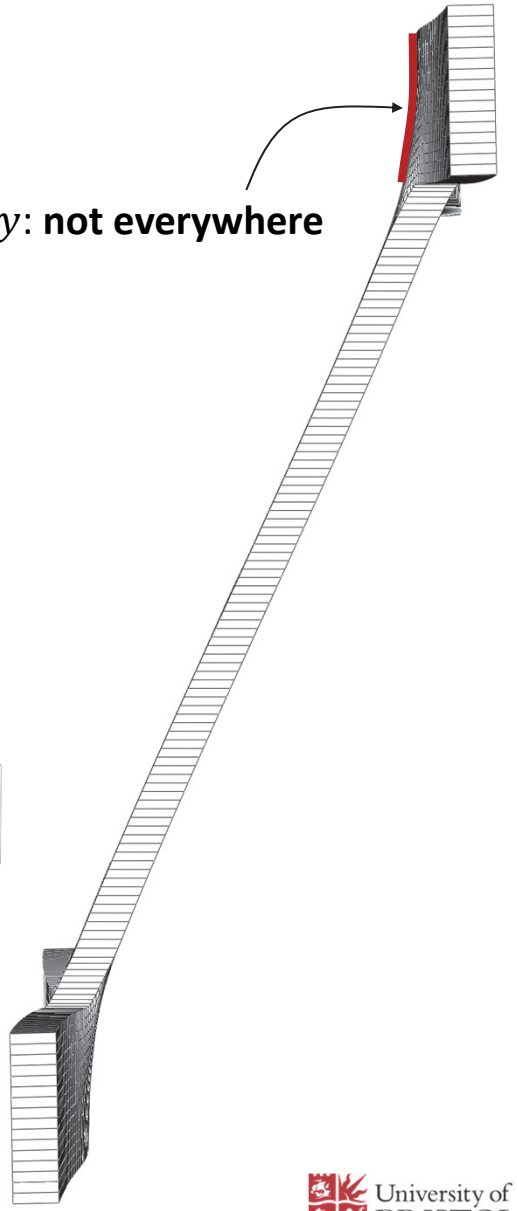




zero t_{zy} in flange = 'straight mesh lines' along y: **not everywhere**





1st order shear strain distribution = 2nd order shear deformation: **~OK**