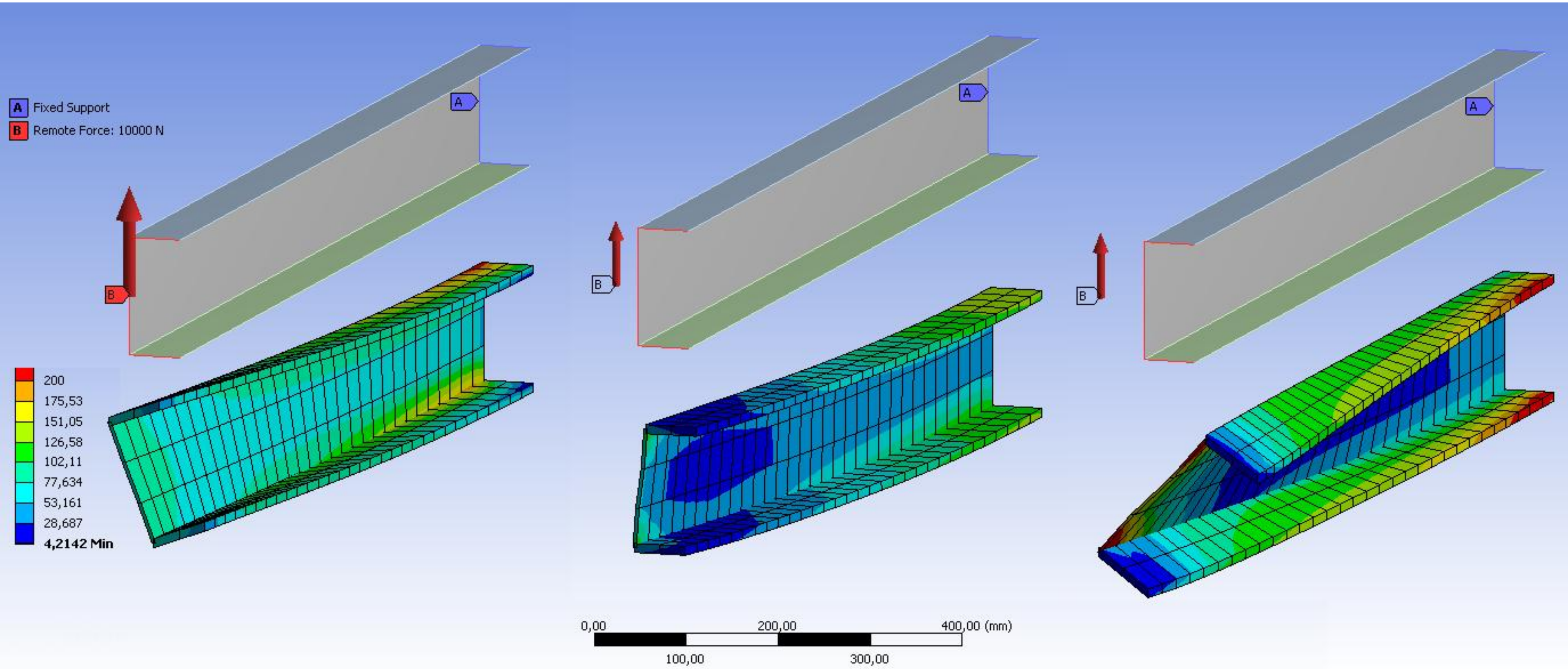
SHEAR Centre

UNIT - 5

SHEAR STRESSES RELATED QUESTIONS

- shear flows due to the shear force, with no torsion;
- <u>shear center;</u>
- torsion of closed contour;
- torsion of opened contour, restrained torsion and deplanation;
- shear flows in the closed contour under combined action of bending and torsion;
- twisting angles;
- shear flows in multiple-closed contours.

SHEAR CENTER - ILLUSTRATION



PROPERTIES SHEAR CENTER

1. The transverse force applied at shear center does not lead to the torsion of thin-walled beam.

2. The shear center is a center of rotation for a section of thin-walled beam subjected to pure torsion.

3. The shear center is a position of shear flows resultant force, if the thin-walled beam is subjected to pure shear.

CALCULATION OF SHEAR CENTER POSITION FOR OPENED CROSS SECTION

Way of calculation:

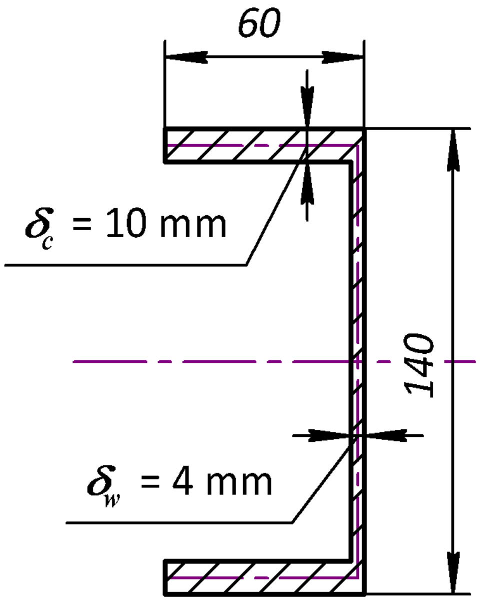
1) calculate shear flows q from the arbitrary chosen force Q_y;
2) calculate the moment of shear flows $M_C(q)$ about some point C;
3) the X coordinate of SC will be

$$X_{SC} = X_C + \frac{M_C(q)}{Q_y}$$

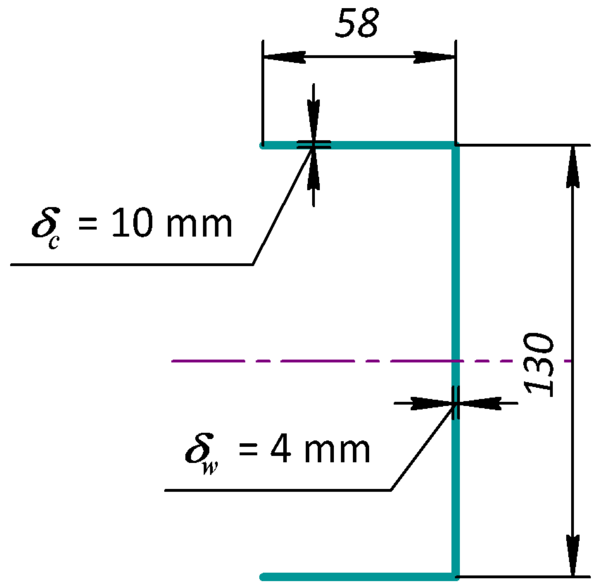
4) make similar calculations to find Y_{SC}.

CALCULATION OF SHEAR CENTER POSITION FOR OPENED CROSS SECTION - EXAMPLE

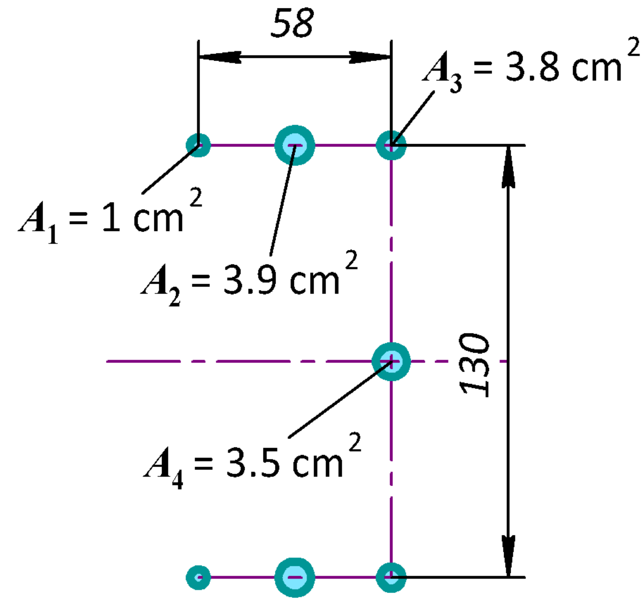
Given cross section



Continuous approach



Discrete approach

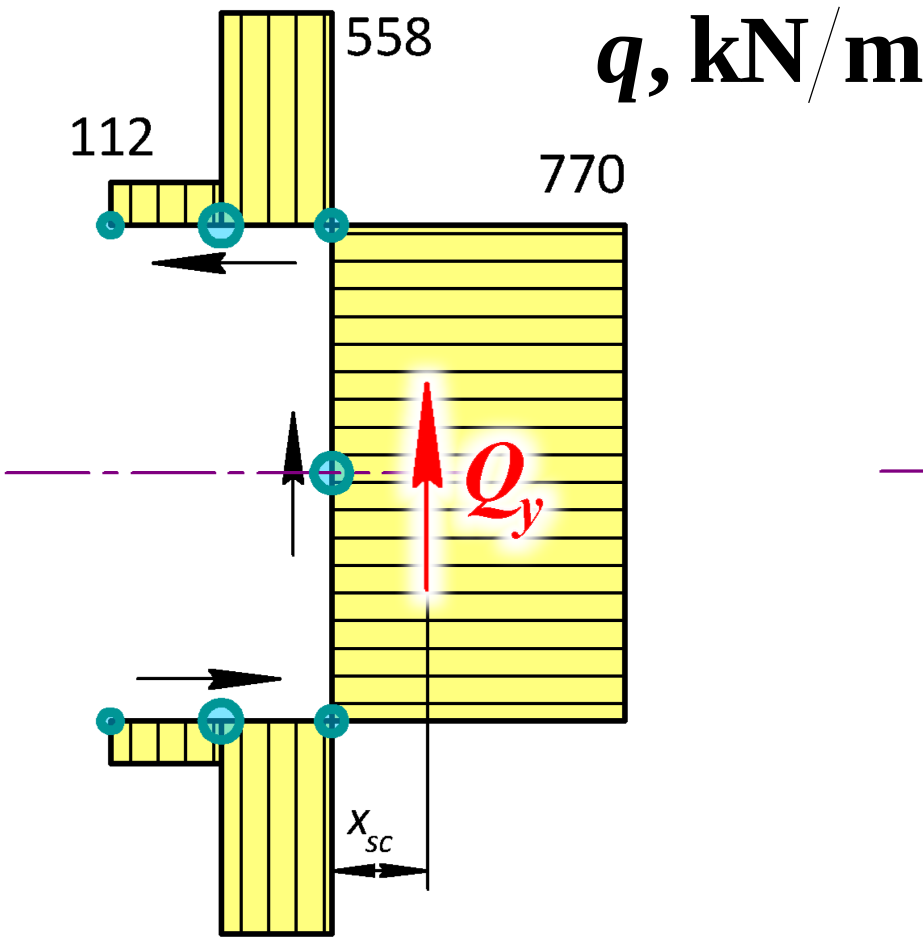


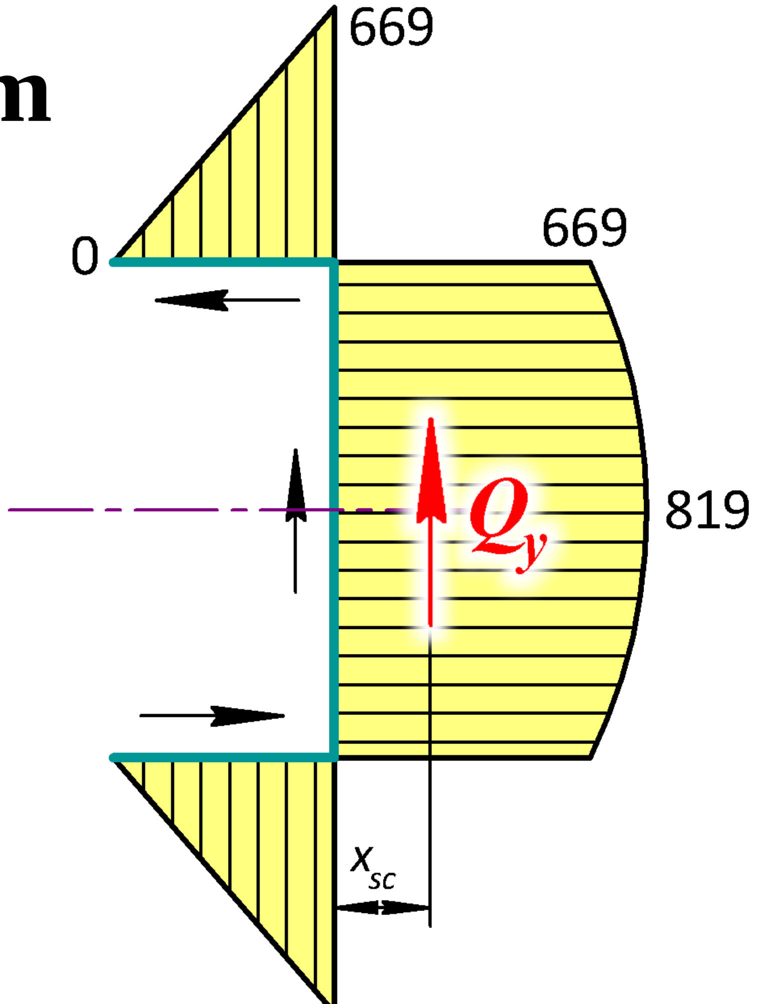
Value of vertical force is chosen arbitrary (100 kN).

CALCULATION OF SHEAR CENTER POSITION FOR OPENED CROSS SECTION - EXAMPLE

Discrete approach

Continuous approach





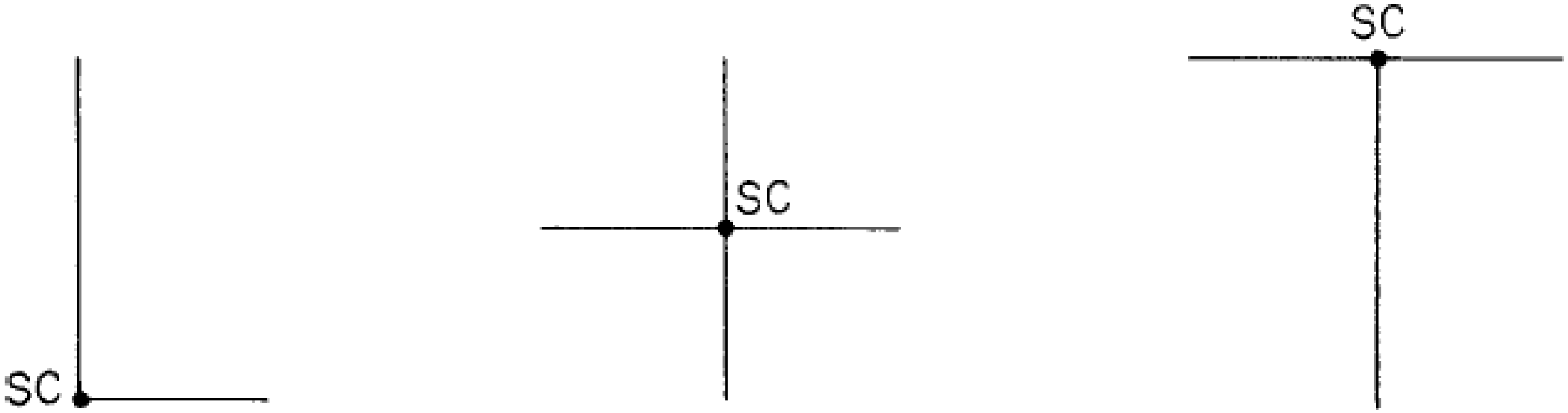
CALCULATION OF SHEAR CENTER POSITION

Properties of symmetrical cross sections:

1) The shear center lays on the axis of symmetry.

2) Thus, for twice symmetrical section the shear center is the point of symmetry axes intersection.

If the cross section is composed of segments converging in a single point, this point is the shear center:



CALCULATION OF SHEAR CENTER POSITION FOR CLOSED CROSS SECTION

For closed cross section, we use equilibrium equations for moments to find q_0. Thus, moment of shear flows $M_C(q)$ would depend on the position of force Q_y and would not be useful to find X_{SC}.

We find the shear center position from the condition that the twist angle should correspond to the torsional moment which is calculated as Q_y multiplied by the distance to shear center:

$$M_T = Q_y \cdot \left(X_Q - X_{SC} \right) = \frac{d\phi}{dz} \cdot G \cdot I_\rho$$

CALCULATION OF SHEAR CENTER POSITION FOR CLOSED CROSS SECTION

Thus, we need to calculate the torsional rigidity of wingbox $G{\cdot}I_\rho$ and relative twist angle $d\phi/dz$:

$$G \cdot I_\rho = \frac{\Omega^2}{\oint \frac{dt}{G \cdot \delta}}$$

$$\frac{d\phi}{dz} = \oint \frac{q \cdot \bar{q}}{G \cdot \delta} dt, \quad \bar{q} = \frac{1}{\Omega}$$

We will study these calculations in detail next semester.

CALCULATION OF SHEAR CENTER POSITION FOR CLOSED CROSS SECTION - EXAMPLE