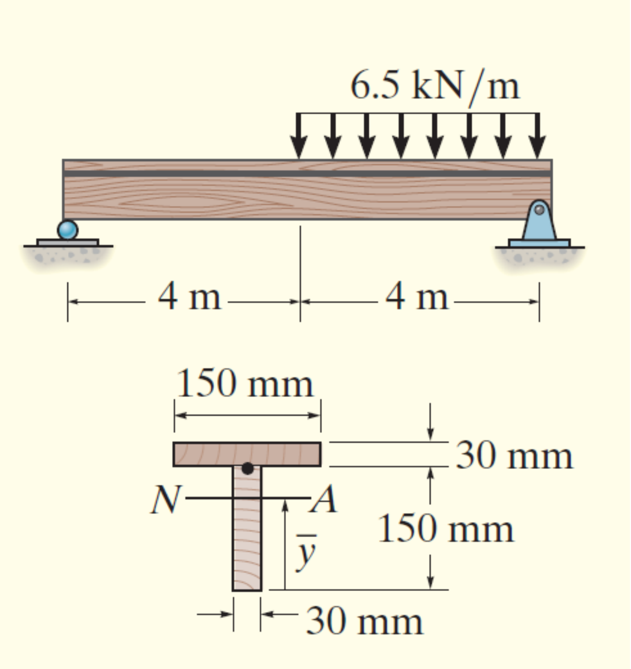
Structural Mechanics
Exercises – shear stresses

Prof. Anastasios P. Vassilopoulos
Ecole Polytechnique Fédérale de Lausanne

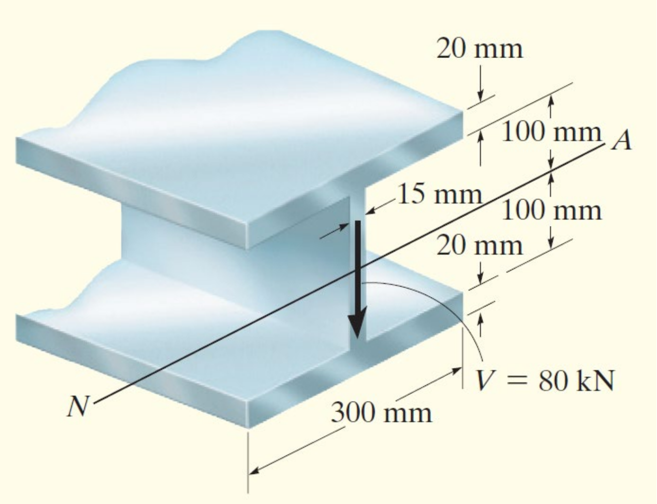
Exercise 1:

The beam shown in the figure is made from two boards. Determine the maximum shear stress in the glue necessary to hold the boards together along the seam where they are joined.



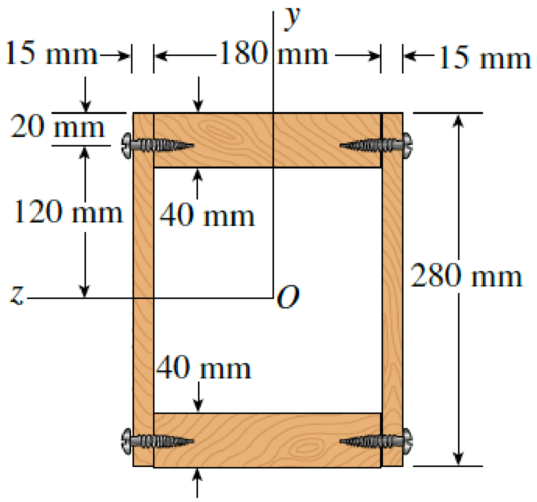
Exercise 2:

A steel wide-flange beam has the dimensions shown in the figure.
It is subjected to a shear of $V = 80kN$,
Plot the shear-stress distribution acting over the beam's cross section.

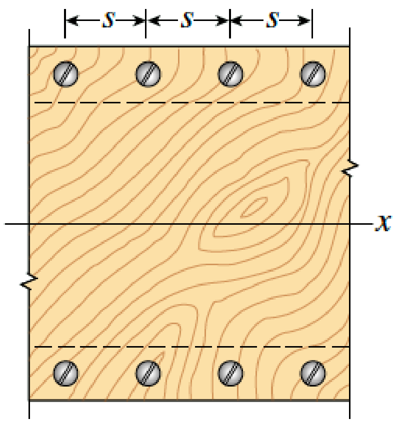


Exercise 3: Shear Flow

- A wood box beam is constructed of two boards, each $40 \times 180mm^2$ in cross section, that serve as flanges and two plywood webs, each 15mm thick. The total height of the beam is $280mm$.
- The plywood is fastened to the flanges by wood screws. The allowable shear force of each screw is $F = 800N$.
- If the shear force V acting on the cross section is 10.5kN, determine the maximum permissible longitudinal spacing s of the screws.



(a) Cross section



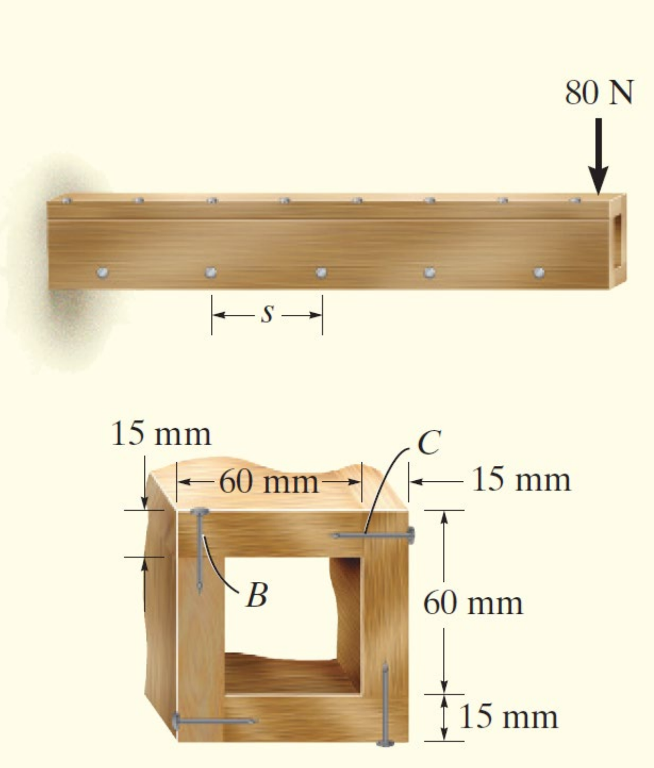
(b) Side view

Exercise 4:

A box beam is constructed from four boards nailed together as shown in as shown in the figure.

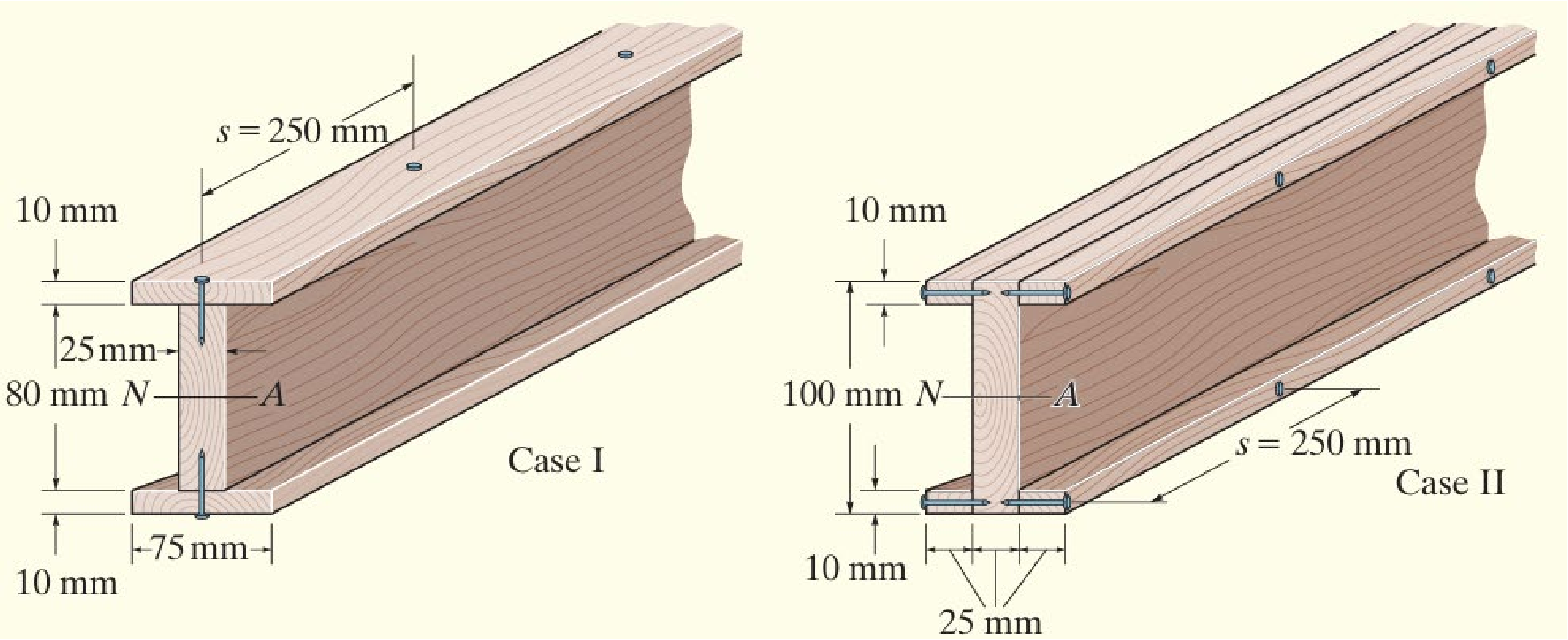
Each nail can support a shear force of 30 N.

Determine the maximum spacing *s* of the nails at *B* and at *C* to the nearest 5 mm so that the beam will support the force of 80 N.

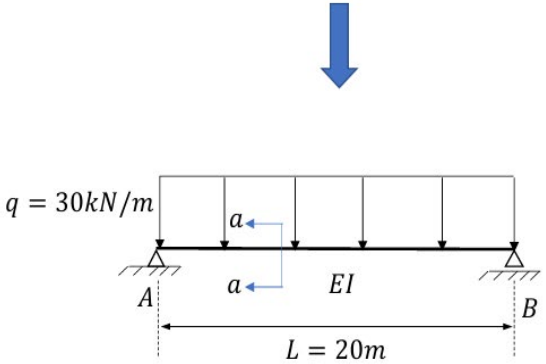


Exercise 5:

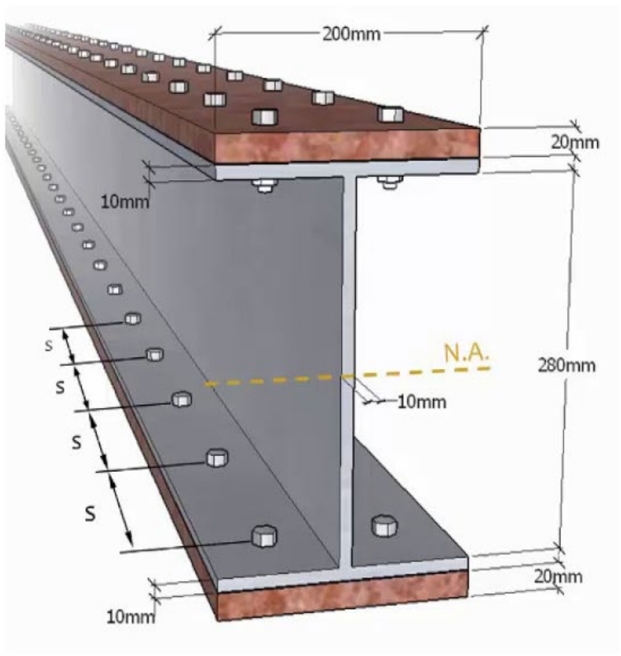
Nails having a shear strength of $900\ N$ are used in a beam that can be constructed either as in Case I or as in Case II, as shown in the figure below. If the nails are spaced at $250\ mm$, determine the largest vertical shear that can be supported in each case so that the fasteners will not fail.



Exercise 6:



Section a-a

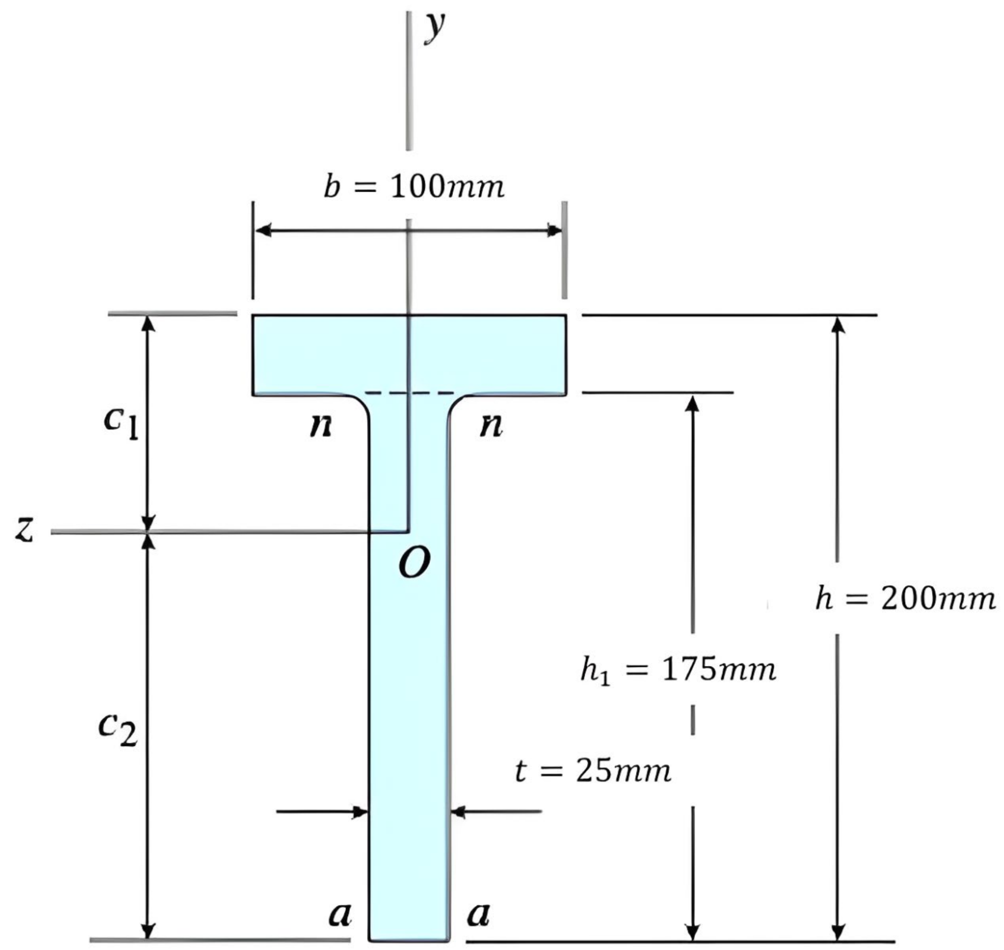


- The pedestrian bridge shown in the figure below is made of two built-up steel girders that are bolted to top and bottom with two 20-mm thick plates as shown in the figure. Each girder sustains a uniform gravity load $q = 30\ kN/m$. The plates are bolted to the girder with structural bolts. Their shear resistance is $30\ kN$. Determine the spacing, s, such that the maximum expected shear force V in the girder can be sustained from the built-up steel girder.

Exercise 7:

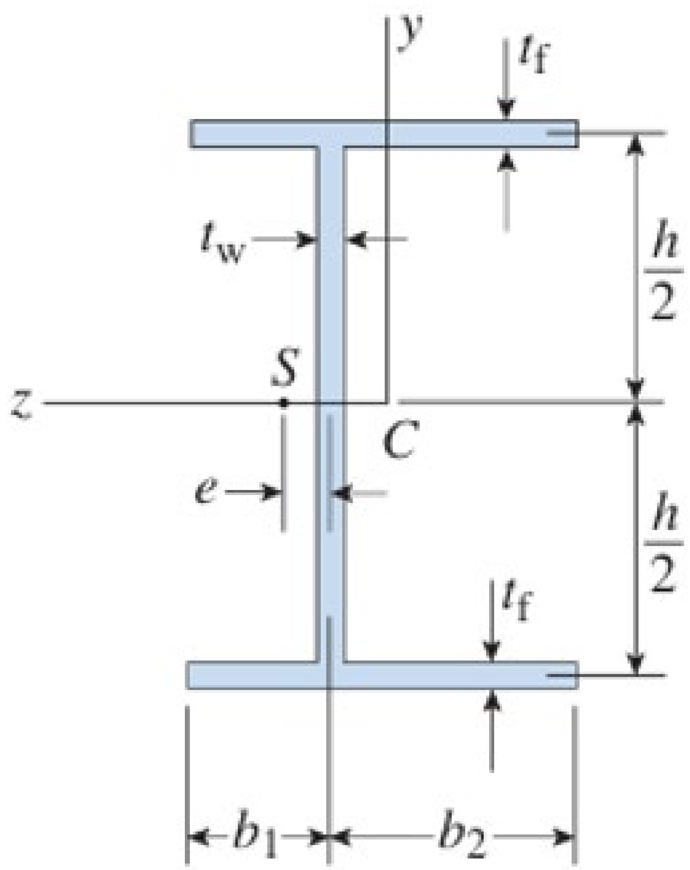
A beam having a T-shaped cross section is subjected to a vertical shear force $V = 50\,kN$. The cross-sectional dimensions are $b = 100\,mm, t = 25\,mm, h = 200\,mm$, and $h_1 = 175\,mm$. Determine the shear stress, τ_1, at the top of the web (level nn) and the maximum shear stress $\tau_{\max}$.

(disregard the areas of the fillets by approximating the shapes into rectangles).



Exercise 8:

The cross section of an unbalanced wide-flange beam is shown in the figure. Derive the following formula for the distance e from the centerline of the web to the shear center S:

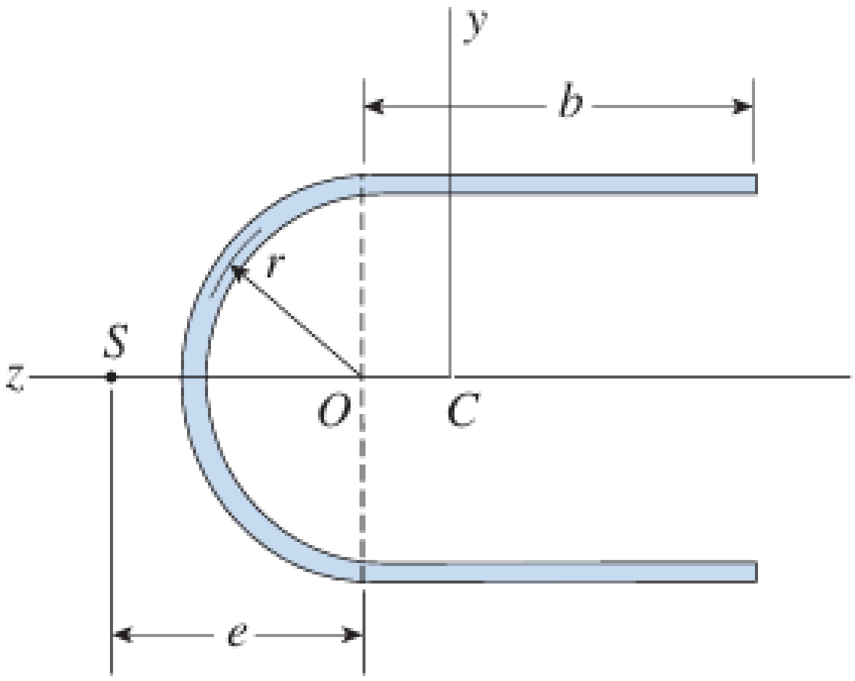


$$e = \frac{3t_f(b_2^2 - b_1^2)}{ht_w + 6t_f(b_1 + b_2)}$$

Also, check the formula for the special cases of a channel section ($b_1 = 0$ and $b_2 = b$) and a doubly symmetric beam ($b_1 = b_2 = b/2$).

Exercise 9:

A U-shaped cross section of constant thickness is shown in the figure. Derive the following formula for the distance e from the center of the semicircle to the shear center S:



$$e = \frac{2(2r^2 + b^2 + \pi br)}{4b + \pi r}$$

Also, plot a graph showing how the distance e (expressed as the nondimensional ration e/r) varies as a function of the ration b/r. (Let b/r range from 0 to 2.)