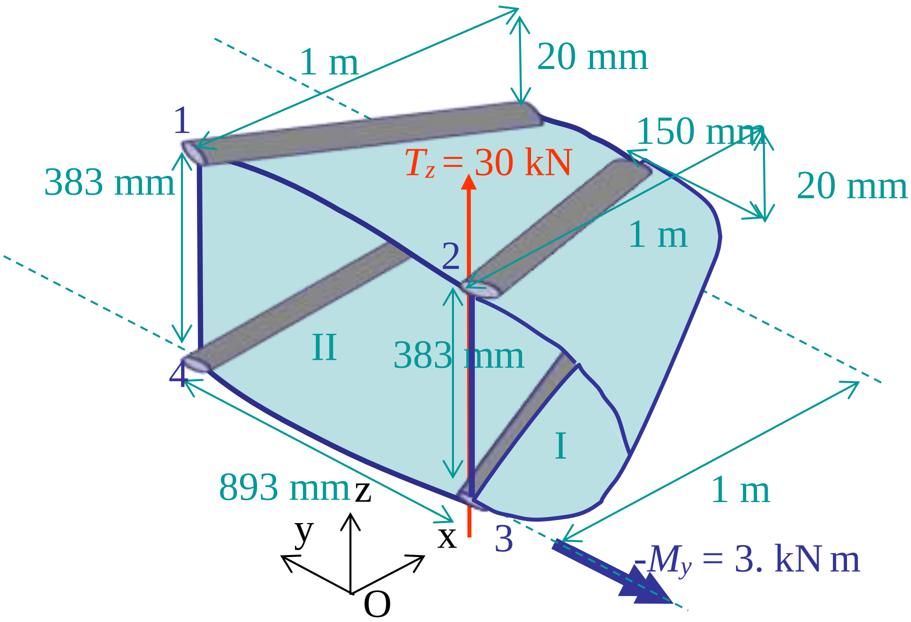
LIÈGE université

Aeronautical Structures (MECA0028-1)

June 2019

Question n° 1



The two-cell wing depicted here above has the largest cross-section properties reported in the three Tables here below.

Wall	Length (mm)	Thickness (mm)	Shear modulus (GPa)
12, 34	900	0.5	22
23(	1148	0.5	22
23|	383	1.5	22
14	383	1.5	71

Boom	Section (mm^2)
1, 2	750
3, 4	500

Cell	Area (mm^2)
I	155 000
II	399 000

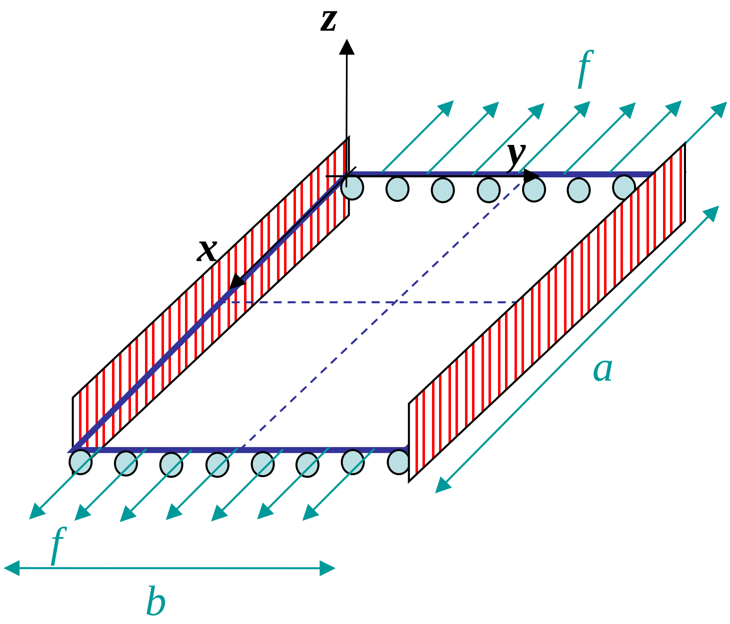
We consider the following assumptions

- The tapper has a single symmetry effect, but the cross-section is not symmetrical because of the booms distribution;
- The booms carry the direct stress (due to bending) only;
- The skin panels sustain the shear stress only;
- The largest cross-section is subjected to the following loading:
  - A shear load T_z applied on wall 23 ;
  - A bending moment M_y .

You are requested to compute:

A) The location of the bending inertia center;
B) The second moment of area I_{yy}, I_{yz} and I_{zz} ;
C) The shear flow in each wall (be careful on the inertia center of the cross-section) ;
D) The cross-section twist rate ;
E) The shear stress in each wall.

Question n° 2



Let a plate be, see figure besides:

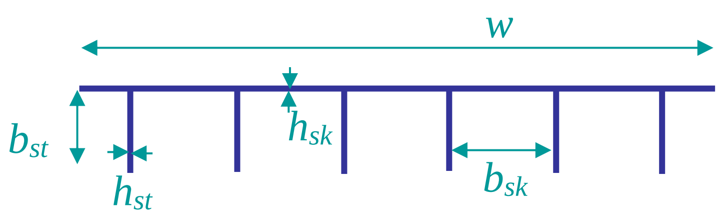
- Of uniform thickness h_0;
- Clamped at the two edges $y = 0$ and $y = b$;
- Simply supported at the two edges $x = 0$ and $x = a$;
- Loaded by a load f per unit length parallel to Ox, and positive in tension.

You are requested to

A) Evaluate, in terms of the lengths a and b, the critical buckling load f_{CR} of the plate. To this end, you are invited to

- Consider an out-of-plane displacement $w = \sum_{m=1}^{\infty} A_m \sin\left(\frac{m\pi x}{a}\right) g\left(\frac{y}{b}\right)$ in which $g\left(\frac{y}{b}\right)$ is a function satisfying the boundary conditions;
- Identify the critical load f_{CR} from the stationary point of the internal energy ;
- Express the critical load in terms of a buckling coefficient k, which depends on the ratio $\frac{mb}{a}$ only;
- To represent graphically the buckling coefficient k in terms of $\frac{a}{b}$.

B) Design the stiffened panel represented here below. In particular you are invited to evaluate the distance b_{sk} and the stringer height b_{st} such that the yield stress is reached before the buckling critical stress.



To this end you will consider

- That both the stringers and the panels are made of aluminum alloy with a Poisson ratio $\nu = 0.3$, a Young's modulus $E = 70$ GPa, and a Yield stress $\sigma^e = 400$ MPa;
- That the panel length a is much longer than the panel and stringer widths b_{sk} and b_{st} respectively;
- That both the stringers and the panels have a thickness h_{st} and h_{sk} of 2 mm;
- Successively two cases of boundary condition between the stringers and the panels: clamping and simply supported.