ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2019 SESSION

Open-book examination Calculators: only authorized models Duration: 3 hours

16-MC-A6 Advanced Strength of Materials

There are (4) questions presented on two pages, each question is worth 25 points.

Question 1 (25 points)

The beam OABC in figure 1 has a constant cross section, is fixed at O and is simply supported in the horizontal direction at B.

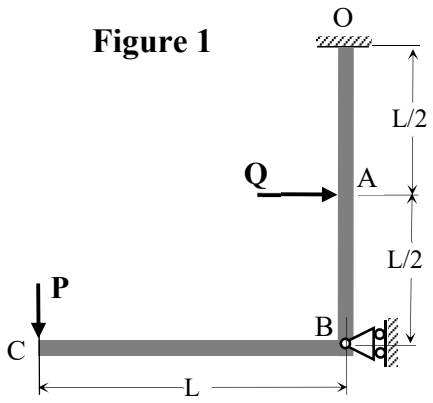
The beam is subjected to a load **Q** to the right at A and a load **P** downward at C.

By neglecting the energies due to shear force,

a) Calculate the reaction force at B as function of P, Q, E (modulus of elasticity) and I (second moment of cross section area).

b) Let $P = Q = 1200$ N, $L = 1200$ mm and $E*I = 20*10^{11}$ N·mm^2, calculate the deflection at A.

Figure 1

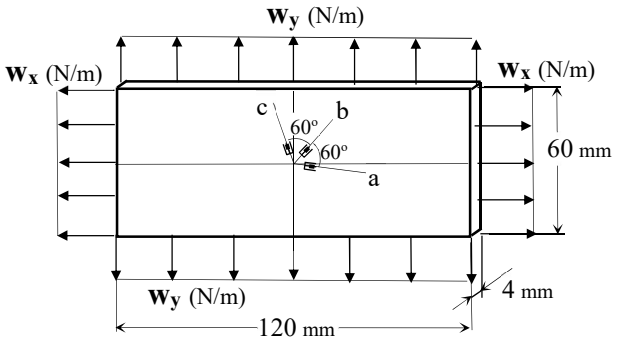


Question 2 (25 points)

The 60° strain rosette a, b and c is glued on a rectangular plate subjected to a uniform distributed loads $\mathbf{w_x}$ and $\mathbf{w_y}$ (Figure 2).

The recorded deformations of the rosette are $\varepsilon_a = 300*10^{-6}$, $\varepsilon_b = 370*10^{-6}$ and $\varepsilon_c = 230*10^{-6}$. The elastic properties of material are Young's modulus $E = 2*10^5$ MPa and Poisson's ratio $\nu = 0.3$.

Figure 2



Calculate the principal stresses and deduct for the loads $\mathbf{w_x}$ and $\mathbf{w_y}$.

Question 3 (25 points)

The beam OABCD is simply supported at three points O, B and D. The beam is subjected to a load **P** downward at A and a load **2·P** downward at C.

The details of the cross section of the beam are given in figure 3. Note that the area of the rectangle and the rectangular tube are equal.

The material of the beam is elastic perfectly plastic with the yield stress $S_Y = 250$ MPa.

Calculate the fully plastic load **P** (P_P) of this beam.

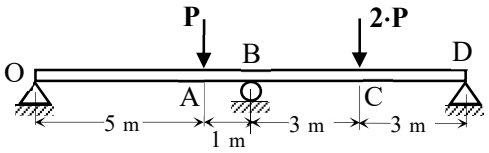
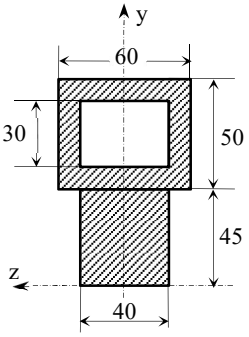


Figure 3

Cross section of beam OABCD

Dimensions in mm



Question 4 (25 points)

a) Considering only buckling in the plane of the structure ABC shown in figure 4, determine the value of the angle **θ** between 0° and 90° for which the allowable magnitude of the load **P** is maximum.

b) Determine the corresponding maximum value of **P** for a factor of safety of 2.0.

Use the modulus of elasticity $E = 2*10^5$ MPa and the yield stress $S_Y = 250$ MPa.

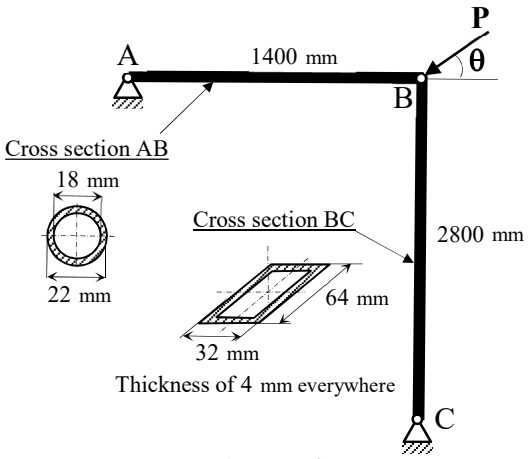


Figure 4