ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2018 SESSION

Open book examination Calculators: Models allowed only Duration of the examination: 3 hours

16-MC-A6 Advanced Strength of Materials

There are four (4) questions presented on two pages.

Question 1 (25 points)

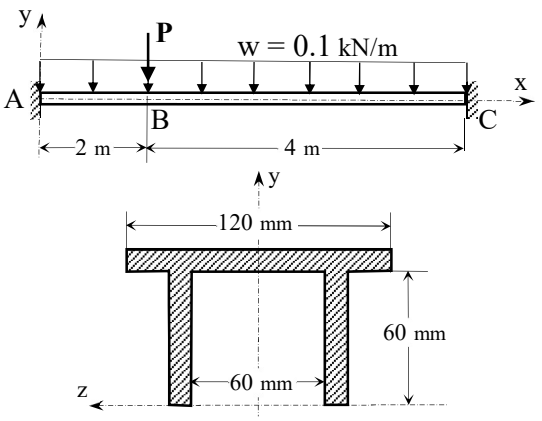
The beam ABC is fixed at points A and C.

The beam is subjected to a load **P** downward at B and a uniform distributed load w = 0.1 kN/m downward.

The dimensions of the cross section of the beam are given in figure 1.

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

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



Thickness of 10 mm everywhere

Figure 1

Question 2 (25 points)

The shaft ABCD of diameters $d_{AB} = d_{CD} = 44$ mm and $d_{BC} = 52$ mm is fixed at points A and D.

The shaft is subjected to two torques: T_B = 0.2 kNm at B and T_C = 0.35 kNm at C as show in figure 2.

The material has a rigidity modulus G = 80000 MPa. Calculate:

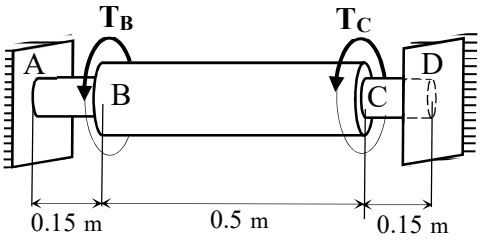


Figure 2

a) the maximum shear stress in the shaft;

b) the rotation angle at B.

Question 3 (25 points)

The beam ABCD has a section of the square tube 50.8×50.8×6.35 mm, is fixed at point D and simply supported in the vertical direction at point A.

A vertical load P = 12 kN is applied at point C as show in figure 3.

The material has a modulus of elasticity E = 200000 MPa.

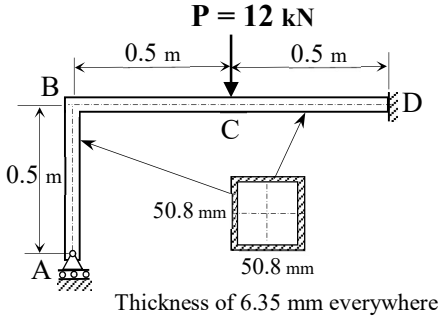


Figure 3

By neglecting the energies due to shear force and the axial force, calculate the vertical displacement at point C.

Question 4 (25 points)

A piping of the outer diameter D_e = 52 mm and the inner diameter D_i = 48 mm is subjected simultaneously to an internal pressure **p** and two loads F_1 = 0.25 kN (F_1 is parallel to the z axis) and F_2 = 0.5 kN (F_2 is parallel to the x axis).

A strain gauge is glued at the outer surface at point **j** (**j** is on the z axis) in the section A and oriented with an angle of 30° with respect to the x axis.

The elastic properties of material are Young's modulus E = 200000 MPa and Poisson's ration ν = 0.3.

a) Calculate the stress components σ_x, σ_y and τ_{xy} at point **j** in function of the internal pressure **p**.

b) Calculate the internal pressure **p** knowing that the strain recorded with the strain gauge **j** is $\varepsilon_j = 150*10^{-6}$.

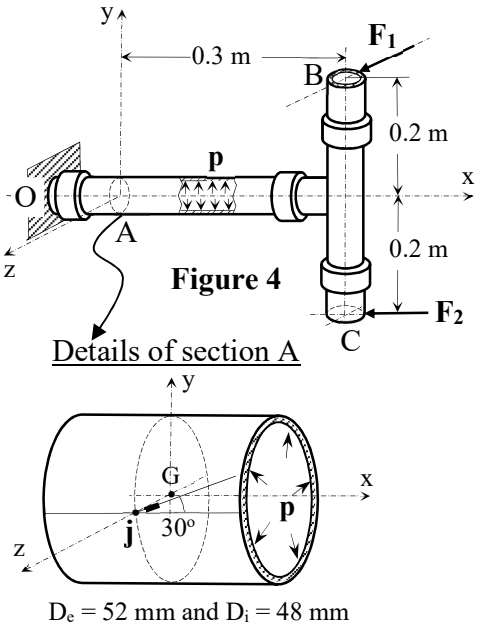


Figure 4