ORDRE DES INGÉNIEURS DU QUÉBEC

SESSION IN MAY 2020

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 OAB illustrated in Figure 1 is fixed at O and simply supported at B in a vertical direction.

The flexural modulus of rigidity is $E{\cdot}I = 4{*}10^6$ Nmm^2 (E is the modulus of elasticity and I is the second moment of cross section area).

A horizontal force P = 5 kN is applied at A.

By neglecting the effect of shear force and the axial force, calculate the reaction at point B.

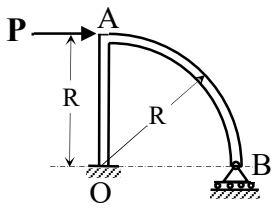

Figure 1

Question 2 (25 points)

The beam OABCD is simply supported at O, A, B, C and D. The beam is subjected to a load P = 10 kN downward at B in the middle of the interval **L**.

The dimensions of the cross section of the beam are given in figure 2.

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

Calculate the value of **L** for a safety factor of 2 at the limit state of this beam.

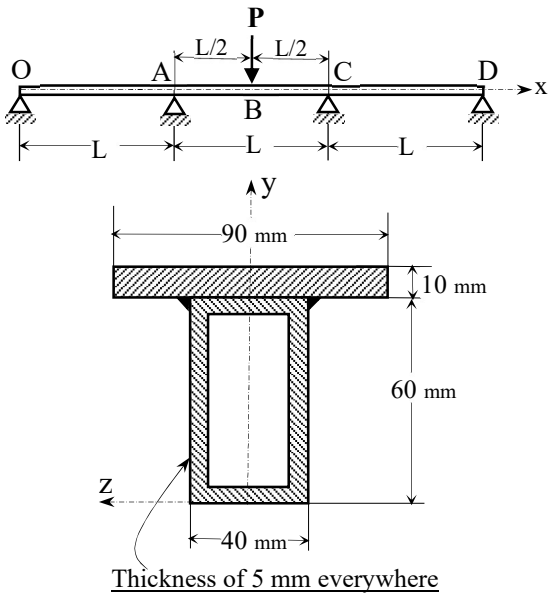

Figure 2

Question 3 (25 points)

Three strain gauges a, b and c (Figure 3) glued on the free surface (i.e. in plane stress state) of the steel part registered the following strains when the part is loaded: $\varepsilon_a = 600*10^{-6}$, $\varepsilon_b = 450*10^{-6}$ and $\varepsilon_c = -75*10^{-6}$.

The elastic properties of steel are: Modulus of elasticity $E = 2*10^5$ MPa; Poisson's ratio $\nu = 0.3$ and Yield stress $S_Y = 250$ MPa. Calculate:

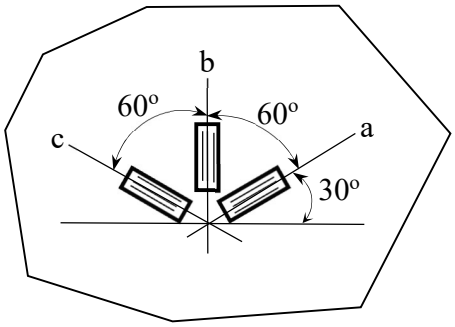

Figure 3

a) the principal strains,

b) the principal stresses of this stress state,

c) its safety factor according to the Von-Mises yield criteria.

Question 4 (25 points)

The rigid beam OACE is supported by two bars AB and CD.

The joints O, B and D are supported in both directions.

The bar AB has a section of the circular tube (d_{out} = 24 mm and d_{int} = 20 mm).

The bar CD has a section of the rectangular tube (50.8×25.4×3.18) mm (Figure 4).

The material of AB and CD has a modulus of elasticity $E = 200000$ MPa and a yield stress $S_Y = 250$ MPa.

Calculate the allowable horizontal load **P** applied at point E for a safety factor of 2.

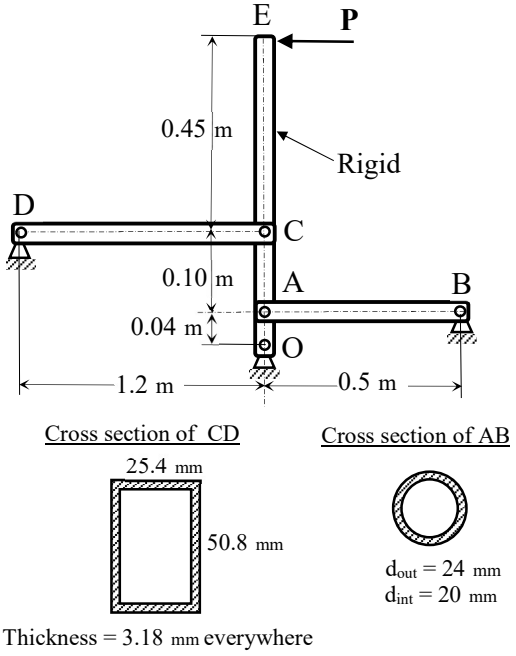

Figure 4