ME 7112: FINITE ELEMENT METHOD - Fall 2023

Assignment 1 (Due by 11:59 pm on 2023/09/25 Mon.)
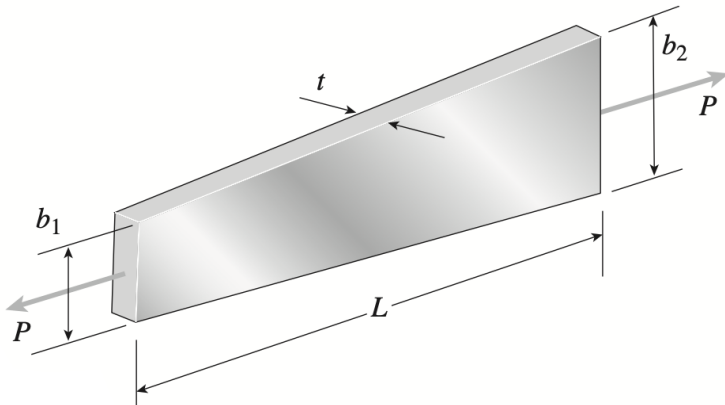
Problem 1

A flat bar of rectangular cross section, length L, and constant thickness t is subjected to tension by forces P (see figure). The width of the bar varies linearly from b_1 at the smaller end to b_2 at the fixed end. Assume that the angle of taper is small.

1. Derive the following formula for the elongation of the bar:

$$\delta = \frac{PL}{E\,t\,(b_2 - b_1)} \ln\frac{b_2}{b_1}$$

2. Solve the elongation by your FEM code, assuming $L = 5$ ft, $t = 1.0$ in., $P = 25$ k, $b_1 = 4.0$ in., $b_2 = 6.0$ in., and $E = 30 \times 10^6$ psi.

3. Please check your finite element results by comparing the calculation in 2. with the analytical solution in 1.

4. Make some comments.

Problem 2

The fixed-end bar ABCD consists of three prismatic segments, as shown in the figure. The end segments have cross-sectional area $A_1 = 840$ mm^2 and length $L_1 = 200$ mm. The middle segment has cross-sectional area $A_2 = 1260$ mm^2 and length $L_2 = 250$ mm. Loads P_B and P_C are equal to 25.5 kN and 17.0 kN, respectively.

1. Determine the reactions R_A and R_D at the fixed supports by hand.

2. Determine the compressive axial force F_{BC} in the middle segment of the bar by hand.

3. Solve 1. by your FEM code.

4. Solve 2. by your FEM code.

5. Please check your finite element results by comparing the calculation in 3. and 4. with the analytical solution in 1. and 2. correspondingly.

6. Make some comments.
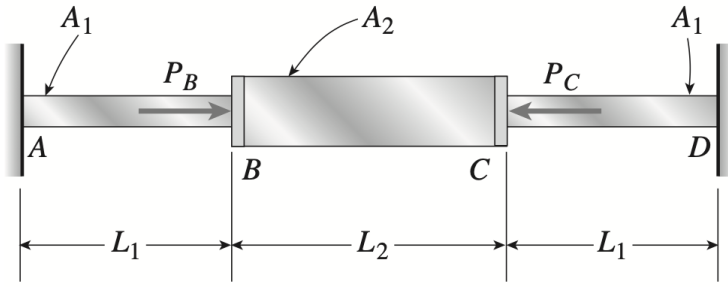
Problem 3

A flat bar with a circular hole shown in the figure is subjected to tensile forces $P = 2.5$ kN. The bar has thickness $t = 5.0$ mm.

1. Determine the maximum stress for hole diameters $d = 12$ mm if the width $b = 60$ mm by hand along with the stress-concentration factor K chart below.

2. Solve 1. by your FEM code.

3. Please check your finite element results by comparing the calculation in 2. and with the analytical solution in 1.

4. Make some comments.
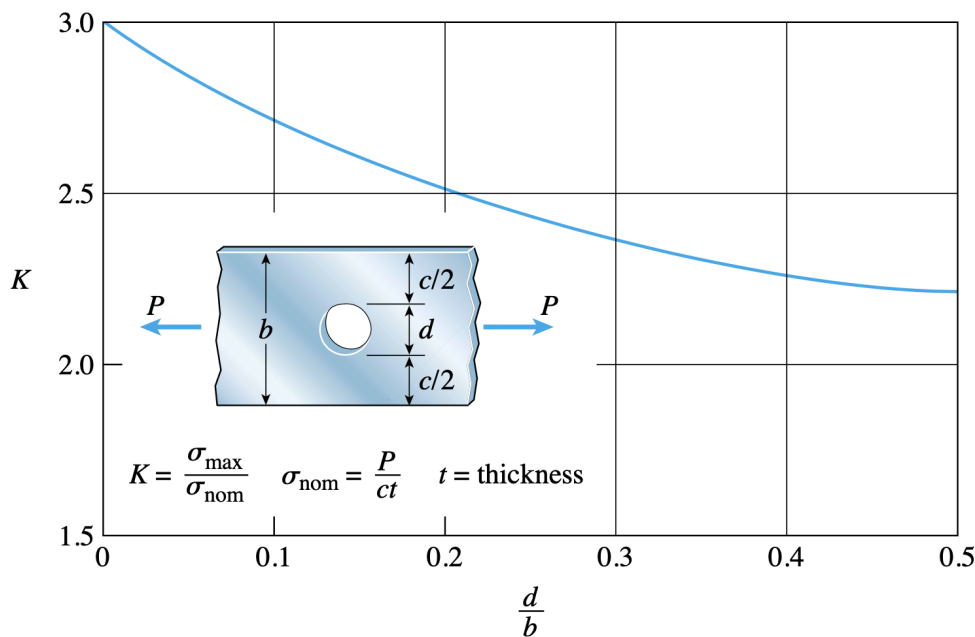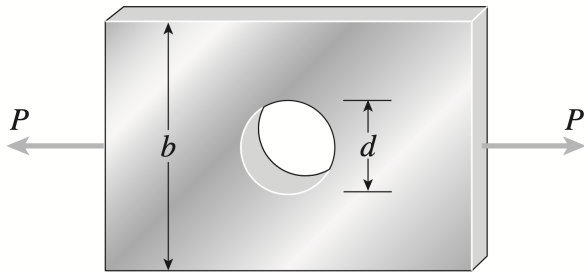
Problem 4

A flat bar with shoulder fillets shown in the figure is subjected to tensile forces $P = 2.5$ kN. The bar has thickness $t = 5.0$ mm.

1. Determine the maximum stress for fillet radii $R = 6$ mm if the bar widths are $b = 60$ mm and $c = 40$ mm by hand along with the stress-concentration factor K chart below.

2. Solve 1. by your FEM code.

3. Please check your finite element results by comparing the calculation in 2. and with the analytical solution in 1.

4. Make some comments.

$R = \text{radius}$

$$K = \frac{\sigma_{max}}{\sigma_{nom}} \qquad \sigma_{nom} = \frac{P}{ct}$$

$t = \text{thickness}$

$$R = \frac{b-c}{2}$$

$$\frac{b}{c} = 2$$

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