Department of Applied Mechanics and Biomedical Engineering, Indian Institute of Technology, Madras.

Fundamentals of Finite Element Analysis (AM 5450)

Assignment 7 – 2D Triangle and Quad Finite elements

Submission Date: 13 October 2024

Instructions:

I. MATLAB/PYTHON scripts used to prepare plots/figures/results should be attached with your answer.
II. Scan all the pages of your hand-written answers, MATLAB/PYTHON scripts, output results, and figures into a PDF file.
III. Submissions sent after the deadline will not be evaluated.

Question 1

Consider a cantilever beam subjected to a surface shear force of 500 kN/m and a tip load of 600 N as shown in Figure 1. Solve this 2-D plane-stress elasticity problem using constant strain triangular (CST) elements. The Young's modulus of elasticity and Poisson's ratio for the beam material are 80 GPa and 0.3, respectively. Compare the obtained FE (i) Displacements at each node, as well as the (ii) Strains and (iii) Stresses over the elements with the solution from ABAQUS/ANSYS in the tabular form. Plot the deformed shape and contour plots of these results. (Generate mesh data – node co-ordinates and node-element connectivity - in ABAQUS/ANSYS to use in your FE code.)

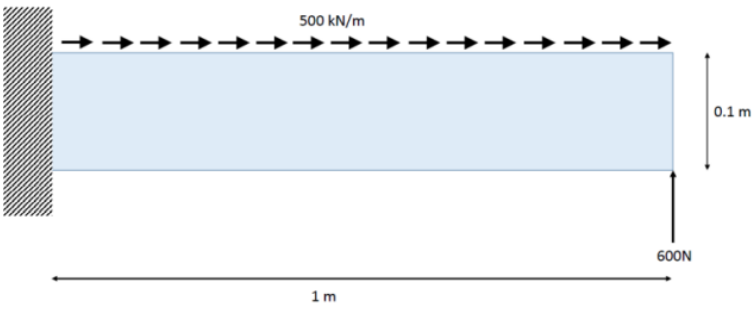

Figure 1

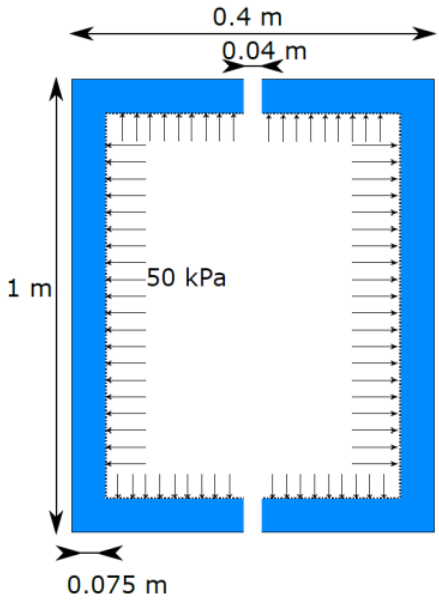

Figure 2

Question 2

Consider a cylindrical pressure vessel of height 1 m with closed ends as shown in Figure 2. The outer diameter is 0.4 m, and the diameter of the holes present in the end caps is 0.04 m. If the vessel is subjected to a uniform internal pressure of 50 kPa, determine the longitudinal and hoop stresses developed in the structure using CST elements. Assume a wall thickness of 75 mm for the vessel. Compare the results with the analytical solution for thin-walled pressure vessels and write your comments. (Generate mesh data – node co-ordinates and node-element connectivity - in ABAQUS/ANSYS to use in your FE code.)

Question 3

Consider two-dimensional heat flow over an L-shaped body with thermal conductivity k =45 $W/m\text{-}deg$C shown in Figure 3. The bottom is maintained at T_0 = 110 degC. Convection heat loss takes place on the top where the ambient air temperature is 20 degC and the convection heat transfer coefficient h = 55 $W/m^2\ deg$C. The right side is insulated. The left side is subjected to heat flux at a uniform rate q_0 = 8000 W$/m^2$. Heat is generated in the body at a rate Q= 5 X 10^6 W$/m^3$. Plot the contour of temperature distribution in the body using 4-node quad elements. Select 3 levels of mesh density and plot the convergence trend for the temperature at the co-ordinate (3,3).

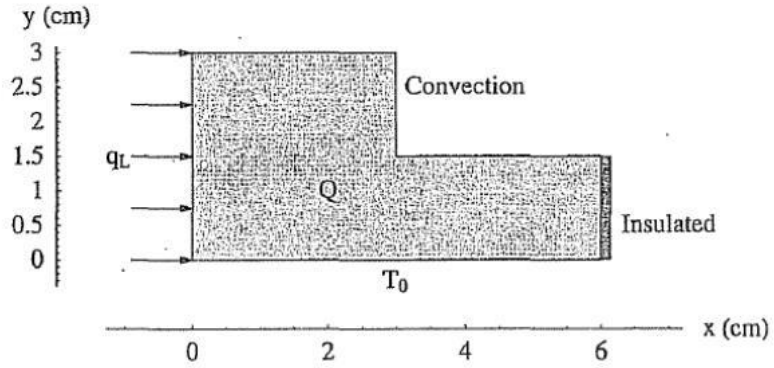

Figure 3