AE4132 - Finite Element Analysis

Spring 2021

Homework 5: Rectangular Elements for Stress Analysis

Due Friday, April 16^{th} 2021

1 Problem 1

Write a finite element program that utilizes rectangular elements as developed in class. The program should be able to read input files with the format described in Appendix 1. Five meshes, representing different levels of discretization of a clamped beam loaded axially are provided.

1. For each mesh, please provide:
   (a) Plots showing deformed configuration (amplified if necessary for visualization purposes).
   (b) Contour plots of all components of strain and stress over the domain.
2. Also, provide the following convergence plots:
   (a) Maximum nodal displacement over the domain.
   (b) Maxim von Mises stress over the domain.
   (c) Strain energy of the entire beam.
3. Discuss your findings regarding convergence.

NOTES:

- Do not worry about units, assume all units are provided consistently.
- For convergence plots, depict the total number of elements on the x-axis and the other variable of interest on the y-axis. Also, explore different scales for the axis to get more insights (e.g., log-log, semi-log, etc.)

Appendix 1: Input file format

```
nnodes
x_1 y_1 rx_1 ry_1 fx_1 fy_1
x_2 y_2 rx_2 ry_2 fx_2 fy_2
.
.
.
x_nnodes y_nnodes rx_nnodes ry_nnodes fx_nnodes fy_nnodes
nels
n1_1 n2_1 n3_1 n4_1 E_1 nu_1 h_1
n1_2 n2_2 n3_2 n4_2 E_2 nu_2 h_2
.
.
.
n1_nels n2_nels n3_nels n4_nels E_nels nu_nels h_nels
```

Where `nnodes` denotes the total number of nodes in the structure, `(x_i, y_i)` the coordinates of node `i`, `(rx_i, ry_i)` the constraints in the x and y directions for node `i` (1 means constrained, 0 free to move), and `(fx_i, fy_i)` the x and y component of the force applied at node `i`. Also, `nels` represents the number of elements in the structure, `(n1_i, n2_i, n3_i, n4_i)` the nodes of element `i` in counterclockwise direction, and `E_i`, `nu_i`, and `h_i` the corresponding Young's modulus, Poisson ratio, and thickness.