ME 475 – Lab #3 Truss Finite Element Analysis

Name: ___________________________
Section: ________

In this lab, you will build a finite element model of a 2D truss structure.

Instructions:


2. Perform the example problem in section 2.3 (stop at 2.3.13, do not rerun the analysis with Abaqus/Explicit).
   a. What, if any, system of units does Abaqus use? ___________
   b. Maximum U2 displacement in the truss: ___________
   c. Maximum S11 stress in the truss: ___________
   d. Minimum S11 stress in the truss: ___________
   e. Safety factor of the truss (assuming \( s_Y = 250 \) MPa): ___________
   f. Will the structure yield under the applied load? ___________

3. Print a contour plot of the S11 component of stress (use the automatically computed scale factor, and use the “quilt” contour display). Show both the deformed and undeformed geometry on the plot. Turn it in with this worksheet.

4. Print a second plot, the same as the first with the 2-component of displacement contours instead of S11 (you will need to use the “banded” contour option). Turn it in with this worksheet.

5. Solve for the internal forces and stresses in the truss by hand. See Instructions for Hand Calculations, below. Include these calculations with this worksheet.
   a. Maximum tensile axial force in the truss: ___________
   b. Maximum compressive axial force in the truss: ___________
6. Compute the critical load under which the members of the truss would buckle. See Model Validation, below. Compare this to the internal forces found by hand calculations.
   a. Critical load for truss members: _____________
   b. Will any truss members buckle? _____________
   c. If so, which members? (You may use the element numbers in Figure 2-14 in the Getting Started with Abaqus: Interactive Edition Manual) _____________
   d. If you built this truss in real-life, and ramped the load from 0 N up until the truss failed, would the truss fail due to buckling or yielding first? The weight of the structure is small compared to the applied load, and the load will be ramped very slowly (so you can neglect the effect of the truss weight and dynamic effects). _____________
   e. At what load value would the truss fail? _____________

7. Based on the results from 2, modify the cross-sectional area (CSA) of the truss members so that the total volume is reduced and (MaxS11) < (MaxS11 from 2).
   a. CSA_1: ________________
      CSA_2: ________________
      CSA_3: ________________
   b. Maximum S11: ________________
   c. Total Volume: ________________
   d. For the new design, include a contour plot of the S11 component of stress with the deformed and undeformed geometry shown on the same plot.
Model Validation:
This structure is statically determinate, so the reactions and internal forces can be found by simple hand calculations. Additionally, it is always good practice to examine the predicted deformed shape of the structure to ensure that boundary conditions are properly satisfied and that the structural deflections are in the expected directions. A good way to verify these motions is to superimpose a properly scaled deformed mesh on the undeformed mesh.

When a truss member carries compressive load, the possibility of buckling should be examined. For buckling analysis, each member in the truss can be considered a pinned column. Hence, Euler’s formula can be used to predict if a member will buckle:

\[ P_{cr} = \frac{\pi^2 EI}{L^2} \]

where I is the second moment of area of the cross-section, E is the Young’s Modulus, and L is the original length of the member.

Instructions for Hand Calculations:

Method of Joints:
- There are 2 reaction forces at A and 1 at C.
- Look at Force and Moment about A: ?Fx=? Fy=? Ma=0. Obtain the reaction forces.
- Look at Joint A: ? Fx=? Fy=0. Obtain axial forces, Tad and Tab.
- Perform similar operations for Joint D, B and E. Obtain all element axial forces.