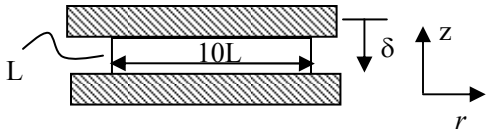
ES 128: Computer Assignment #3

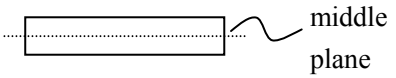
Due in class on Monday, 29 Mar 2010

Problem 1.

In homework #3 problem 4, you were asked to analyze a thin rubber layer pressed between two steel plates. The rubber is welded to the steel plates. The relative squeezing displacement between the two steel plates is δ. Far away from the edge, the rubber is under uniform compression. In the uniform deformation region,



$\varepsilon_z = \delta/L, \varepsilon_r = 0$, and $\sigma_r = \frac{E}{1+\nu}\frac{\nu}{1-2\nu}\varepsilon_z$,

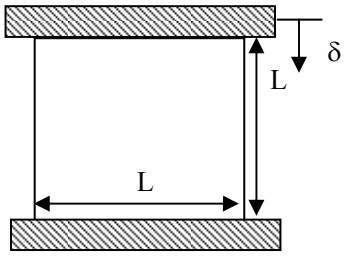


$\sigma_z = \frac{E}{1+\nu}\left(1+\frac{\nu}{1-2\nu}\right)\varepsilon_z$. Due to the constraint of the rigid bodies, the edge will bulge so that the field near the edge is nonuniform. We model this rubber layer as a cylinder. The naming convention in ABAQUS for axisymmetric problem is: 1 stands for *r* (the radial direction), 2 stands for the z direction (axial direction). Use linear quadrilateral element to determine the displacement, stress, and strain components on the middle plane. Plot them and see how uniform field gives way to nonuniform field near the edges. Postprocessing techniques are documented at the end of this assignment.

Model the cylindrical layer using 3D elements. Compare the results obtained with those obtained using axisymmetric elements.

Problem 2.

Similar to the above problem, consider a cylinder squeezed by the two rigid bodies. The relative squeezing displacement between the two rigid bodies is δ. The interfaces between the rigid body and cylinder are rigidly welded. Due to the constraint of the rigid bodies, the cylinder will bulge. Suppose the Poisson's ratio of the cylinder is ν=0.4.



Task 1

Use linear quadrilateral element to determine the deformation shape of the cylinder for two different Young's modulus say E=100MPa, and 100GPa to see whether this deformed shape is dependent on the modulus. You need to plot the shape (displacement u1 along the vertical edge) normalized by δ as a function of z/L.

Task 2

Still for E=100MPa, and 100GPa, find the total reaction force in the z direction at the top of the interface. Compare the magnitude of these two reaction forces and give an intuitive explanation.

Task 3

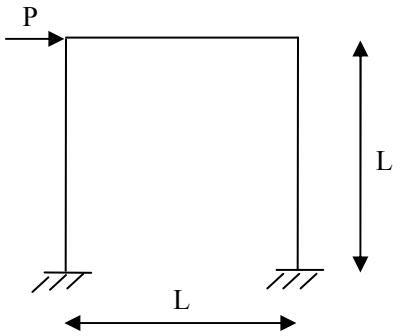
Plot the maximum displacement of u1 for Poisson's ratio ranging from 0~0.45 (You just calculate some ratios, say, 0, 0.1,0.2,0.3,0.4,0.45, and then plot them). Explain the curve trend.

Problem 3.

Task1

Consider a square welded frame structure as shown in the right, where L=1m. The horizontal concentrated load is P=100N. Each of the 3 beam has a square cross-section of width w=2cm. The material is steel with E=200GPa.

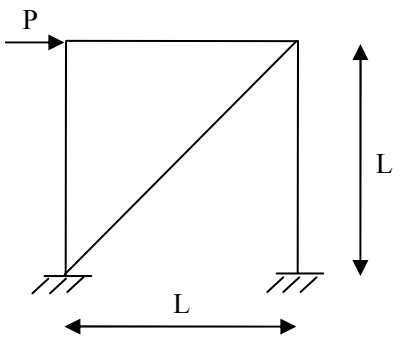
First, use 1 beam element for each beam (3 elements in total). Print the displacements at the top-left and top-right corners. Then, double your mesh density and check that indeed, 1 element per member gives the accurate result. You should have a sketch indicating your node and element numbers.



(Specific details related to beam problem in CAE is attached at the end of this assignment.)

Task2

Now we add a diagonal beam to change the frame into the new structure shown in the right. Repeat the process you have done in Problem 1, namely, use 1 element per member and 2 elements per member to solve this problem. Compare the displacements at the top-left and top-right corners with the results you obtained from Problem 1. In Problem 1 and 2, which one is dominated by stretching (or compression) and which one is dominated by bending?

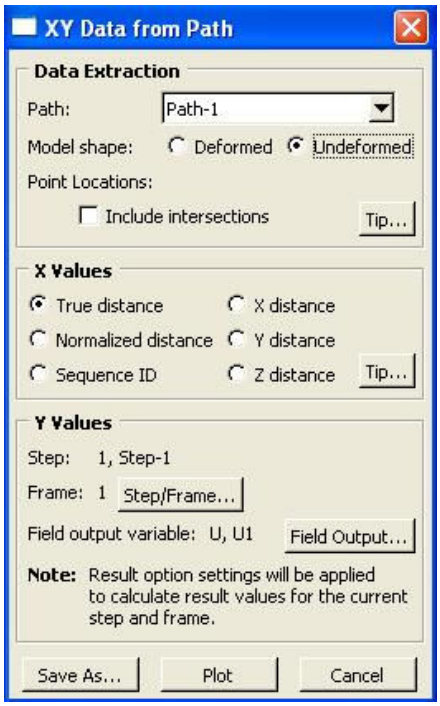


Task3

Instead of quadratic beam elements, use truss elements (T2D2) to solve Task 2. A total of 4 truss elements will be used. Compare the results obtained from truss elements with results from Problem 2. Are they close to each other?

CAE Postprocessing to obtain data along a path

Postprocessing to plot the shape: First you need to define a path in Visualization module. Go to Tools→Path→Create→Give a path name, select Type: node list→Continue→In part instance, write: PART-1-1, (if you did give a name when you create a part. Notice here it is case sensitive.) →Put Node labels, for example, 2:102:2, which means the starting node lable for the path is 2, the last node at the path is 102, the node number increment along the path is 2. →OK. →Go to Tools→Path→Plot Path to see the path you just defined. Go to the left panel and click on the icon "create XY data". →Select source: path→ Notice the following window, Check undeformed, True distance, Select field output variable to be the one you want plot, say U1. →Save As…→Plot.



Click he icon "XY data manager", You can Edit or plot the data you just created. A tip: to copy the data to Excel: Edit the data, then select the data, you can only use Ctrl+c to copy and paste to Excel.

Some specific details in CAE for beam problem

Last time, we have solved 2d plane problems by using CAE. There are some additional details for beam problem, mainly in the PROPERTY MODULE. Here are steps to describe beam properties in the PROPERTY module.

1. After you have finished sketching your part, exit the Part module and go to Property module;
2. First create material by B11 (clicking Button at the first line and the first column at the left panel.)
3. Create beam cross section profile by B41→give a profile name→select Rectangle OR circular, etc.→continue→input geometry information (ABAQUS sketches the cross section for you at the left)→OK
4. Create a section by B21→give a section name→select Category beam and Type beam→continue→Select Section integration: During analysis, Profile name, Material name and leave other things intact→OK
5. B31 assigns section as you know
6. Last thing is to assign beam orientation by B32