Creating Axisymmetric Models in FEMAP

1. Introduction

NE/Nastran does not support 2-d axisymmetric elements. 3-d axisymmetric models are supported, and can be generated with a few additional steps. The 3-d axisymmetric method does not consist of the same assumption during analysis that the 2-d method does and is thus a more accurate method of solving an axisymmetric model. Additionally, the 2-d axisymmetric approach is limited to models that are axisymmetric in a planar slice. This method cannot be used for any axisymmetric model with holes or other types of repeated patterns; however, with a 3-d model this type of axisymmetric model can be analyzed. The following outlines the basic steps:

- Create the 2-d axisymmetric model using either axisymmetric or plot only element types in FEMAP.
- Revolve these elements through an arc between 5-15 degrees. 10 degrees usually works best.
- Apply symmetric boundary conditions to the symmetry planes and any other constraints necessary to restrain rigid body motion.
- Apply loads as required to the affected surfaces.

2. Example

The following is an example of the basic procedure on how to build and analyze an axisymmetric model. The geometry and mesh density are saved as Axisymmetric.mod and can be found at www.nenastran.com.

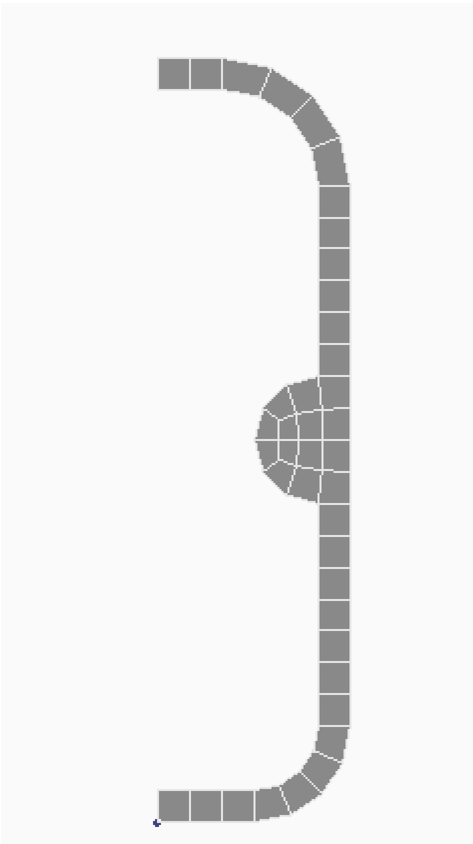

Figure 1. Geometry from Axisymmetric.mod

To generate 3-d solids from the 2-d shell elements use the **Mesh**, **Revolve**, **Element** menu in FEMAP. Select all the elements to revolve.

Click on the **New Property…** button to define the 3-d solid element properties.

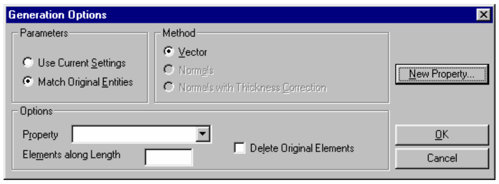

Figure 2. Property and Material Generation Options

Select the **Solid** element type.

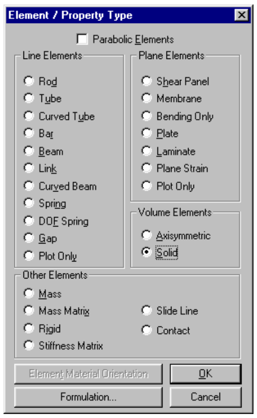

Figure 3. Element/Property Type

Select **Material**. In this case we will use the existing material already defined for the 2-d elements.

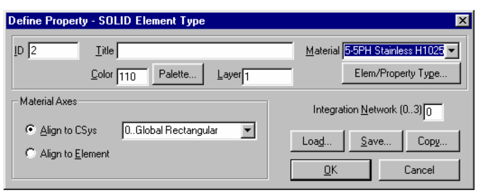

Figure 4. Solid Element Type Property Definition

Type in **1** for the **Elements along Length** box, click on the **Delete Original Elements** box, and hit **OK**.

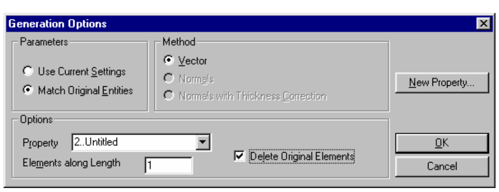

Figure 5. Property and Material Generation Options

Since we want to revolve the section into a solid about the y-axis, define a rotation vector that defines the y-axis.

Use 10 degrees for the rotation angle. Generally the angle is based on what will give reasonably shaped elements. 10 degrees usually works well.

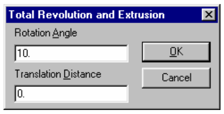

Figure 6. Total Revolution and Extrusion

You can rotate the view now to see the 3-d model by selecting **View**, **Rotate** from the main toolbar.

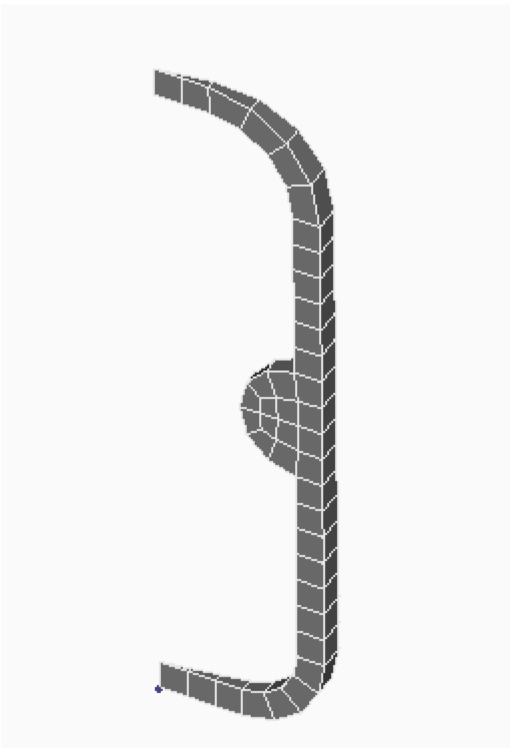

Figure 7. Axisymmetric Solid Model

To apply the symmetric boundary conditions to the model, a cylindrical coordinate system with its z-axis coincident with the rotation vector is required. If we had generated this model from scratch, it would have been a good idea to start by defining the 2-d elements in the x-z or y-z plane with the z-axis as the rotation vector. In this case we will need to define a new coordinate system. To do this we select **Model**, **Coordinate Sys…**. Click on the **Cylindrical** and **ZX Locate** buttons and hit **OK**.

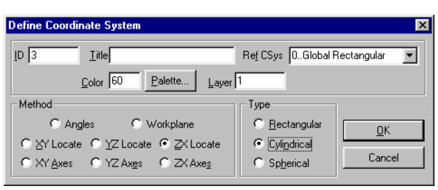

Figure 8. Coordinate System Definition

Define the points as (0,0,0) for the origin, (0,1,0) for the z-axis, and (1,0,0) for the x-axis.

Apply the symmetry boundary conditions to the model by selecting **Model**, **Constraints**. Select All nodes, and select the created cylindrical coordinate system and constraint DOF as shown (Y Symmetry).

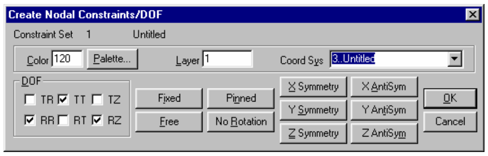

Figure 9. Nodal Constraints Creation

Apply a constraint to the bottom four nodes to restrict movement in the z-direction of the new cylindrical coordinate system as shown below.

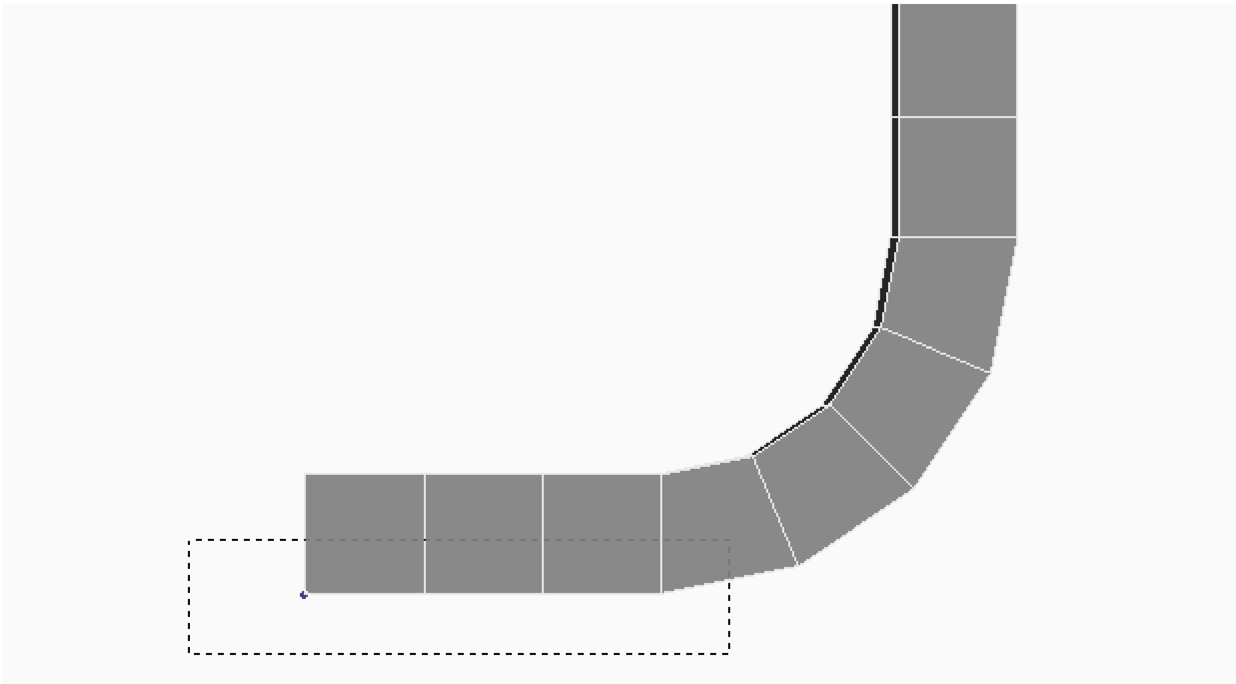

Figure 10. Nodes to Apply Constraint

Apply a pressure load of 100 to the faces of the elements on the inner surface of the part.

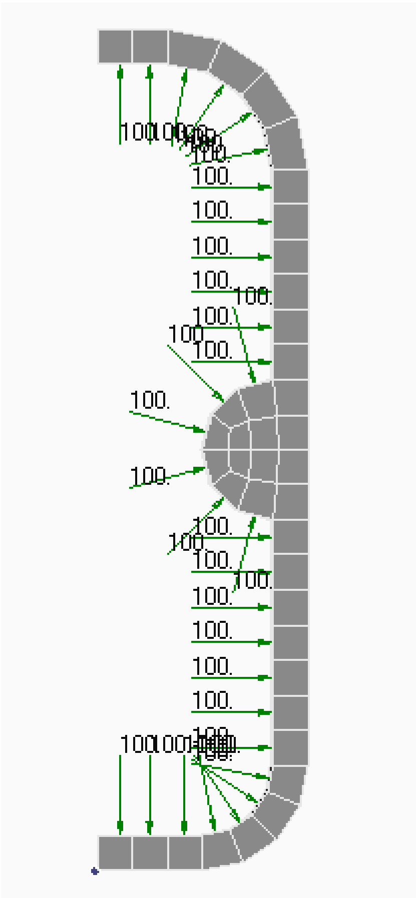

Figure 11. Pressure Loading

Now the model is done and ready for analysis.

3. Results

The von Mises stress is plotted on the deformed shape below.

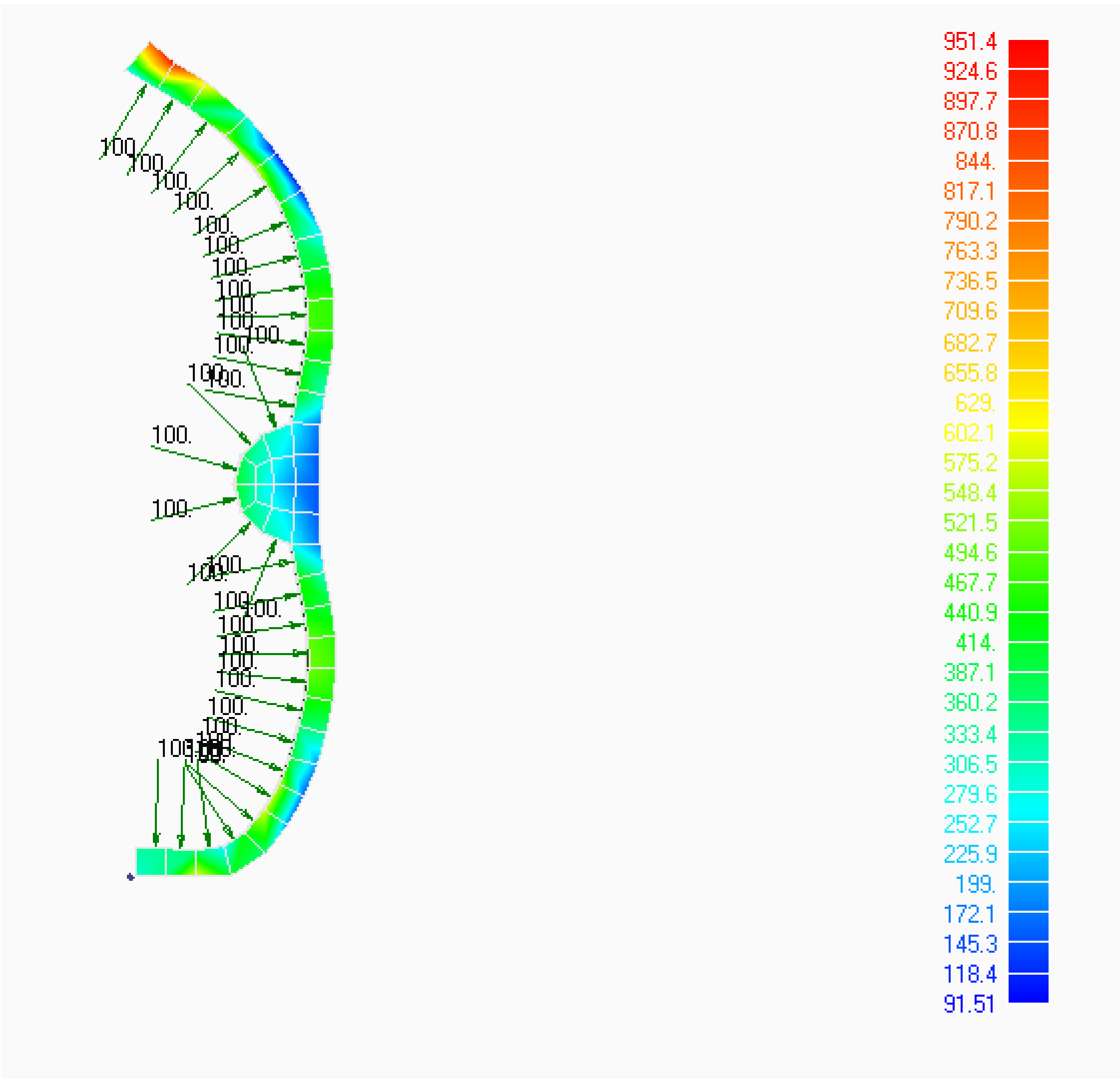

Figure 12. Von Mises Contour and Total Deformation Results

4. General comments

- This model can also be built by defining the cross-section in the x-z plane. Then use the FEMAP default cylindrical system to revolve your part. This can be done so that the global cylindrical direction will now have the z-direction and t-direction correct and there will be no need to create a new cylindrical coordinate system.
- Do not use triangular elements when quadrilateral elements will work. Quadrilateral elements are usually more accurate.