TITLE: ANSYS Cast Iron Material model matches experimental data

PURPOSE: Verify the accuracy of the ANSYS Cast Iron material model. Results from ANSYS are compared with experimental data for a biaxially loaded cruciform geometry.

CONCLUSIONS:

- Cast Iron material model results from ANSYS Rev. 7.0 match experimental data very well for the cruciform geometry with equal and opposite biaxial loading.

- The Cast Iron material model converged reasonably well in ANSYS for this problem which included very nonlinear stress states. The number of iterations for convergence should be less in actual components due to the fact that the stress states are usually lower and typically a smaller percentage of the material's volume is highly stressed.

- Uniaxial input data for the ANSYS Cast Iron material model should be generated in tension and compression from bars cut from the component being evaluated, or from a component with as similar of a design and casting process as is practically possible.

DISCUSSION:

The verification presented here was done to validate the new material model by comparing results with experimental data.

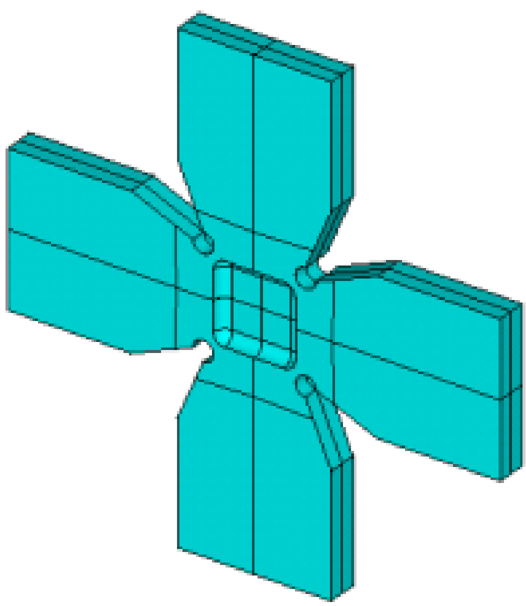

Figure 1: Isometric View of Cruciform Geometry

The cruciform geometry used to generate the biaxial stress state is shown above in Figure 1. The goal in developing the biaxial specimen was to maximize the state of biaxial stress in the center of the specimen while minimizing the stress in the drillings in the 4 corners where the legs join.

These drillings are where the maximum stress occurs, so they represent the weak link of the specimen. Additional goals included minimizing the stress gradient in the center of the specimen so that results were not overly sensitive to gage location as well as designing a specimen that could be easily machined.

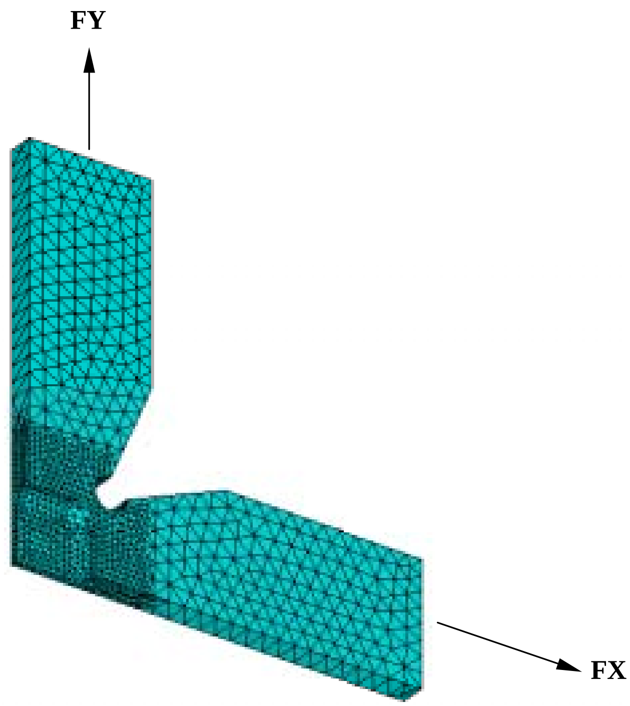

Figure 2: Mesh for 1/8th Symmetry Model and Loading Directions

Figure 2 shows the mesh on the 1/8th symmetry section that was used in the analysis. There is one remaining plane of geometric symmetry along a line at 45 degrees between the X and Y directions. However, 3 of the 5 load cases evaluated did not have symmetric loading around this plane. Consequently, the 1/8th symmetry model was used for all load cases. Note that although the model is 1/8th symmetry, the ends of the legs where the load is applied have ¼ of the area of the full geometry. Therefore ¼ of the load applied in the test of the actual specimen was applied to the model.

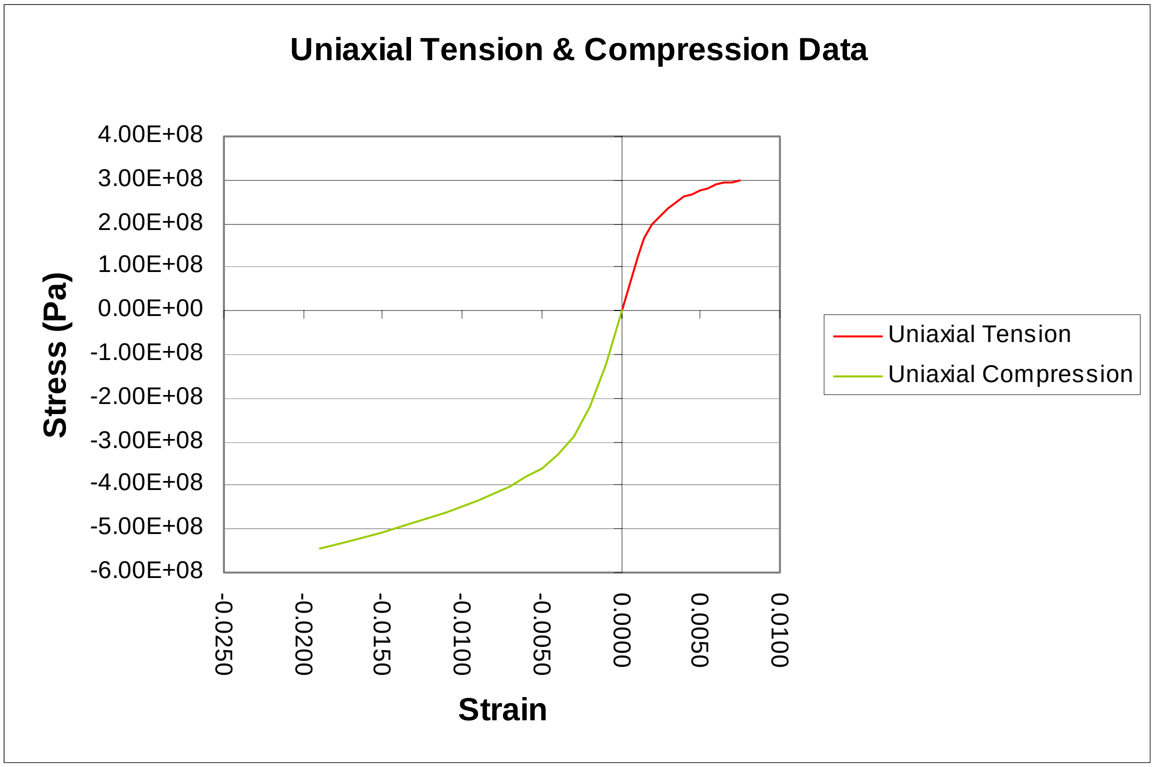

Figure 3: Uniaxial Tension and Compression Input Data

Uniaxial tension and compression data was generated using bars cut from failed cruciform specimens and this was uas input to the ANSYS model. Uniaxial Tension and Compression Input Data is shown in Figure 3.

In evaluating the material model, only limited experimental testing was available. Therefore, experimental testing was performed for an opposite biaxial load case. This loading produces a complex stress state.

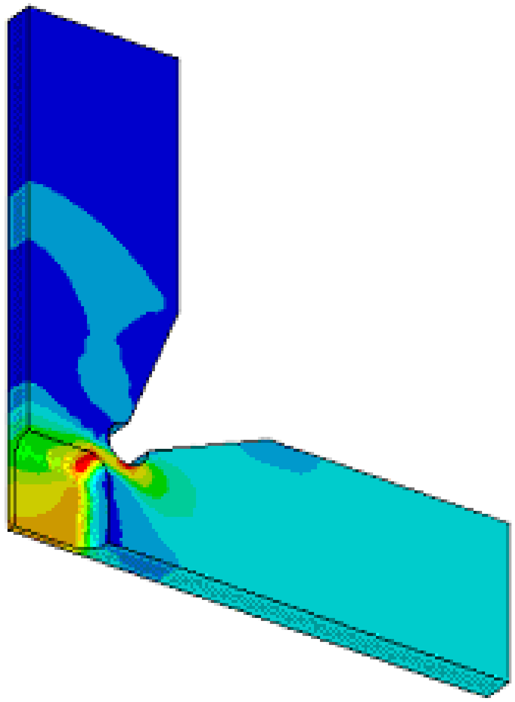

Figure 4: First Principal Stress Contours for The Opposite Biaxial Load Case

The first principal stress state for the Opposite Biaxial Load Case at its maximum load is shown in Figure 4. Note that the stress in the center of the specimen is approximately 210 MPa, while the stress in the drilling is about 300 MPa. Note that the tensile strength of the material is roughly 300 MPa.

The purpose of the cast iron material model is to accurately represent the nonlinear response of cast iron in multi-axial stress states. The material's response becomes increasingly nonlinear with increasing strain levels. Therefore it was important to be able to obtain relatively high strain levels in the gage location prior to having the specimen fail in the drillings. Figure 4 shows that the cruciform geometry used was able to attain relatively high stress levels in the gage location.

RESULTS:

Figure 5 shows the results for The Opposite Biaxial Load Case . This plot includes data from the experimental tests and from ANSYS. ANSYS matches the experimental data very well. The only portion of the response where any significant difference can be seen is in the unloading in the X direction.

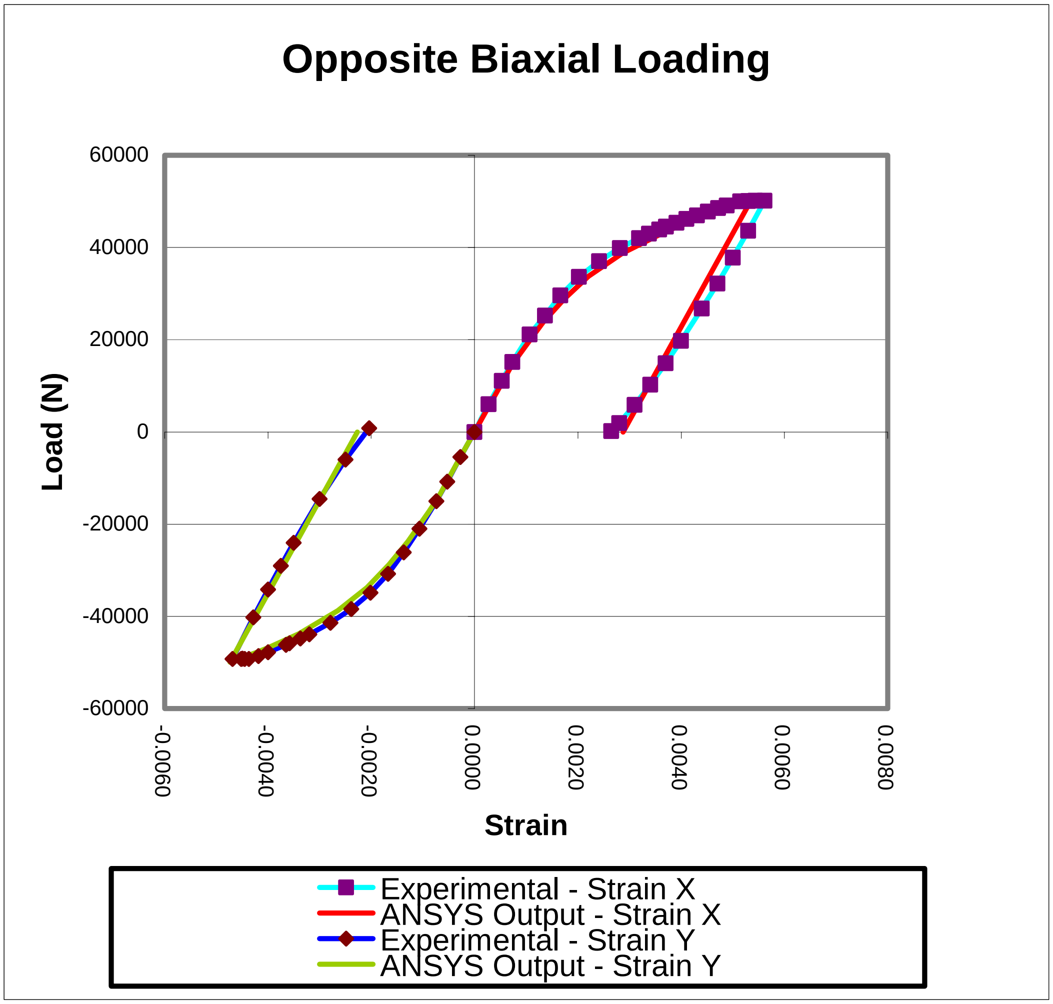

Figure 5: Results for The Opposite Biaxial Load Case - Opposite Biaxial Loading