Evan Sayer (ets756)

COE 321K

28 April 2023

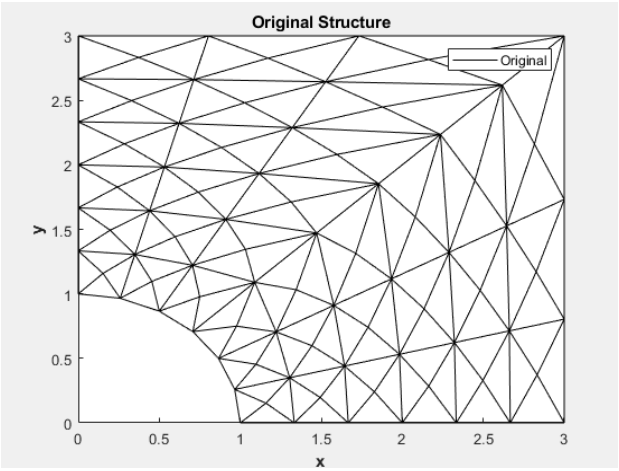
Final Report

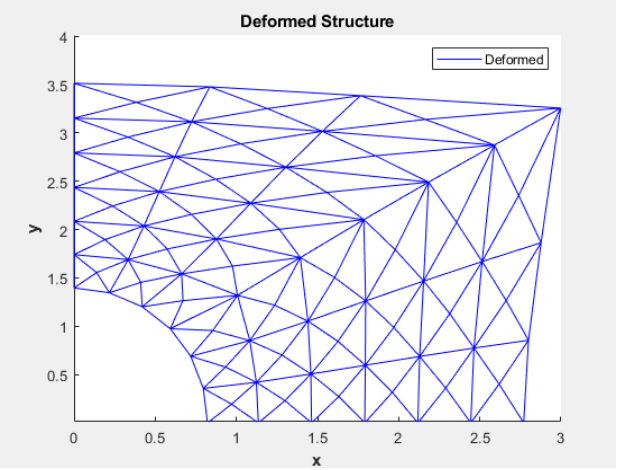
The computer code I've written will determine the nodal displacements, element strains, and element stresses for an arbitrary two-dimensional solid structure using 3-noded triangular elements. In this case it is used to determine these parameters for a plate with a hole in it. This was computed multiple times, each time a few variables were changed. The plate was constructed with a different number of triangle elements and a different number of forces was applied in each case. The code uses four input files to do its computation:

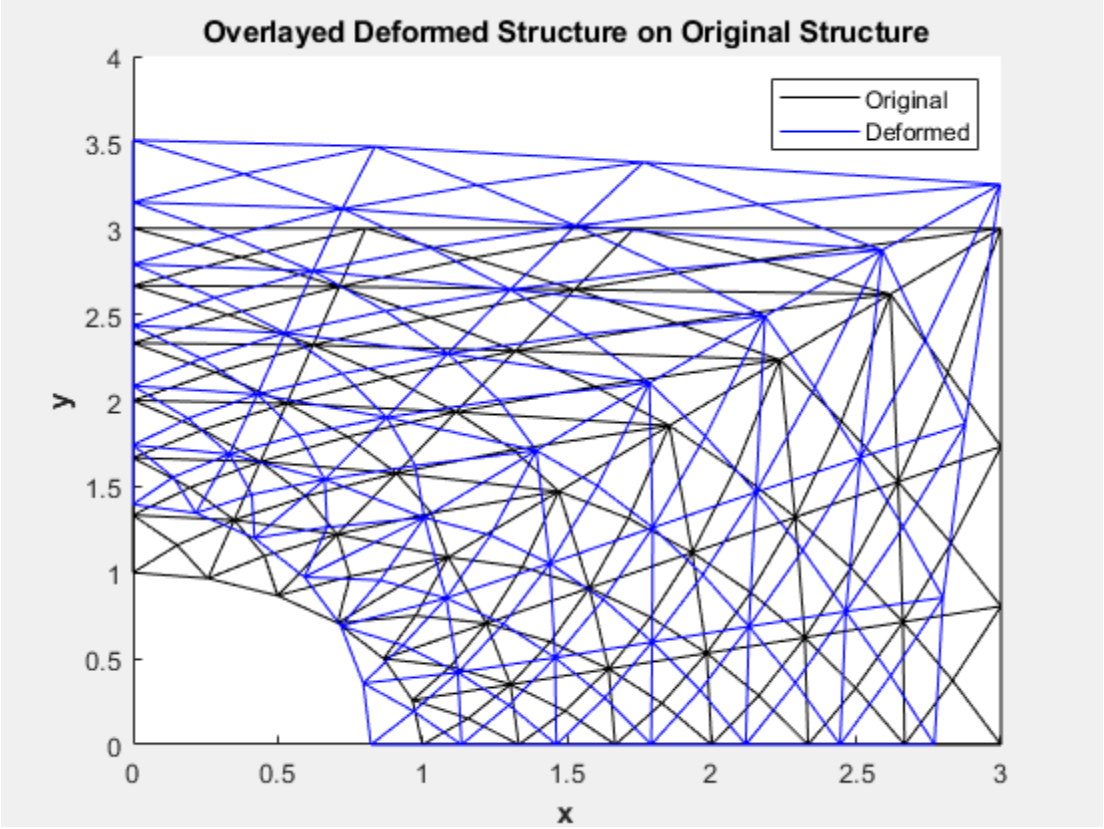
- A file containing a list of the nodes and their respective x and y coordinates.
- An elements file, listing each triangular element and the nodes that make it up.
- A file with the forces applied to the structure, showing their locations and magnitudes.
- A file containing any initial displacements or edge conditions.

These files give the code an image of the structure and its loading conditions. Along with the files, the element type and number of degrees of freedom are specified. Because triangular elements are being analyzed in a two dimensional structure, there are 2 degrees of freedom and 3 elements per node.

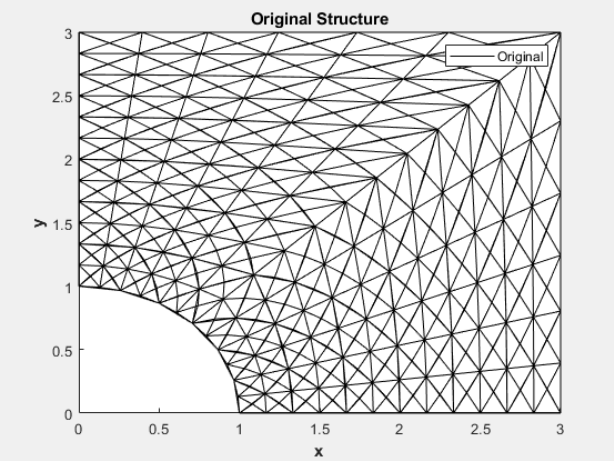
To display the finding computed by the computer code, I've drawn the elements in a triangular mesh. This helps visualize the structure both before and after it is deformed by the stresses it experiences. Shown below are the original, deformed, and overlaid mesh plots for each test case.

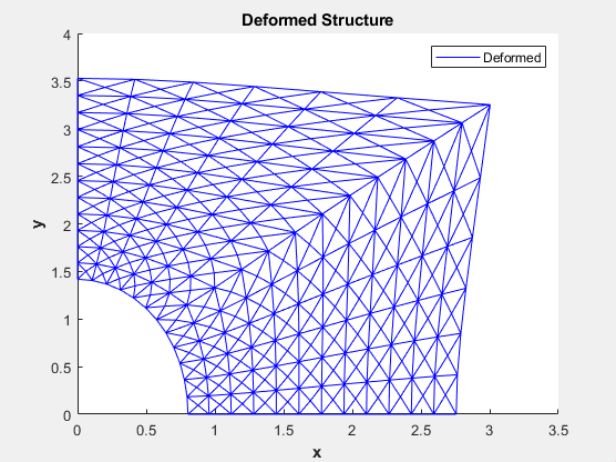

Original Structure
Original
x
y

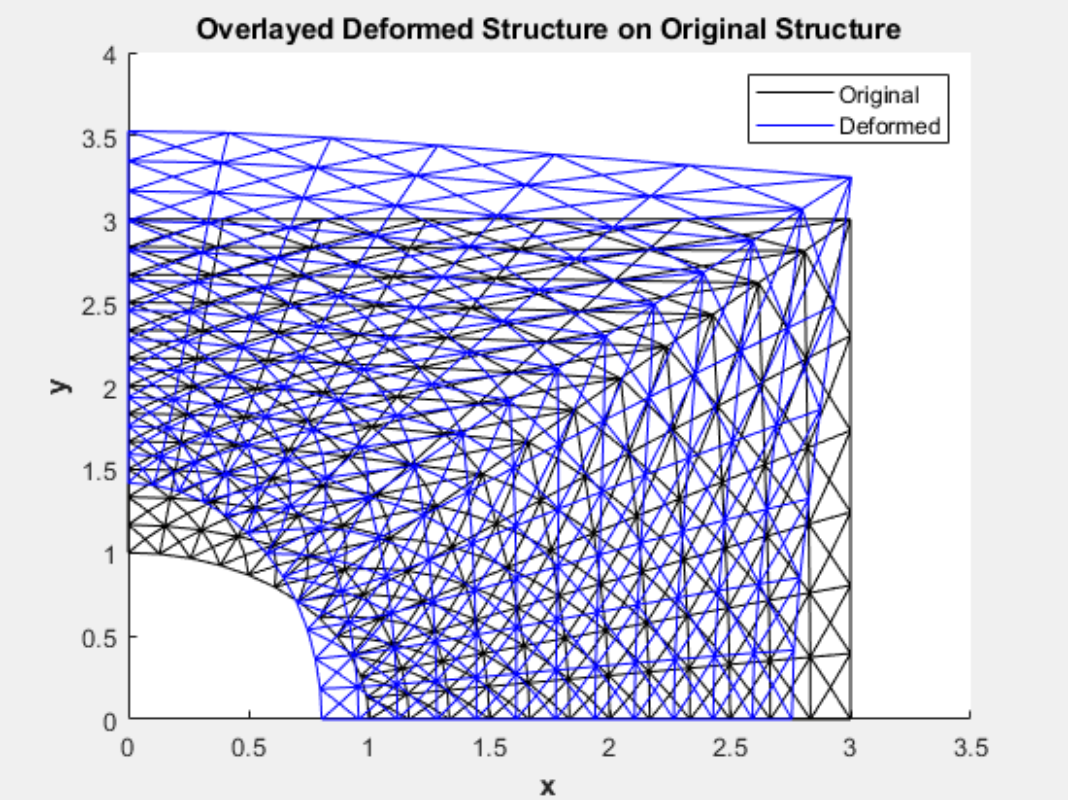

Deformed Structure
Deformed
x
y


Overlayed Deformed Structure on Original Structure
Original
Deformed
x
y

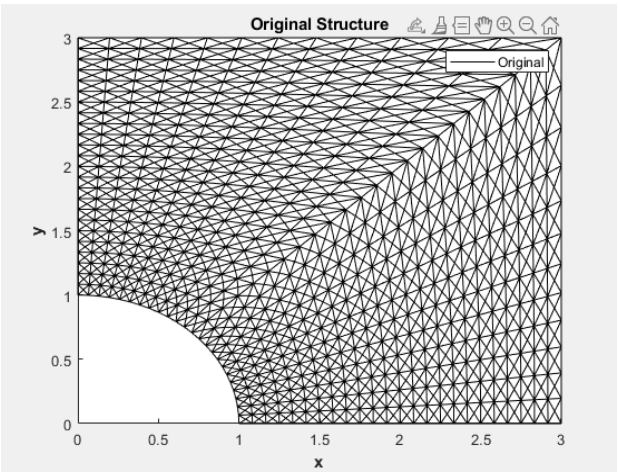
Test Case “6”

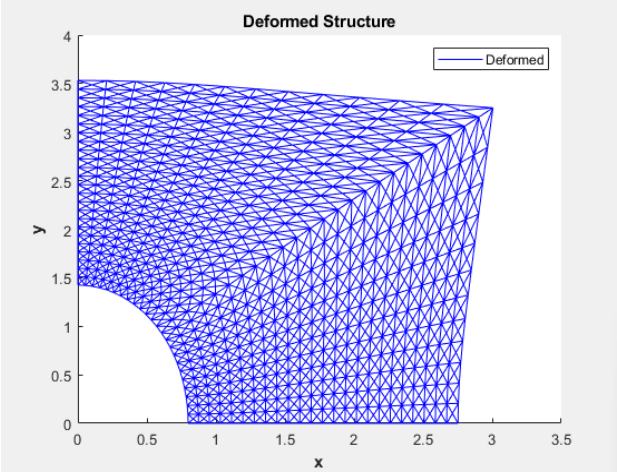

Original Structure
Original
x
y

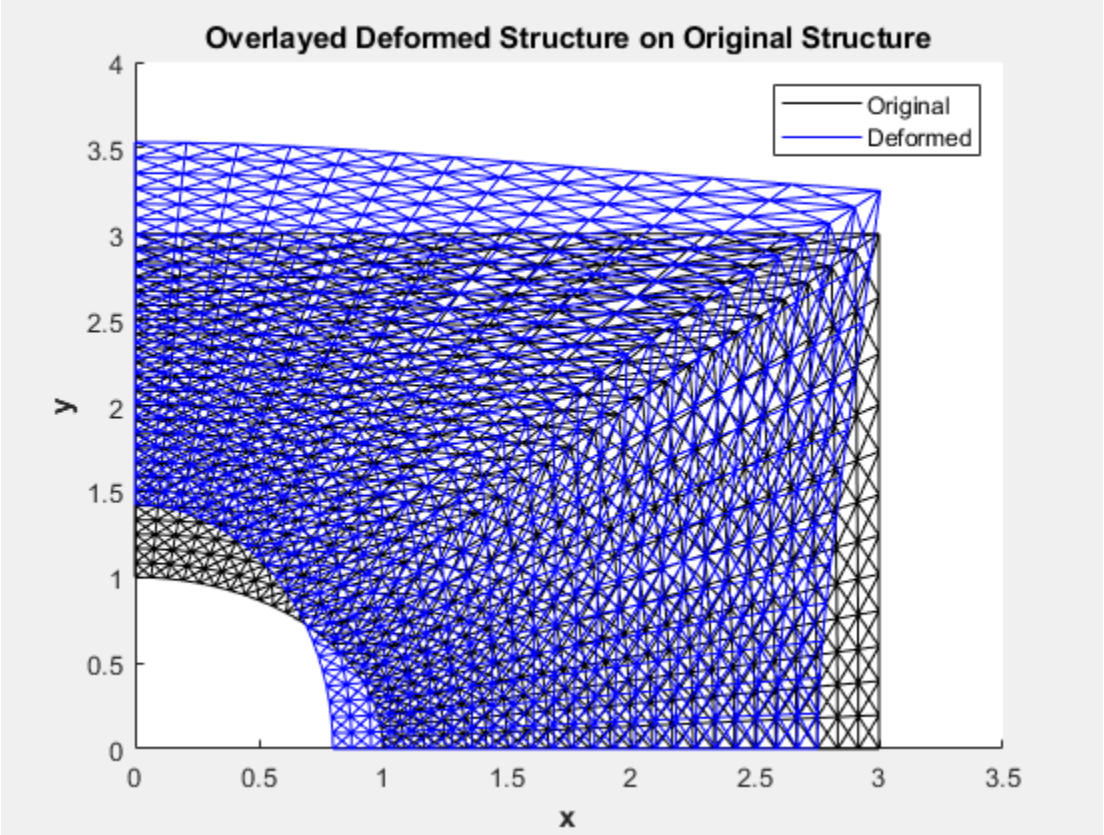

Deformed Structure
Deformed
x
y


Overlayed Deformed Structure on Original Structure
Original
Deformed
x
y

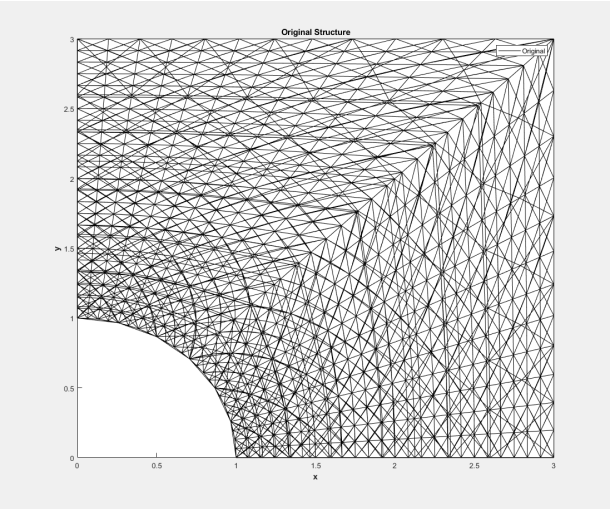
Test Case "12"

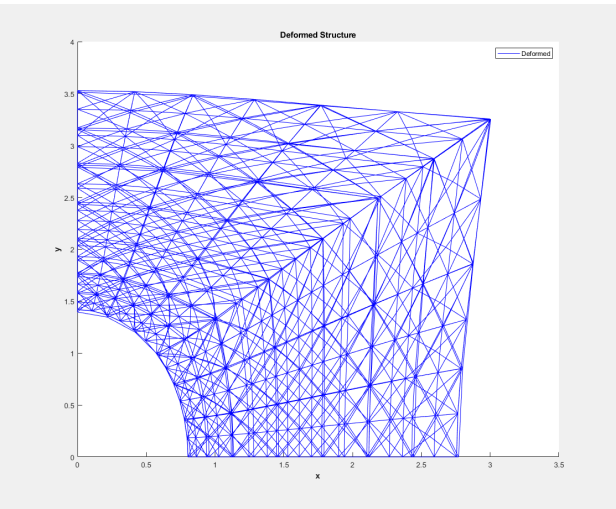

Original Structure
Original
x
y

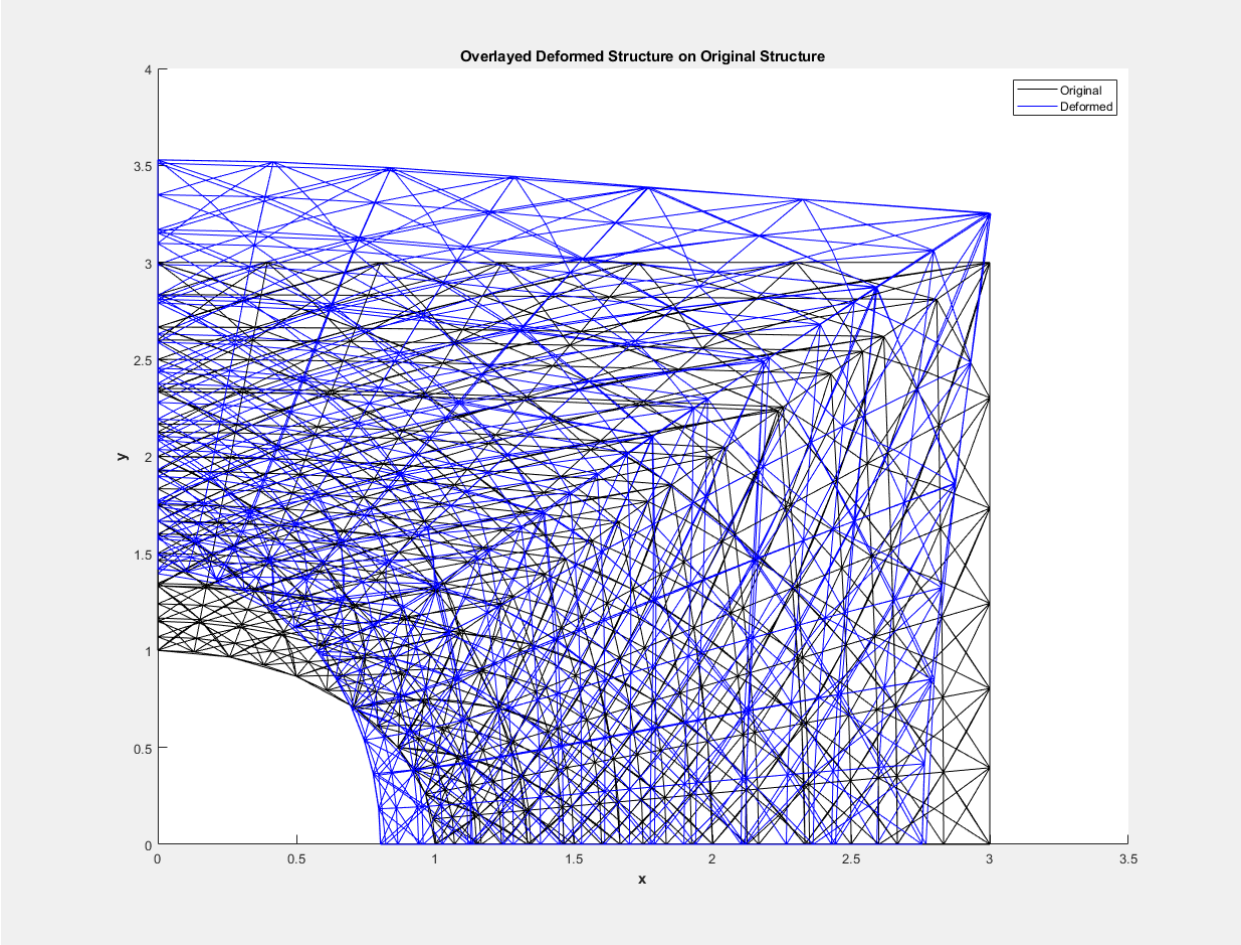

Deformed Structure
Deformed
x
y


Overlayed Deformed Structure on Original Structure
Original
Deformed
x
y

Test Case "24"


Original Structure
Original
x
y

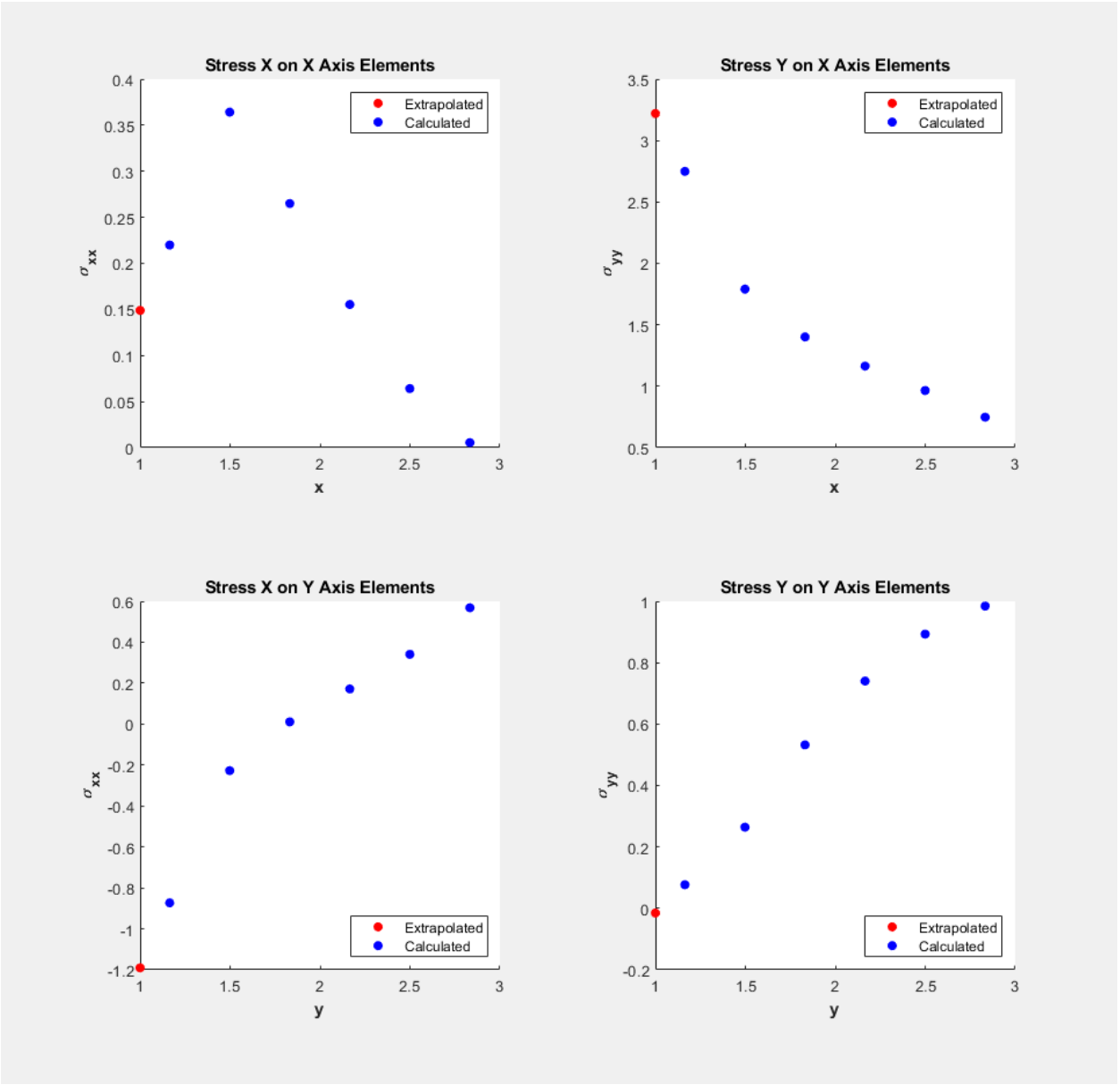

Deformed Structure
Deformed
x
y


Overlayed Deformed Structure on Original Structure
Original
Deformed
x
y

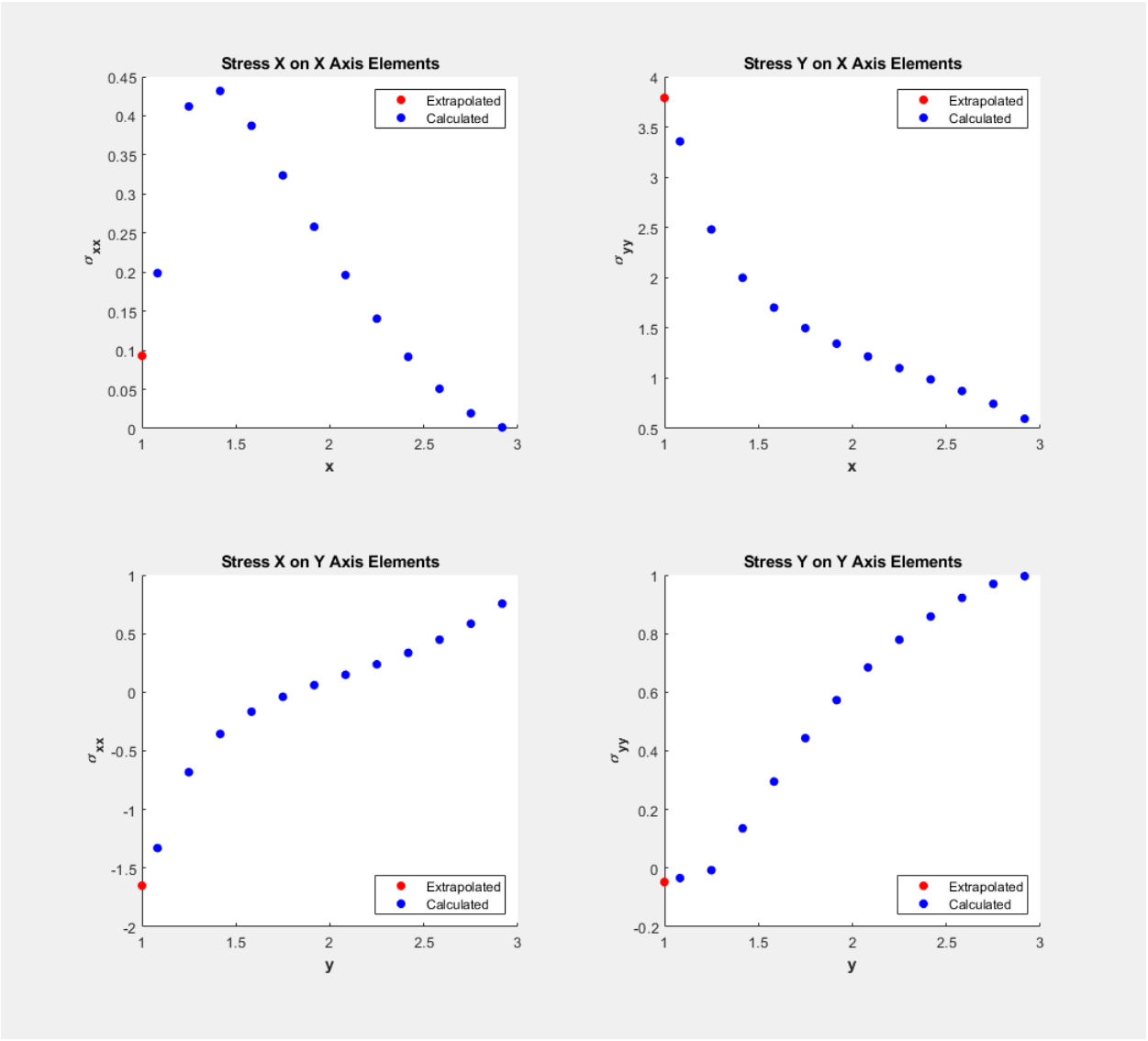
Test Case “R”

The plots are an excellent visual representation of the structure's deformation as they clearly depict how the displacements cause a dramatic distortion in the structure. Something similar to a heat map wouldn't be able to provide as much visual information as these displacement mesh plots can.

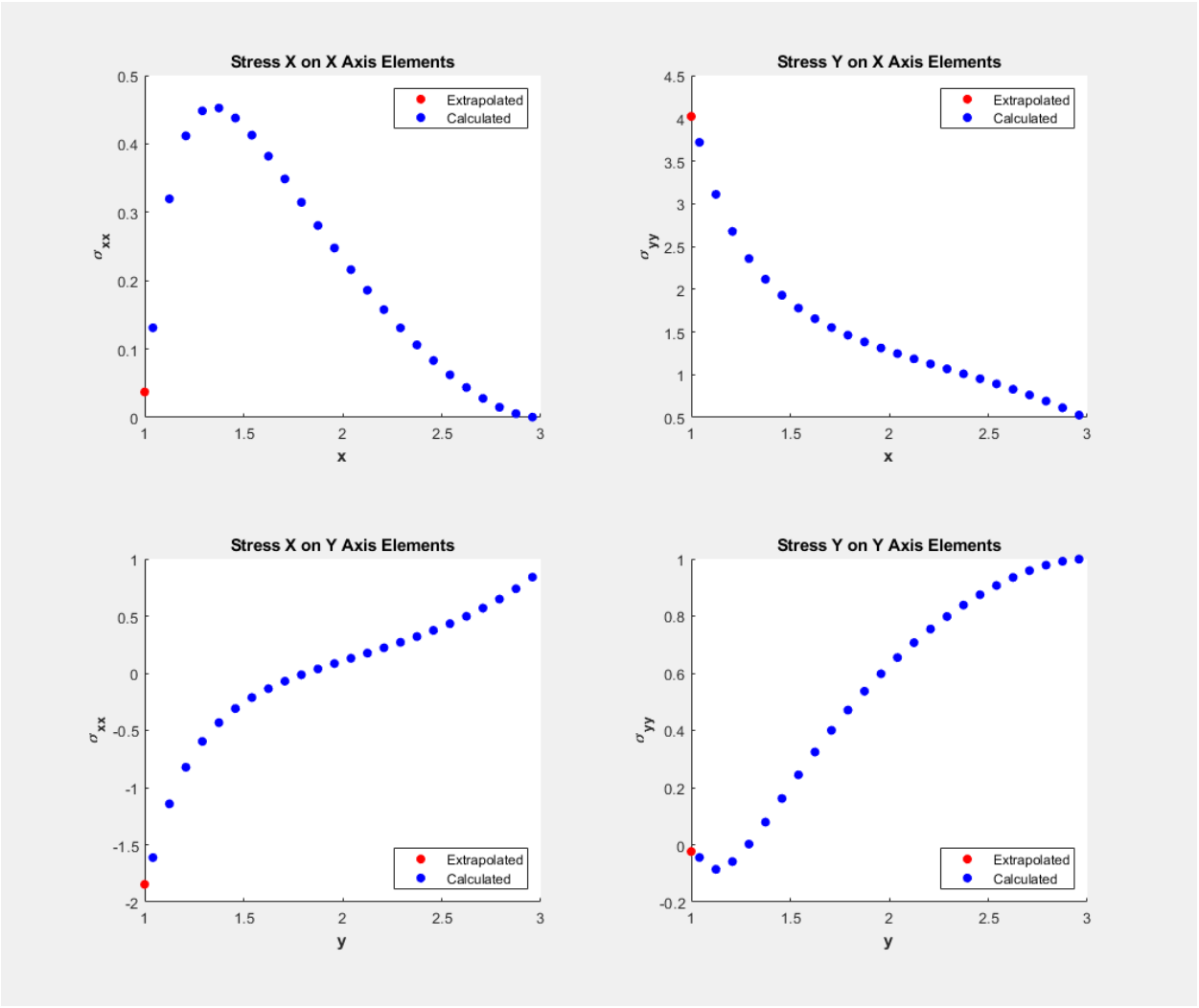
After calculating and plotting the displacements in the structure, the computer code seeks to explain their causation. Therefore, the xx, yy, and xy stresses in each element are calculated. I wanted, in particular, to investigate how the stress changes as a function of distance from the hole in the center of the plate. This is most easily done on the axes, so the code draws graphs of the x and y stresses in each element bordering a specific axis. Both the x and y axis were analyzed, so there are four graphs for each test case. After these stresses were plotted, I was curious about the stress at the very edge of the hole. Because it wasn't specifically calculated, it is extrapolated by the code using the two closest calculated stresses. Below are these graphs, again for each of the four test cases. All of these visualizations use dimensionless ratios to avoid any discontinuities between test cases. By doing this the graphs should look quite similar despite each structure being slightly different.


Stress X on X Axis Elements
Extrapolated
Calculated
σ_{xx}
x
Stress Y on X Axis Elements
Extrapolated
Calculated
σ_{yy}
x
Stress X on Y Axis Elements
Extrapolated
Calculated
σ_{xx}
y
Stress Y on Y Axis Elements
Extrapolated
Calculated
σ_{yy}
y

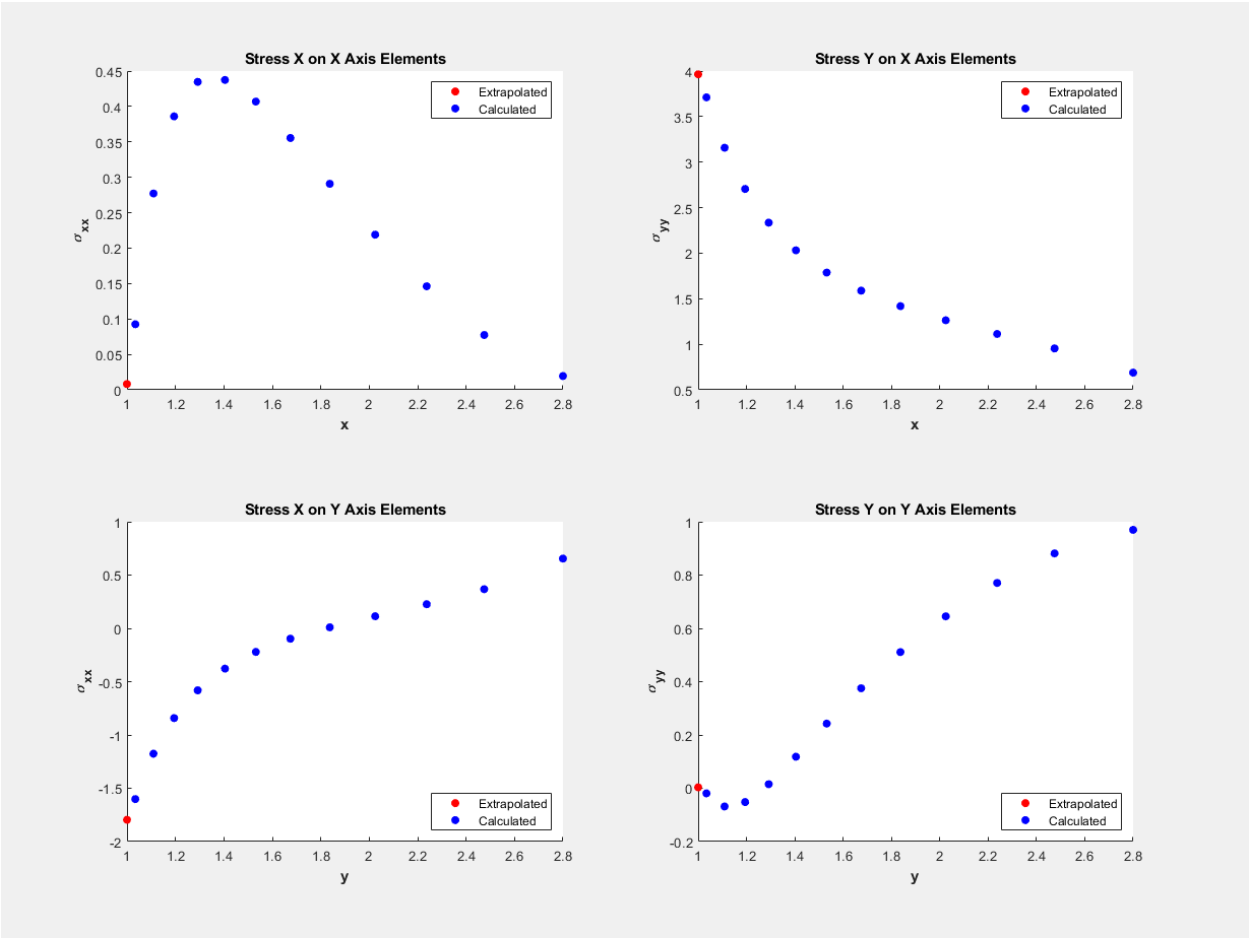
Test Case "6"


Stress X on X Axis Elements
Extrapolated
Calculated
σxx
x
Stress Y on X Axis Elements
Extrapolated
Calculated
σyy
x
Stress X on Y Axis Elements
Extrapolated
Calculated
σxx
y
Stress Y on Y Axis Elements
Extrapolated
Calculated
σyy
y

Test Case "12"


Stress X on X Axis Elements
Extrapolated
Calculated
σ_{xx}
x
Stress Y on X Axis Elements
Extrapolated
Calculated
σ_{yy}
x
Stress X on Y Axis Elements
Extrapolated
Calculated
σ_{xx}
y
Stress Y on Y Axis Elements
Extrapolated
Calculated
σ_{yy}
y

Test Case "24"


Stress X on X Axis Elements
Extrapolated
Calculated
σ_{xx}
x
Stress Y on X Axis Elements
Extrapolated
Calculated
σ_{yy}
x
Stress X on Y Axis Elements
Extrapolated
Calculated
σ_{xx}
y
Stress Y on Y Axis Elements
Extrapolated
Calculated
σ_{yy}
y

Test Case “R”

From these plots there are a few interesting and notable trends. As the number of elements increases across the test cases, there is a slight ducktail or lip in the stress y on the y axis elements that shows an increase in the stress near the hole in the plate. This was not otherwise viewable with a lower number of elements. The stress x on the x axis elements shows a dramatic dropoff in stress as the hole in the plate approaches. The extrapolated value implies that there is almost no stress at the edge of the hole. In general, the x axis elements decrease in stress as distance from the hole in the plate increases while stress in the y axis elements increases. This makes sense intuitively as well when looking at the mesh plots from earlier; the mesh is being stretched upward in the y direction and inward in the x direction. Lastly, it's interesting to note that the stress y on the x axis elements is the only stress that is always decreasing away from the plate's hole. With these trends in mind, I believe this analysis provides valuable insights into the behavior of the structure under different loading conditions and demonstrates the efficacy of the developed code.