Universitat Polytechnica de Catalunya
MSc Computational Mechanics
Spring 2018

Computational Structural Mechanics and Dynamics

Assignment 8

Due 16/04/2018

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1 Analysis of Hyperbolic Concrete Shell Under Self Weight

1.1 Problem Definition

Here we will be analyzing the hyperbolic concrete shell under self weight seen in the left hand side of figure 1 below. This is done by implementing the project geometry in GID and then exporting to the corresponding MAT-FEM Matlab solver. Once the problem has been solved in Matlab, the results are printed back into a flavia and mesh file that the GID postprocessor can read.

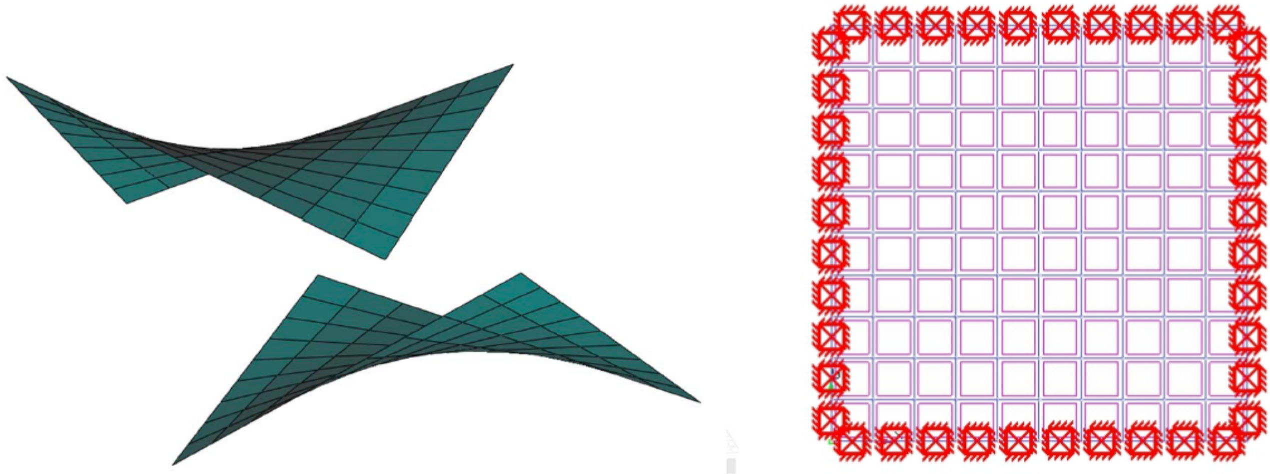

Figure 1: Implementation of project geometry

1.2 Displacement Results and Discussion

We will now begin to analyze the results of the test with a 1681 node triangular element mesh, we will start by taking a look at the resulting displacements. Below we can see various displacement results for the shell under self weight.

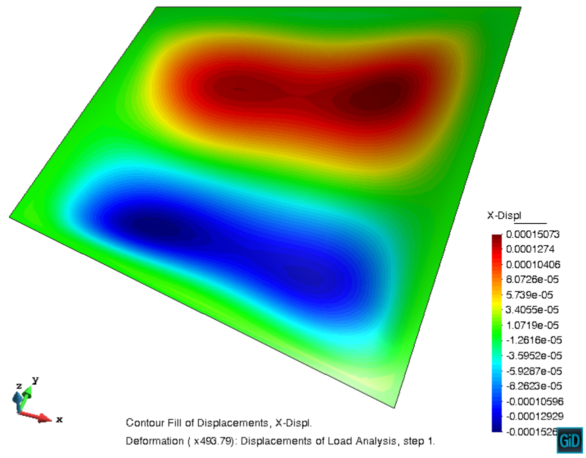

Figure 2a: X-Displacement

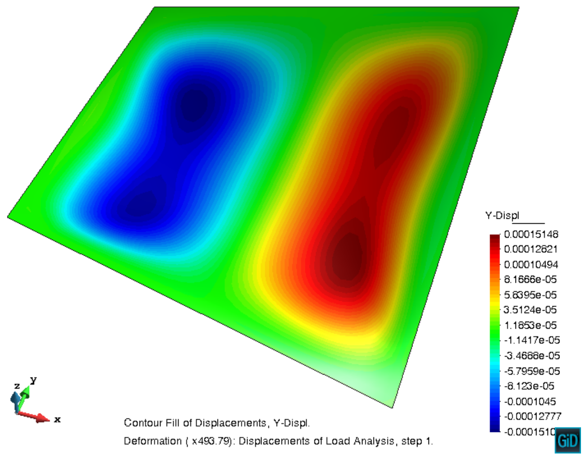

Figure 2b: Y-Displacement

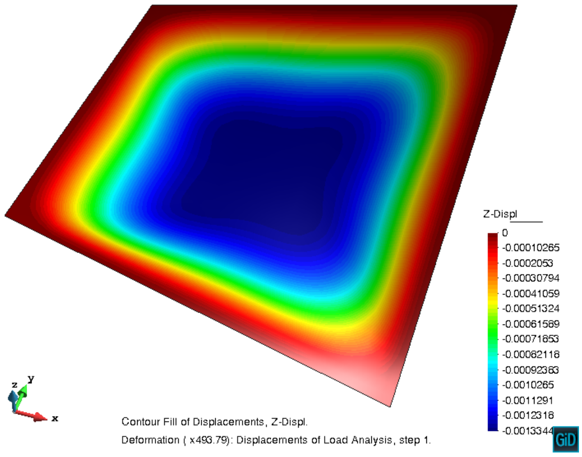

Figure 2c: Z-Displacement

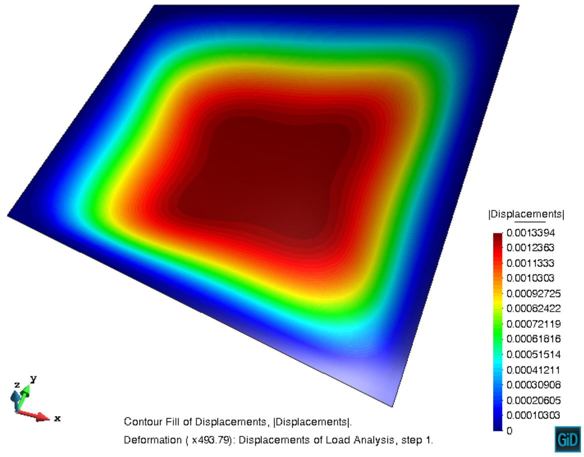

Figure 2d: Displacement Norm

Above and on the previous page we can see the displacement of the concrete shell in various directions. As expected, we see the maximum displacement in the center of the shell as the deformation is due to self weight. We can also see localized regions of high/low x and y displacement corresponding to the positive and negative surface geometry gradients respectively. This is consistent with one would expect from the theory and literature. We will now take a look at the local rotations of the geometry. This can be seen below in figures 3a and 3b.

1.3 Rotation Results and Discussion

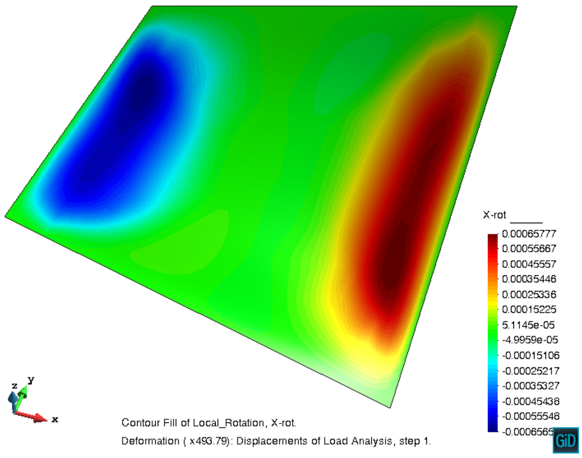

Figure 3a: X-Rotation

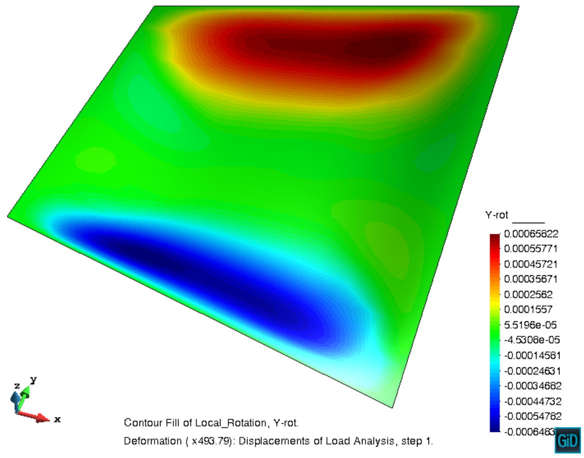

Figure 3b: Y-Rotation

Above we have the respective local rotation results. On the left in figure 3a, we have local rotation around the x axis. And on the right in figure 3b, the local rotation around the y axis is shown. We can notice that the highest amount of each respective rotation takes place far away from the rotation axis as expected but also far enough away from the three-directional fixed boundary conditions on the sides as where there is enough significant rotation. This behavior is expected and is consistent with the theory. Next, we will analyze the shear generated in the hyperbolic concrete shell under self weight.This can be seen on the next page.

1.4 Membrane Force Results and Discussion

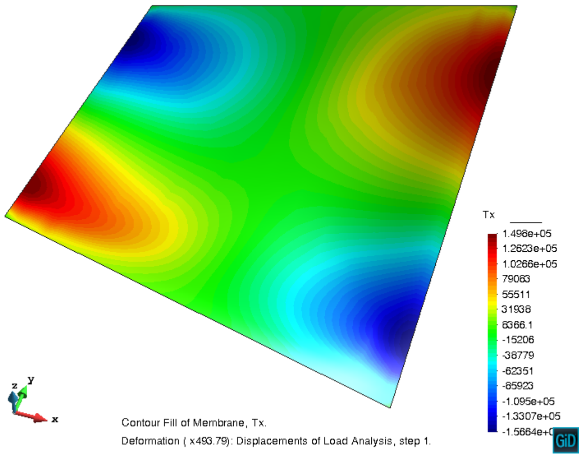

Figure 4a: X-Force

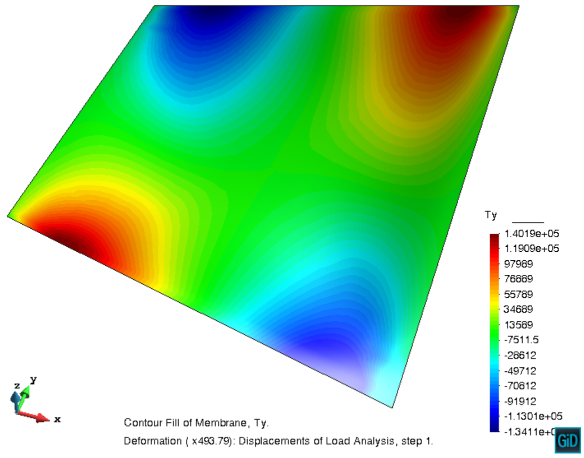

Figure 4b: Y-Force

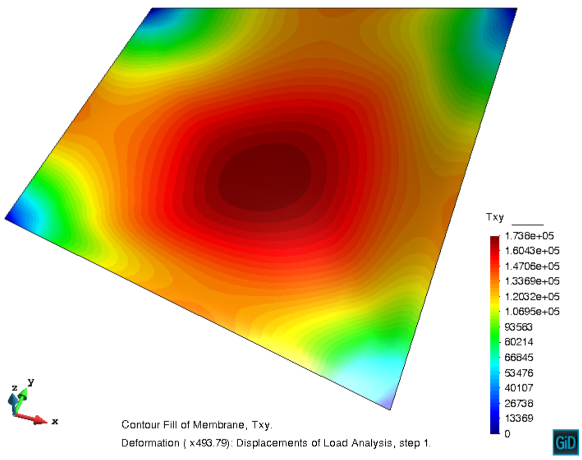

Figure 4c: Z-Force

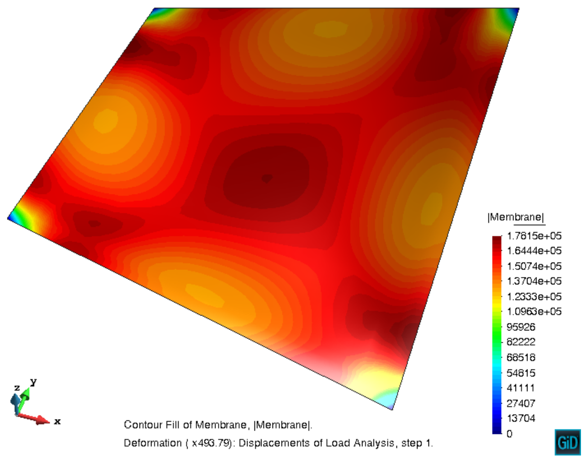

Figure 4d: Force Norm

Above we have four plots of the membrane forces acting on the hyperbolic shell. The first thing that can be noticed is the symmetric distribution of these forces across the hyperbolic shell. At both of the high corners, we can see there is the high tensile stress in both x and y directions. In the lower corners, we can see the higher regions of compressive stress. This is consistent with the theory and what we would expect from a concrete slab supported in this manner under self weight. The weight of the slab would pull on the higher z regions and push into the lower z regions. We also see that the highest z direction membrane force happens in the center of the shell. This is expected as that is where the maximum z displacement occurs. We will now take a look at the bending moments happening on the shell. These results can be seen on the next page.

1.5 Bending Moment Results and Discussion

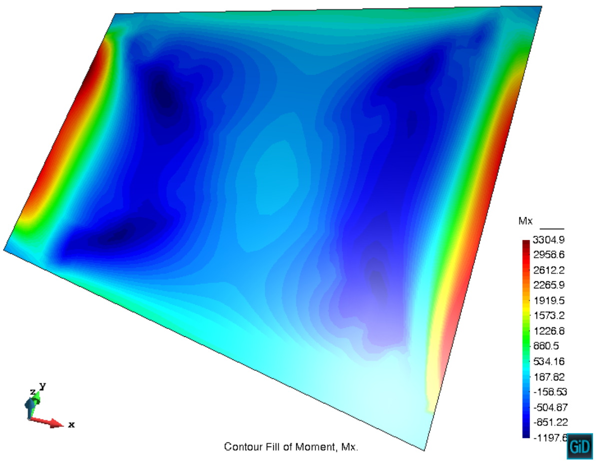

Figure 4a: X-Bending Moment

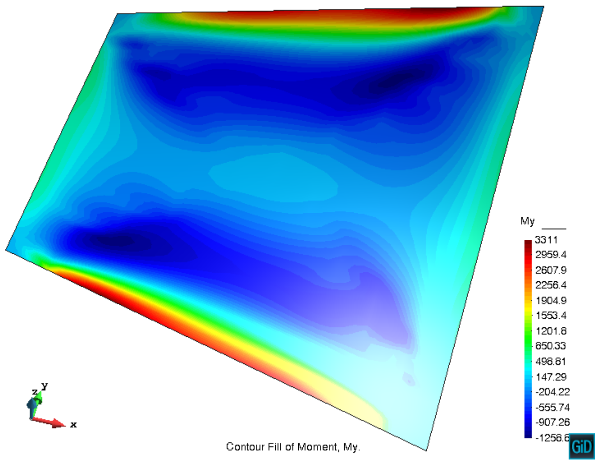

Figure 4b: Y-Bending Moment

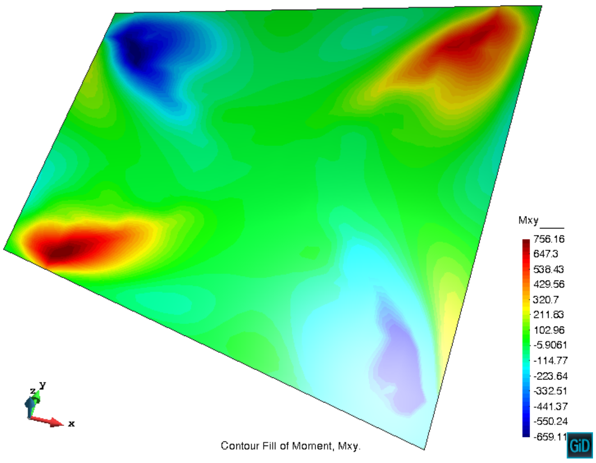

Figure 4c: XY-Bending Moment

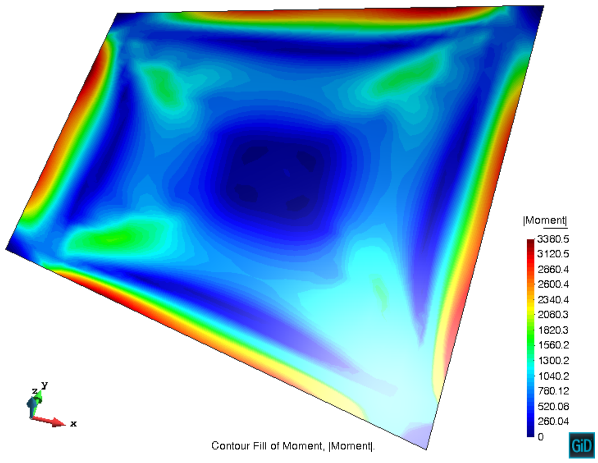

Figure 4d: Bending Norm

Above we can see the bending moments induced as a result of the self weight of the concrete hyperbolic shell under the prescribed boundary conditions. As expected, the highest bending moments around both the x and y occur at the center of their respective edges. This is a result of the cumulative weight of the concrete shell "pulling' down at the the fixed boundary conditions, inducing a high bending moment at these regions.