Assignment 8, Computational Structural Mechanics and Dynamics

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Problem

- Analyze the following concrete hyperbolic Shell under self weight. Explain the behavior of all the Stresses presented. t = 0.1.

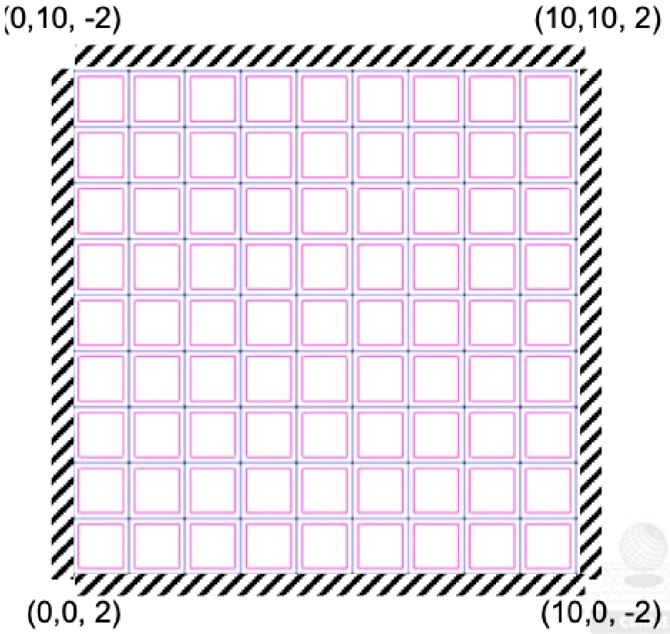

Figure 1: The hyperbolic concrete shell considered in the assignment.

First step of evaluating the shell construction was to implement the `MAT-fem.Shells.gid` interface to my GiD-version. Next step was to produce the geometry and a triangular mesh of the construction. The geometry and mesh is shown below:

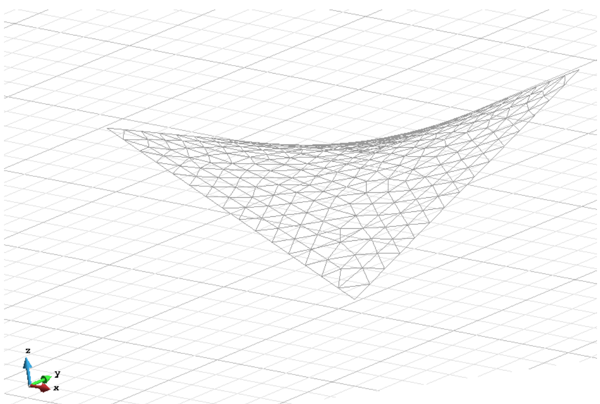

Figure 2: Triangular mesh of the geometry stated in the exercise.

The triangular mesh is made up of only three-node triangular elements. Material and self-weight were added to geometry before exporting the file to Matlab. GiD has concrete as an embedded material, which gave the properties:

Young Modulus, E = 2,1 $\cdot 10^{11} \frac{N}{m^2}$
Poisson Ratio, $\nu = 0,2$
Self-weight, $\rho = 78000 \frac{N}{m^3}$
Thickness, t = 0,1 m

In the `MAT-fem.Shells.gid` interface there is a possibility to write a Matlab input file based on the mesh produced in GiD. This was utilized, and the mesh was analyzed by using the `Lamina-T-RM.m` Matlab script. The matlab scripts analyze the shell with 3-node triangular Reissner Mindlin elements. The result of the analysis was given as a `.res` file, and was exported back into the postprocess of GiD. Now the result of the analysis can be displayed in stresses, moments and displacements.

The displacement is shown in all x-, y- and z-direction, where the biggest displacement is in z-direction. This is due to the self-weight working in negative z-direction. Obviously the largest displacement occurs in the middle of the shell, the point furthest away from the fixed supports along the boundaries. The largest displacement is equal to approximately 1,6 mm. Displacements in x- and y-direction are of a smaller value, but occurs parallel to its representative axis and produces a pattern that is roughly similar to a plate-buckling pattern.

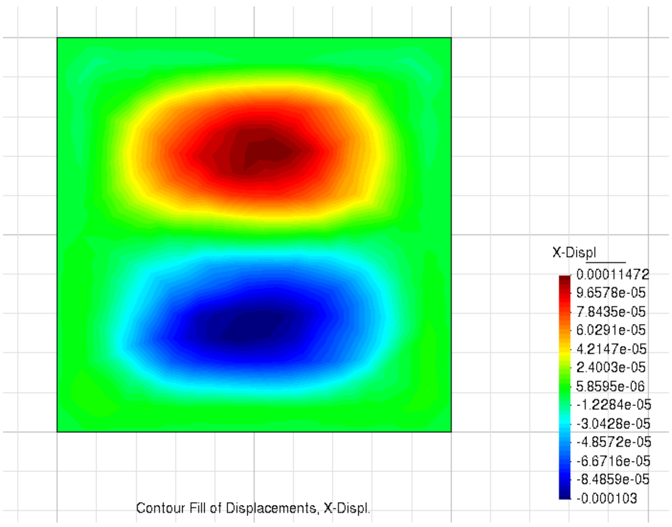

Figure 3: Displacement in x-direction.

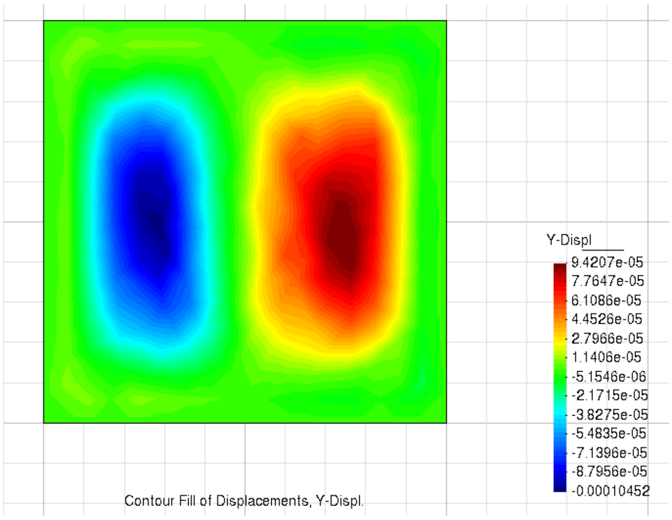

Figure 4: Displacement in y-direction.

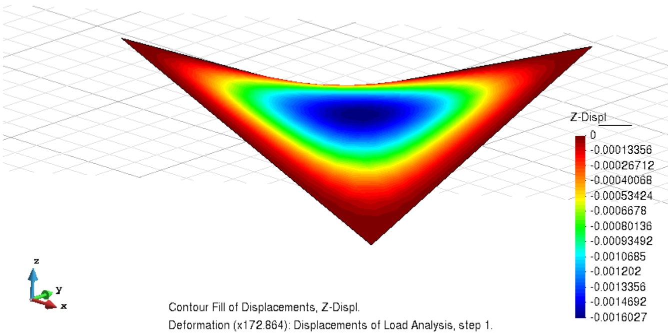

Figure 5: Displacement in z-direction.

When assessing a hyperbolic shell, membrane stresses occurs. Membrane stresses are stresses acting in the plane of the shell construction. These stresses acts in different directions in the plane and are therefore displayed in three directions below. In general, the stresses are at pretty low values. The highest stress obtained is equal to $1,68 \cdot 10^5 \frac{N}{m^2}$, which is equal to $0,168$ MPa. Given that the shell is only subjected to its self-weight, it is reasonable with low stress values. When assessing the stress distribution for T_x and T_y it is clearly show that the highest stresses occurs along the boundaries along the x- and y-axis. When considering that all the boundaries are fixed, the moment at the boundary will probably be the biggest, and therefore bigger stresses. The smallest stresses is found at the middle of the shell. For T_{xy} it is the other way around, smallest stresses along the boundary and maximum stresses at the middle of the shell.

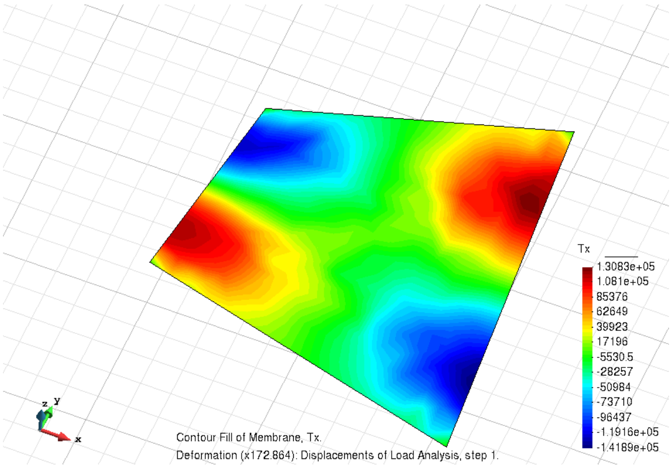

Figure 6: Displacement in x-direction.

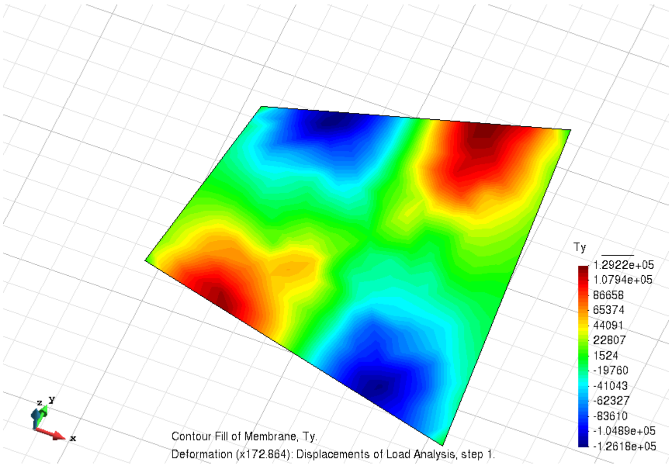

Figure 7: Displacement in y-direction.

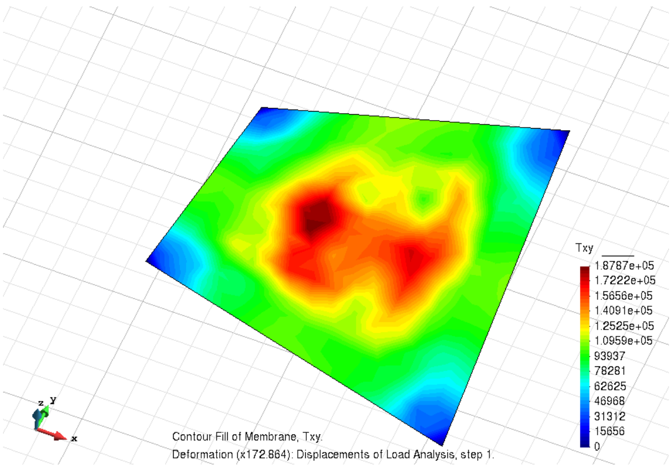

Figure 8: Displacement in z-direction.

The moment distribution of the shell could be considered as symmetrical for each component. For M_x and M_y the largest moments occurs at the boundaries, while a negative moment occurs in the middle of the shell. The have similarities with a beam with both end fixed, subjected to a uniform load (self-weight). Maximum moments for this beam occurs at the fixed supports

($\frac{qL^2}{12}$), while the moment at the middle of the span is negative sign and half the value ($\frac{qL^2}{24}$). For our shell, the factor between maximum and minimum moment is equal to $2,6 - 2,7$ and not 2. The maximum moment is equal to $1679,1$ Nm, which should be considered as a small loading.

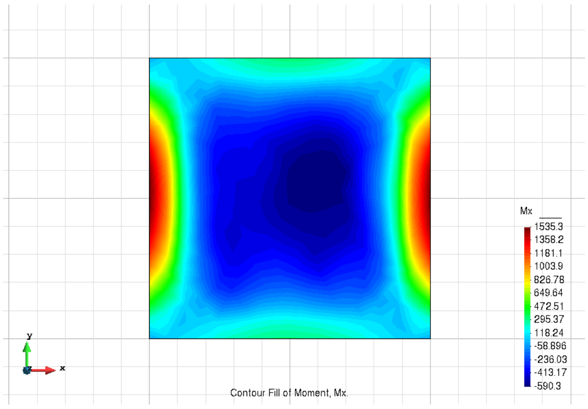

Figure 9: Displacement in x-direction.

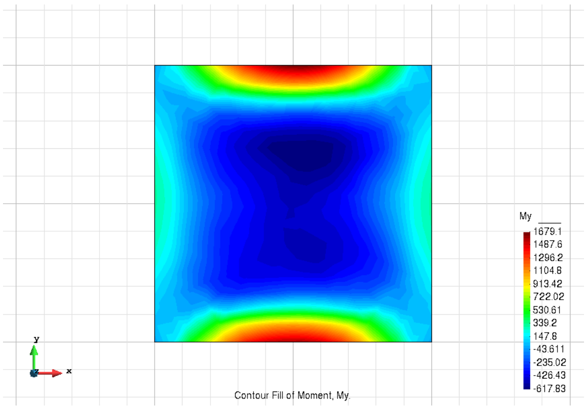

Figure 10: Displacement in y-direction.

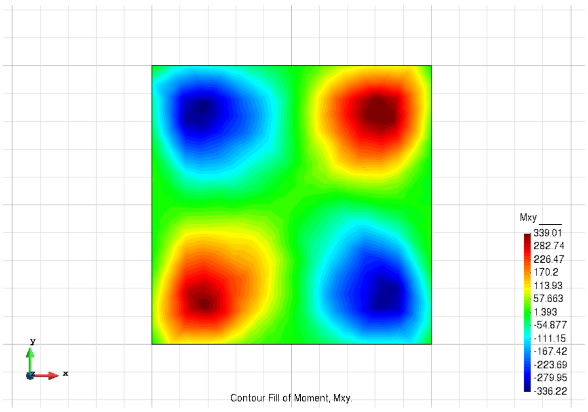

Figure 11: Displacement in z-direction.

The results for the parabolic concrete shell clearly shows that the construction is only subjected to its own self-weight. All the values are considered to be small, and the stresses are not close to reach the limit stress for a concrete construction.