UPC - BARCELONA TECH
MSc Computational Mechanics
Spring 2018

Computational Structural Mechanics and Dynamics

Homework 8: Shells

Due 16/04/2018

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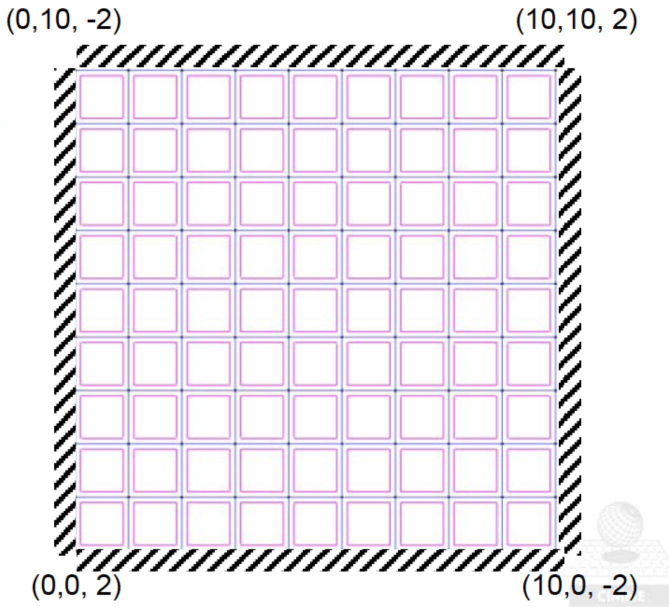
Analyze the following concrete hyperbolic shell under self weight. Explain the behavior of all the stresses presented.



In this assignemnt corresponding to the Shell lecture, we will analyze a hyperbolic concrete shell under self weight. For this task, we will use the MatFEM code provided to solve the shell finite element formulation. First of all, we create the geometry of the shell using GID.

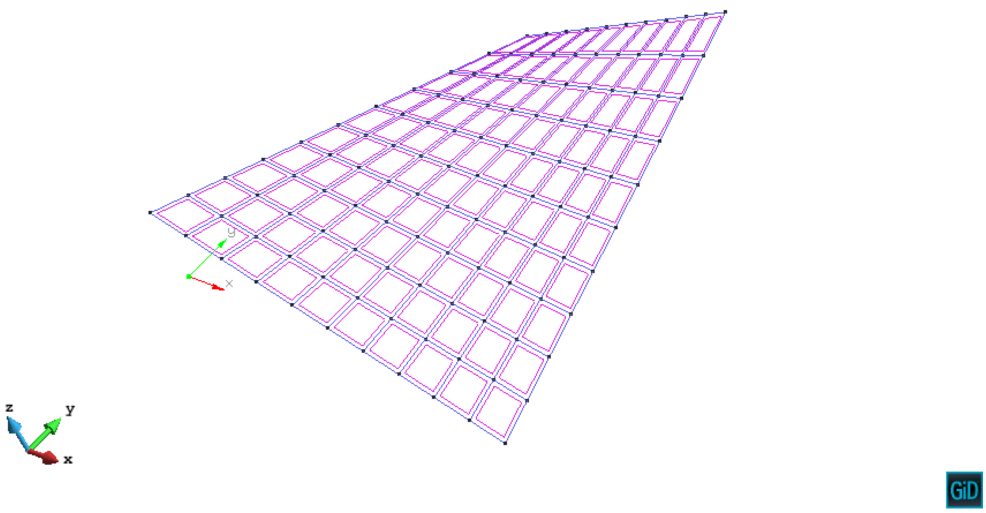


Figure 0.1: Geometry definition of the shell using GiD.

The shell is assumed to be made of concrete with standard mechanical parameters provided by GiD and thickness $t = 0.1$ m. Also, for this analysis, the following boundary conditions are imposed:

- Displacement Constraints / Linear Constraints: The edges of the shell (the ones on the boundary) are completely clamped. Thus, we impose zero displacement are rotations. See Figure 0.2 (a).

- Loads: No external loads are considered.

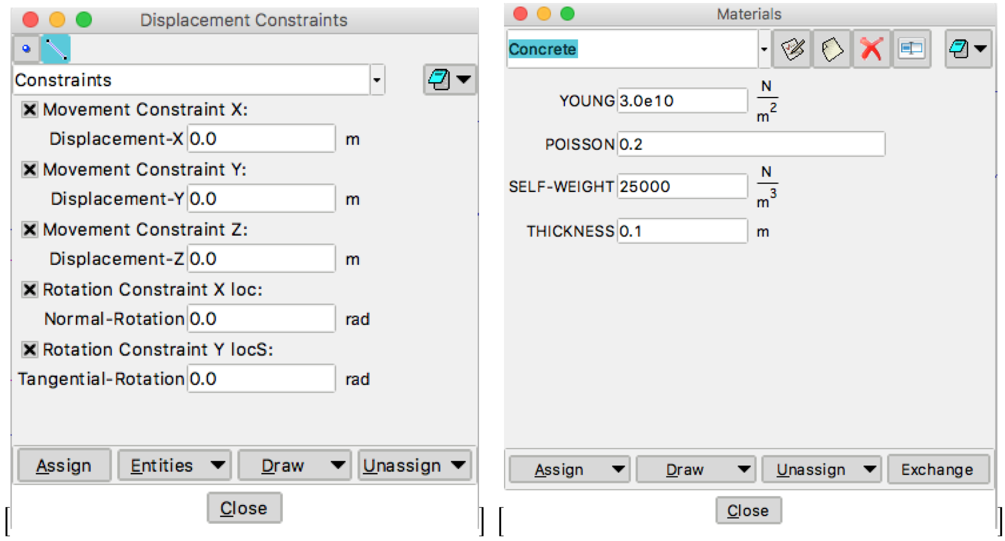


Figure 0.2: (a) Displacement constraint definition in GiD and (b) Material parameters for the analysis.

In the problem data window we need to check the self-weight box in order to ensure that the self-weight of the structure is taking into account in the analysis. In fact, in this case it is the only load considered.

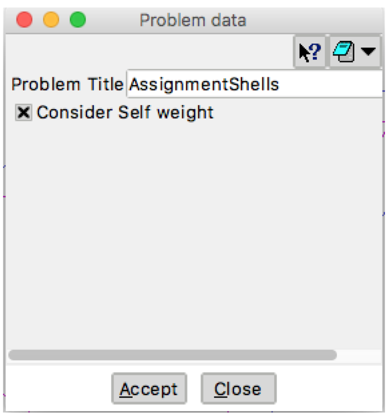


Figure 0.3: Problem data definition in GiD.

Next step is to define the mesh for the simulation. The code provided uses the 3-noded rriangular thick shell (RM) element. Let us now consider a mesh of triangular element with a reference mesh size of 0.5. Then, we obtain the mesh in Figure 0.4. Finner meshes could be considered for the analysis.

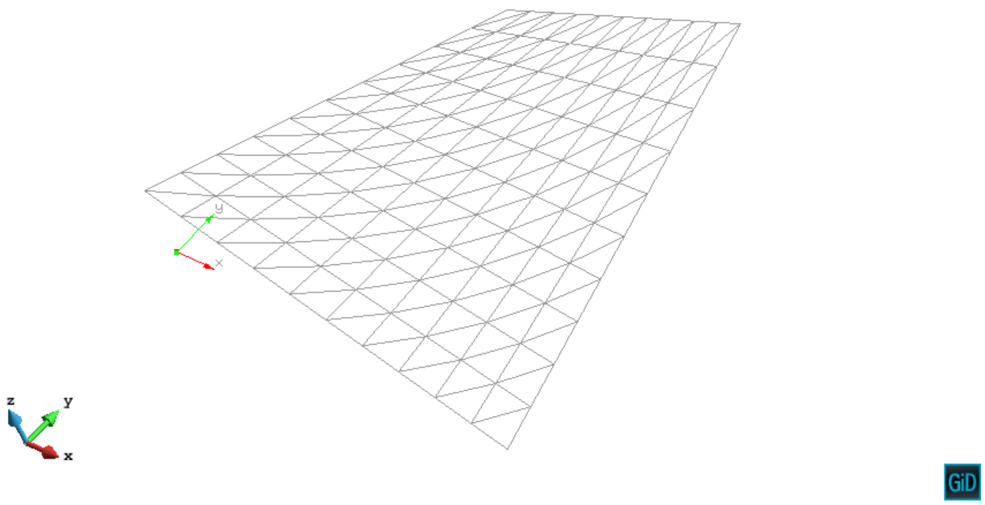


Figure 0.4: Considered mesh for the calculation.

Now, the input file for the MATLAB solver can be generated and executed when running the main file of the code *Lamina_ T_ RM.m*. After executing it, two more files are obtained, a *.msh* and a *.res* files which contain the solution of our problem. Finaly, these files are viewed in the GiD postprocess mode. The following figures, show the results obtained for the analysis.

Figure 0.5 down below, shows the deformation in the z direction. As we can see, displacements in the boundary of the shell are exactly zero, and maximum displacement is achieved in the middle part. Figure 0.6 shows just the deformed shell, for clarity.

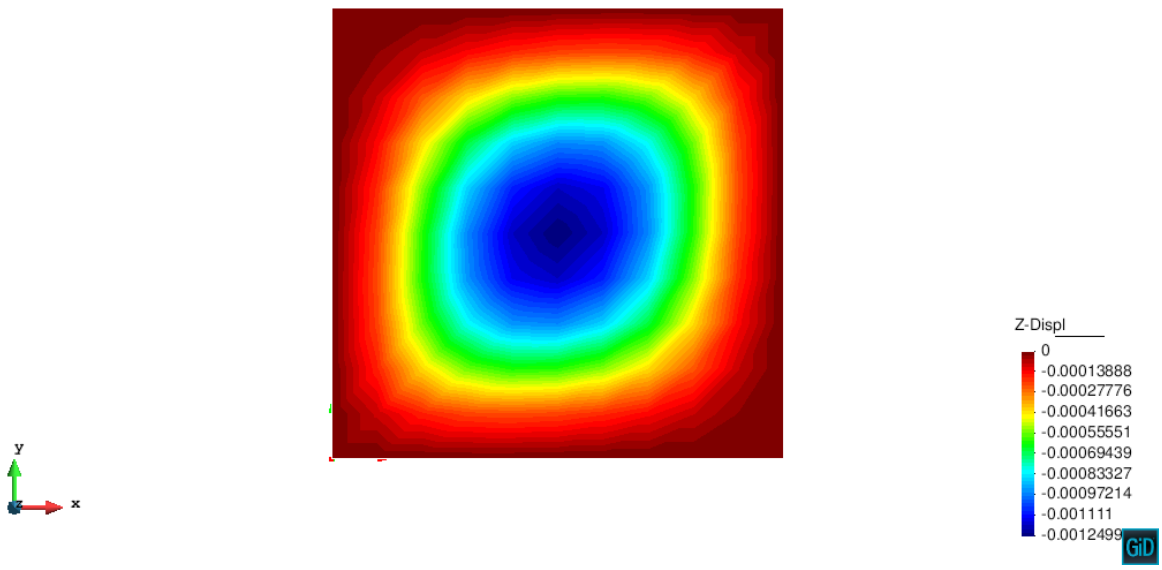


Figure 0.5: Displacements in the z direction.

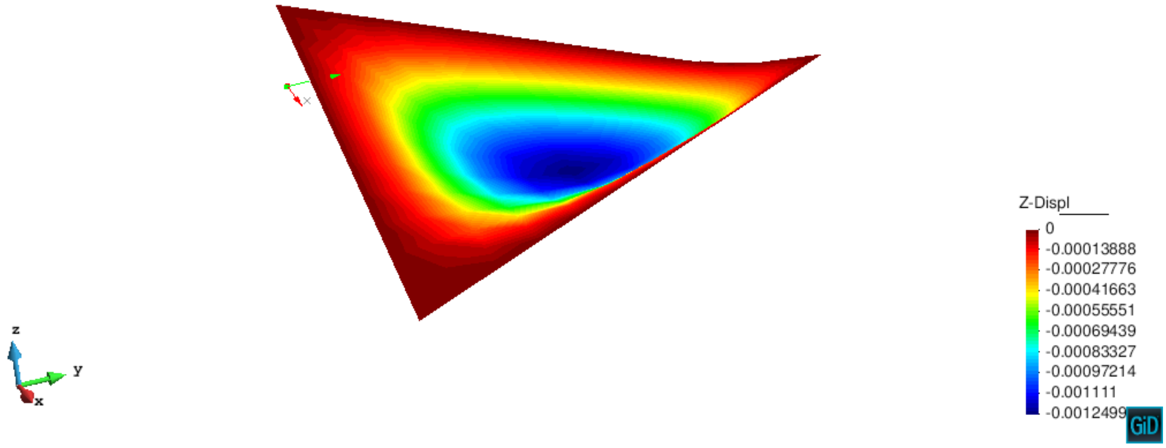


Figure 0.6: Displacements in the z direction.

Figures 0.7, 0.9 and 0.11 show the membrane stresses T_x, T_y and T_{xy}. This are obtained uppon integration of the in-plane normal stresses $\sigma^m_{x'}$, $\sigma^m_{y'}$, and the in-plane shear stress $\tau^m_{x'y'}$. For the case of T_x, maximum values are achieved mainly at the corners of the hyperbolic shell which are in the upper part while minimum values are appear in the lower corners. See Fig 0.8 for detail.

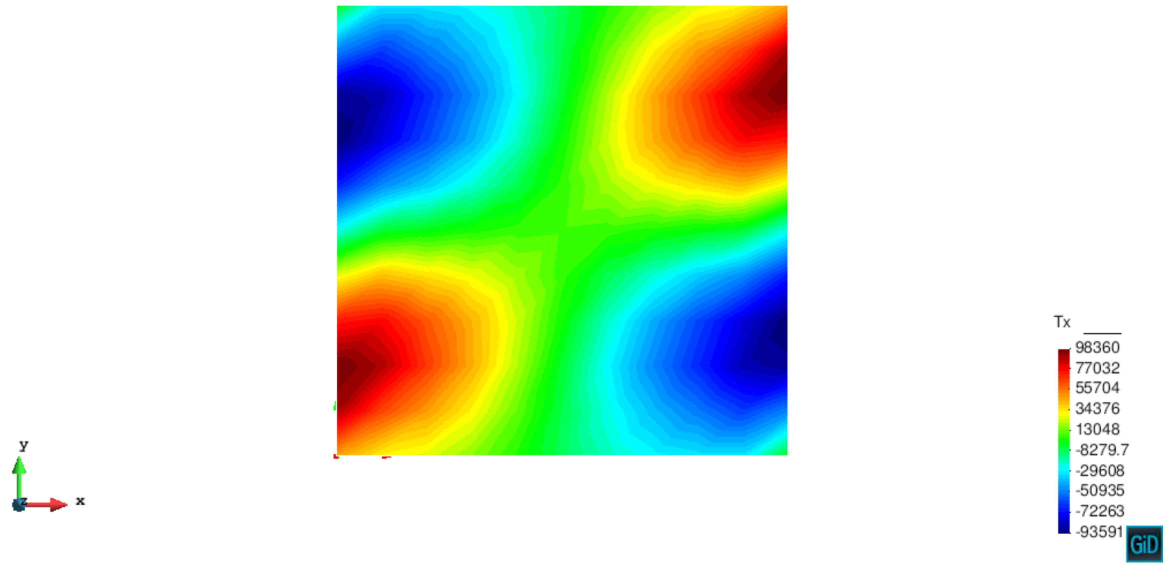


Figure 0.7: Result for the T_x stresses.

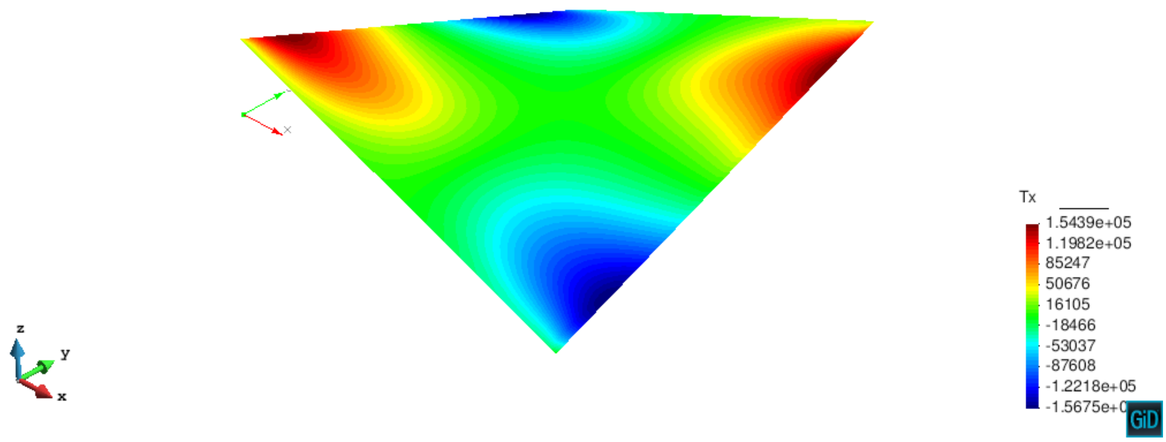


Figure 0.8: Result for the T_x stresses with the deformed shape of the shell.

Similar results are obtained for the membrane stress T_y. Now, note the analogy of the results with the one obtained for T_x. Analogy in the sense that where we obtained maximun and minimum values for T_x, now we obtained similarly for T_y but somewhat transpose. Again, highest (lowest) values are achieved in the corners.

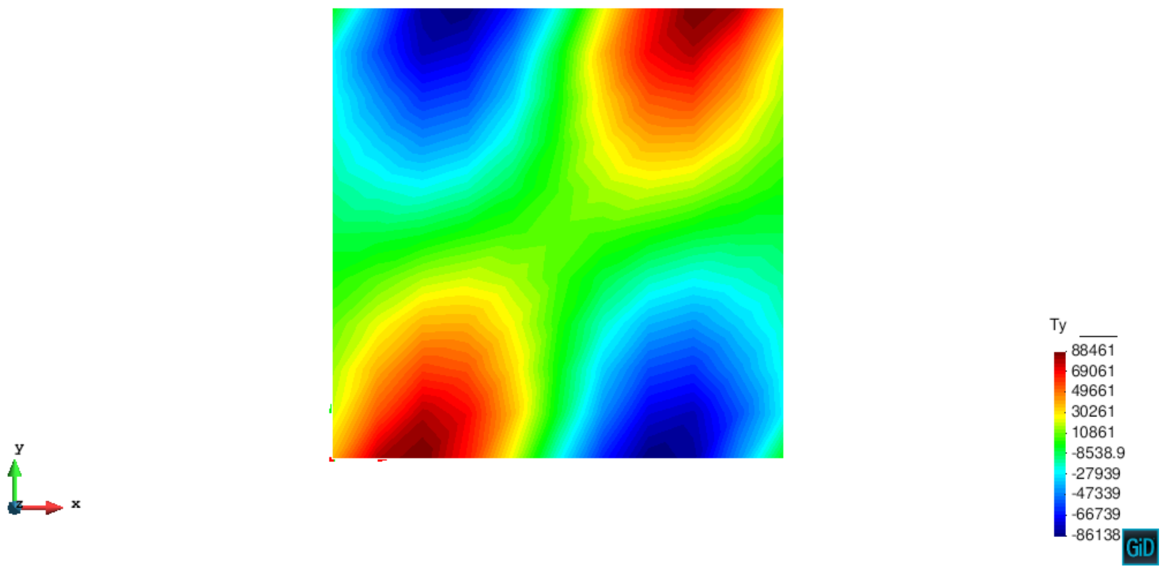


Figure 0.9: Result for the T_y stresses.

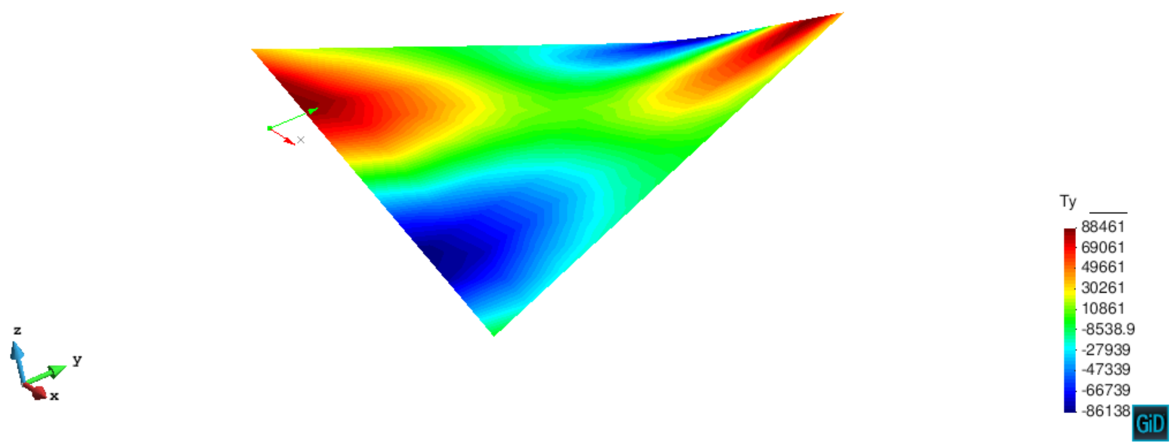


Figure 0.10: Result for the T_y stresses viewed in the deformed shape.

The case of the T_{xy} membrane stresses is somewhat particular. Figure 0.11 mainly says that, this stress vanish at the corner, where the contributions of bot T_x and T_y cancel, and it is maximum in the center of the shell, where both contribution, let's say, are added.

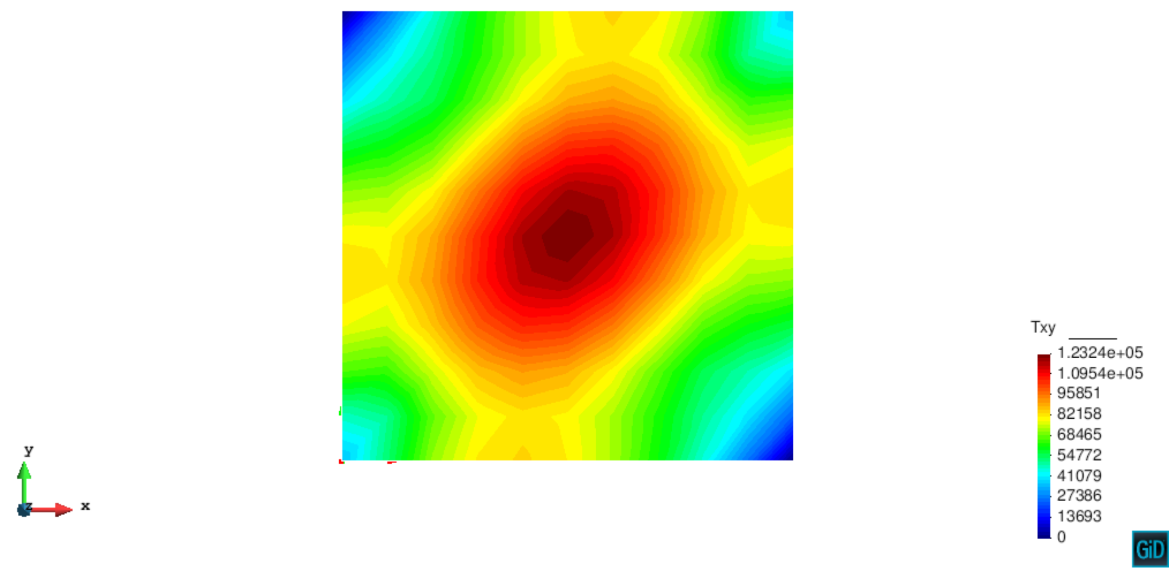


Figure 0.11: Result for the T_{xy} stresses.

Now, let us present the result obtained for the bending stresses M_x, M_y and M_{xy} which corresponde to the integration of the in-plane bending stresses. For the case of M_x, maximum values are reached again at the boundaries of the shell, where the values of the local coordinate x of the plot (see Figure down below) are minimum and maximum. Minimum values for this rotation are achieved at the center of the shell, where rotations mainly vanish, as expected.

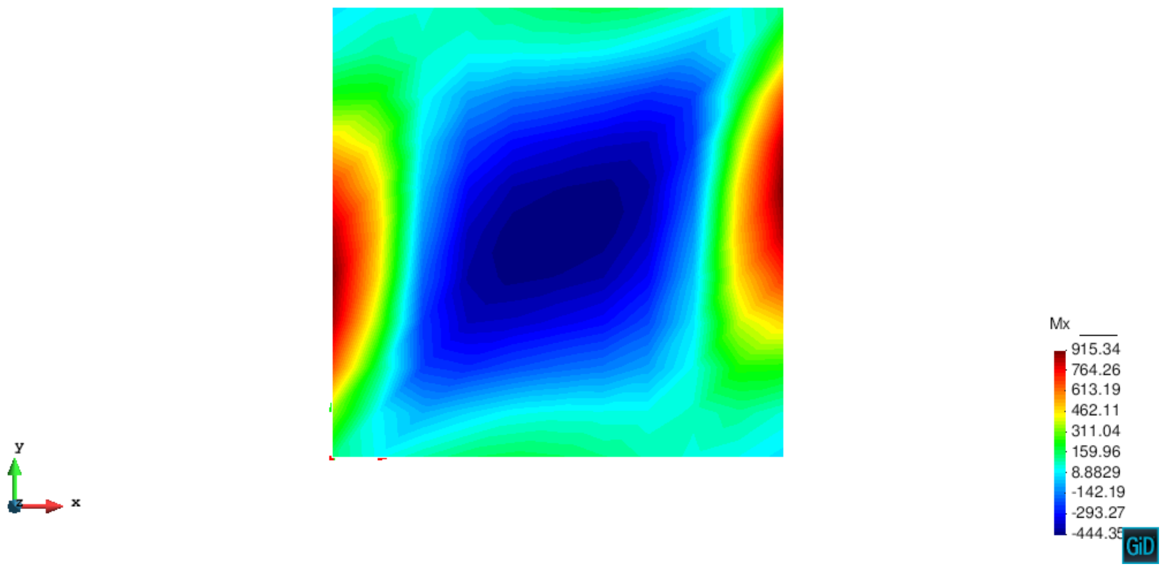


Figure 0.12: Result for the M_x stresses.

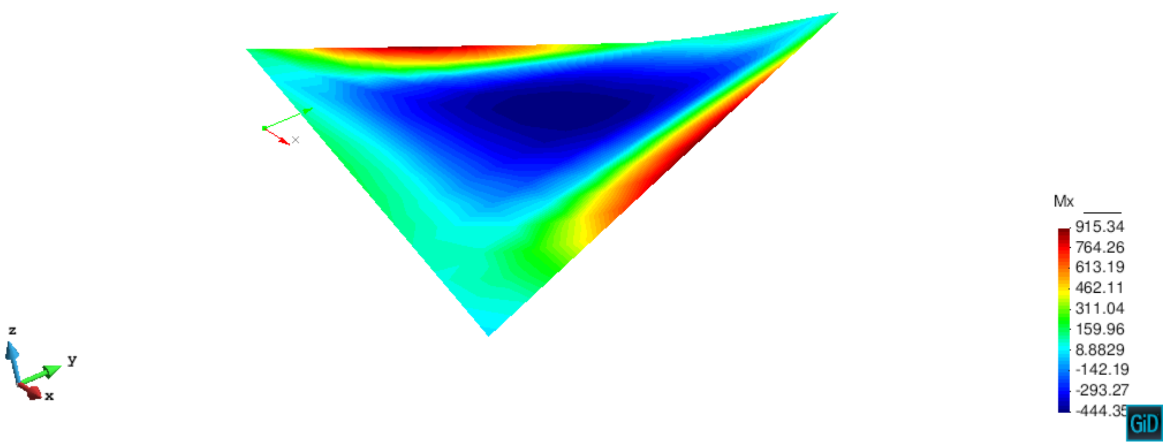


Figure 0.13: Result for the M_x stresses viewed in the deformed shape.

The results for M_y follow the same explanation. In fact are the same as those for M_x but rotated. See Figure 0.14.

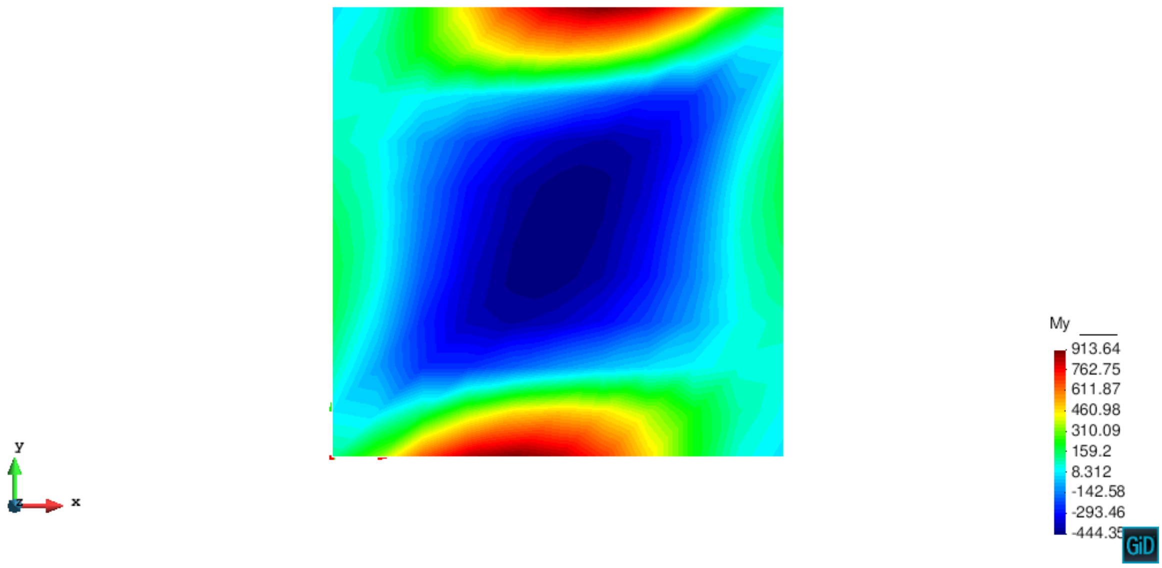


Figure 0.14: Result for the M_y stresses.

For the case of M_{xy} is interesting to note the complete symmetri with respect a diagonal of the shell. Recall that the analyzed shell is in fact symmetric with symmetric load (self weight).

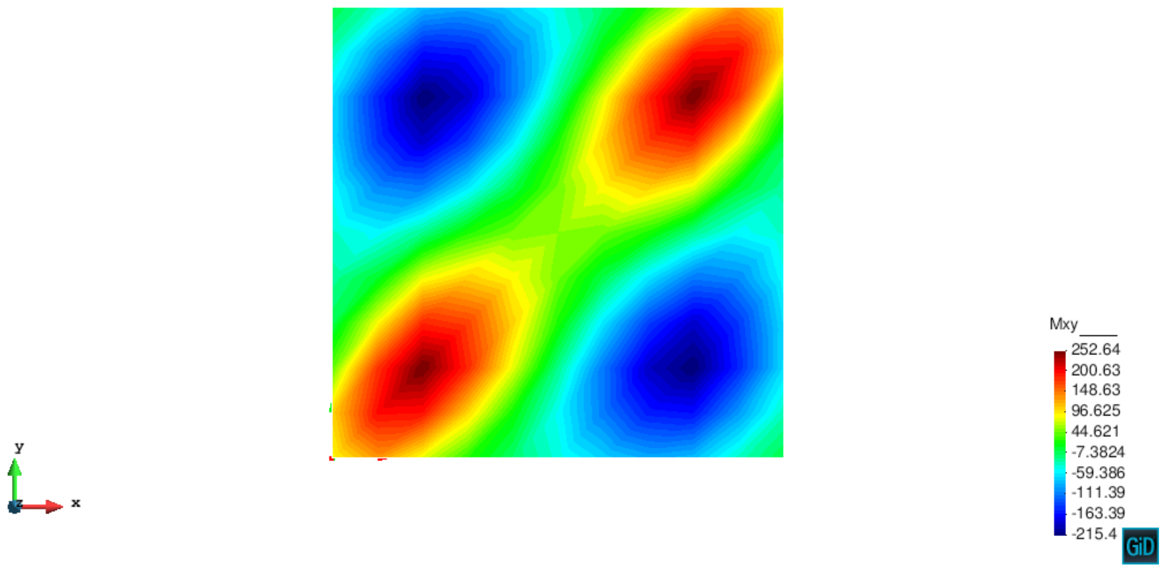


Figure 0.15: Result for the M_{xy} stresses.

Finally, we present in Figures 0.16 and 0.18 the transverse shear affect on the shell, Q_x and Q_y. Within the framework of the Reissner-Midlin theory, these stresses are constant across the thickness of the shell. The result for both is equivalent as one can see in the following figures. The distribution is mainly uniform at the plate center and starts increasing as we reach the boundaries. Higher values are reached at these points as they are clamped.

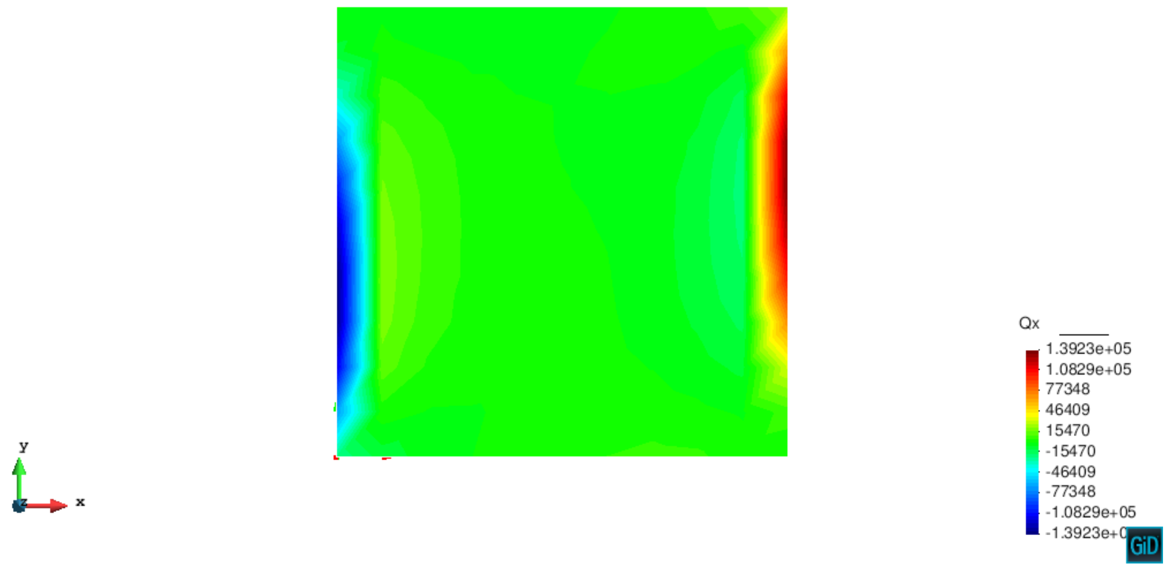


Figure 0.16: Result for the Q_x shear stresses.

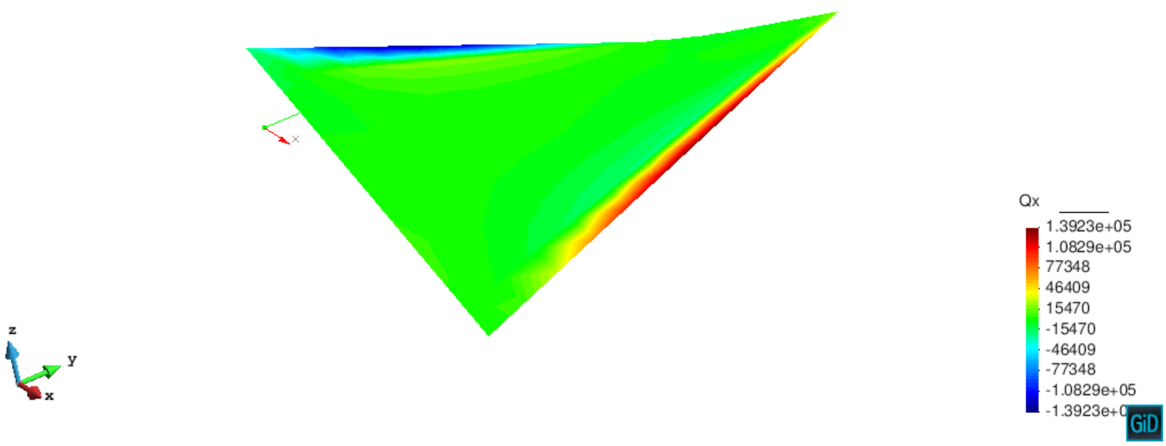


Figure 0.17: Result for the Q_x stresses viewed in the deformed shape.

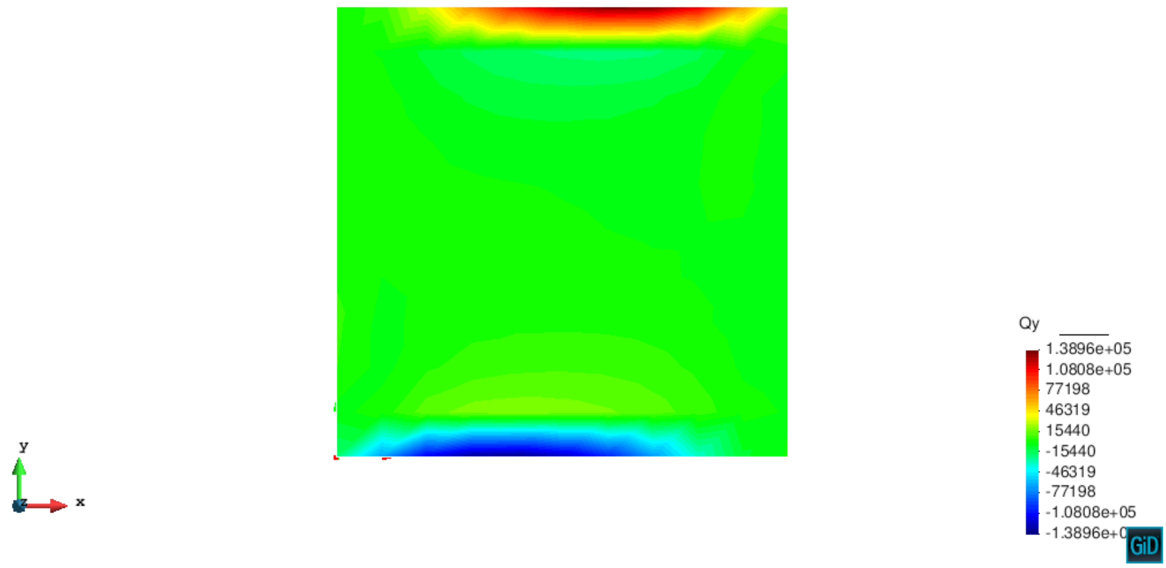


Figure 0.18: Result for the Q_y shear stresses.