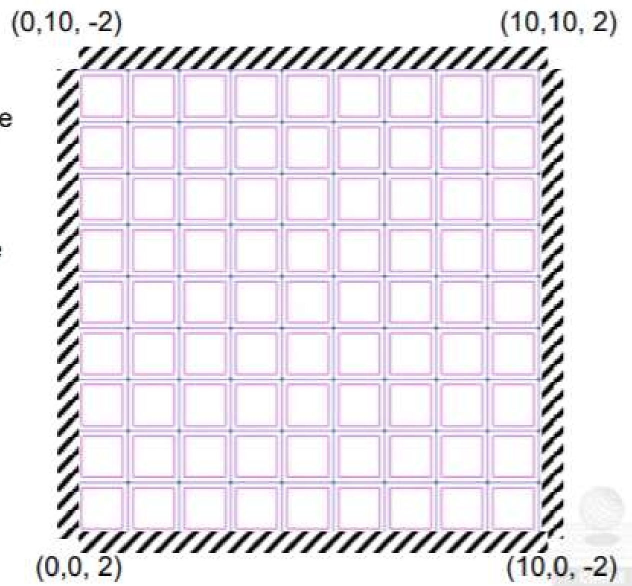
Computational Structural Mechanics and Dynamics

Assignment 8

Jose Andino Saint Antonin

Analyze the following concrete hyperbolic Shell under self weight.

Explain the behavior of all the Stresses presented.
t = 0.1



<u>Solution:</u>

The mesh was generated in GID using a 4-sided prism of 10mx10mx0.1m.

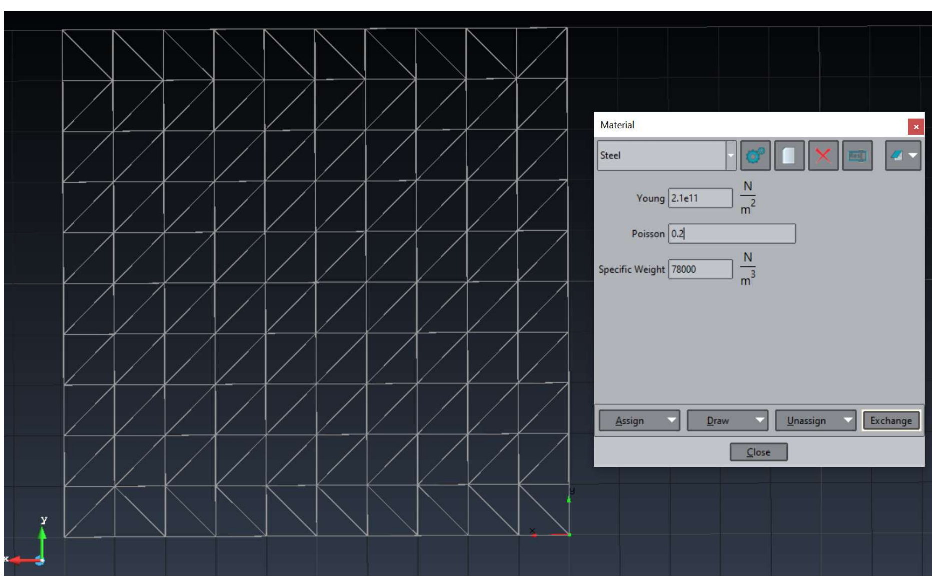


Figure 1 GID model. Num. of Tetrahedra elements=600, Num. of nodes=242

The following properties were used, E2x10^11, density = 7800kg/m3, Poisson ratio = 0.2.

Prescribed displacements on the corners were imposed as point displacements:

- 2m in the z direction at (0,0) and (10,10)
- -2m in the z direction at (0,10) and (10, 0)

It should be noted that the problem has symmetry over a 45-degree line. If it were a computationally expensive problem, it could be simplified utilizing this symmetry. However, it's a small problem, so to make plots look better we simulated the entire problem.

There are no prescribed loads other than the self-weight. The weight was modelled by equally distributing the force on node:

- Total weight = 10m*10m*0.1m*7800kg/m3*9.8m/s^2 = 764kN
- Weight per node = 3158.6N in negative z direction.

The results of the simulation are shown in the figures below. The displacements are almost exclusively in the vertical direction. This is due to the fact that the shell is being tensed (extended) to achieve the +/-2m vertical displacement.

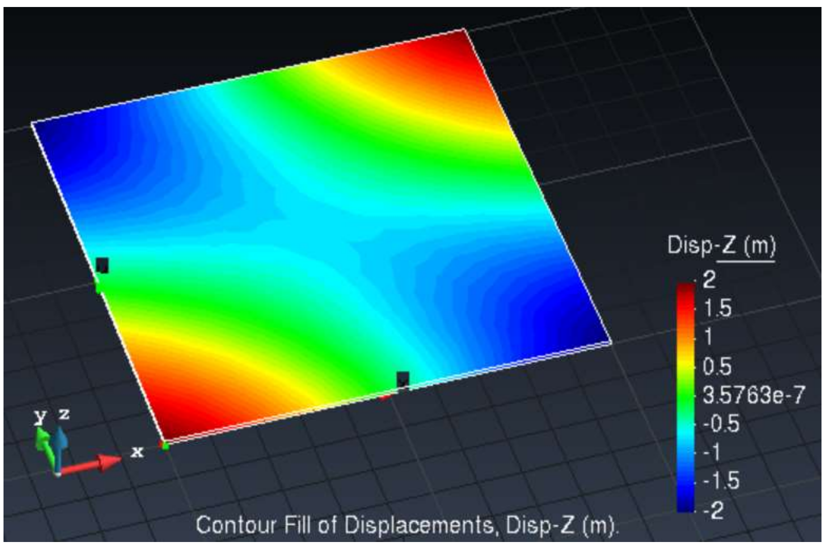


Figure 2 displacements in Z-direction

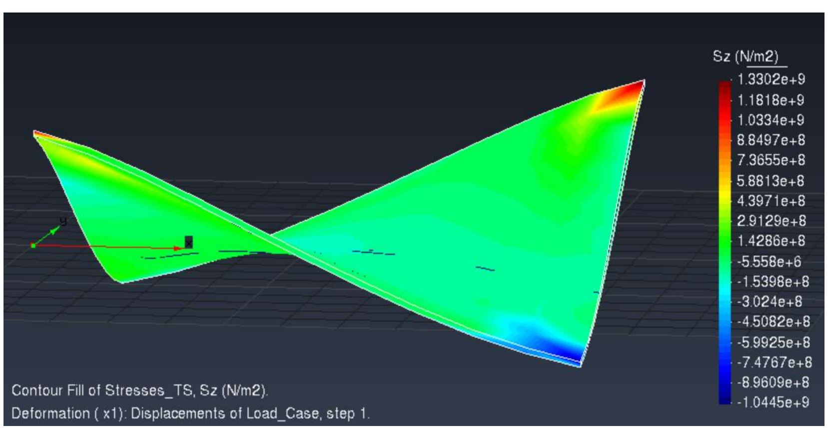


Figure 3 Actual shape of the shell (1x scale factor vertically). Stresses shown in color code.

Horizontal displacements remain small relative to vertical

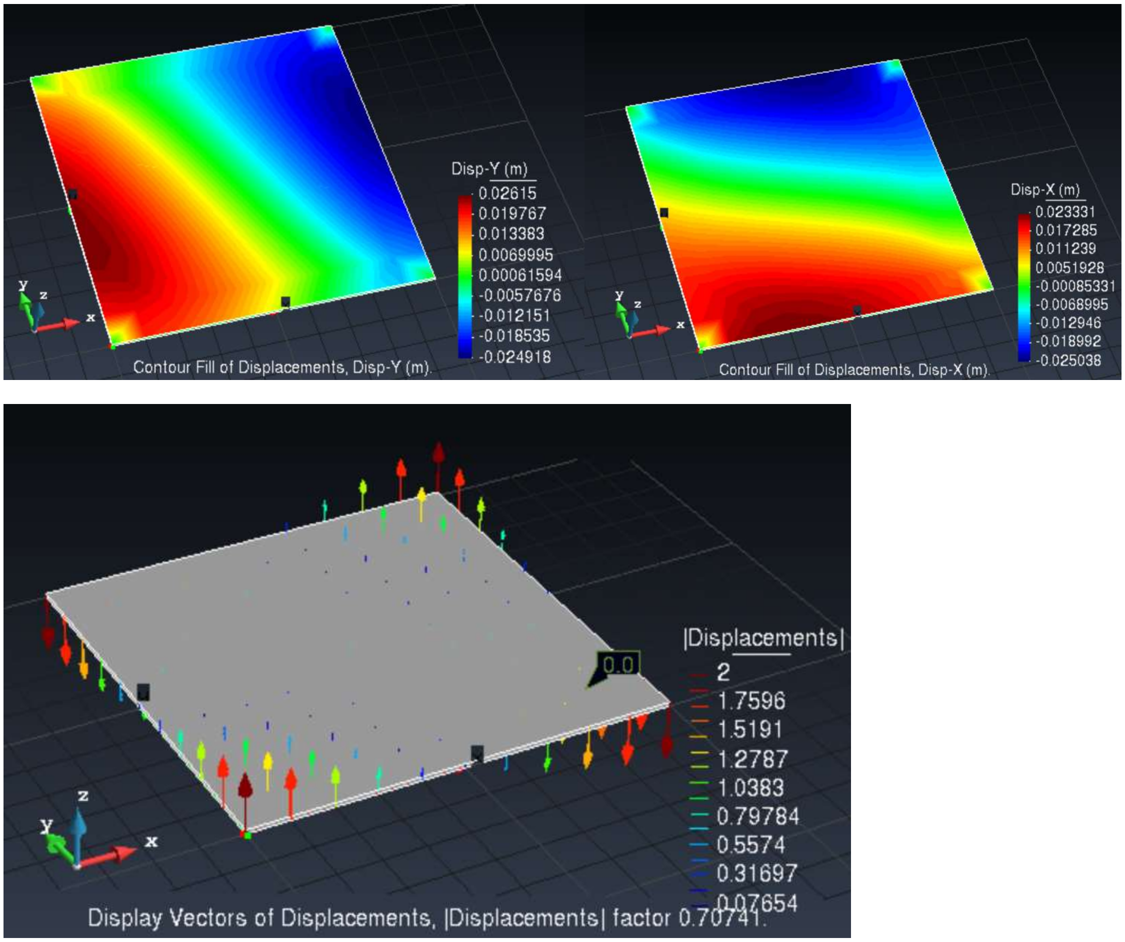


Figure 4 displacements (Y-direction, top left, X-direction, top right and vector representation, bottom)

It should also be pointed out that the main stresses occur in the ‘high’ corners, from which the shell is being pulled up. Also, the reaction forces are very large in the positive Z direction on corners (0,0) and (10,10).

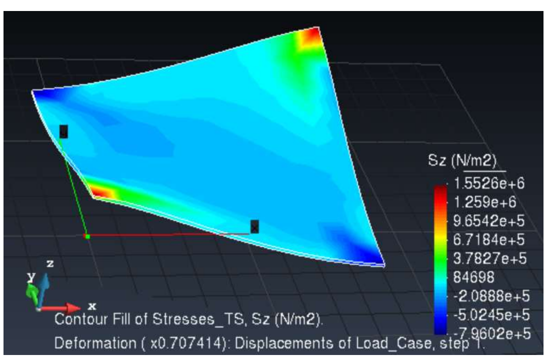


Figure 5 Stresses in the Z direction

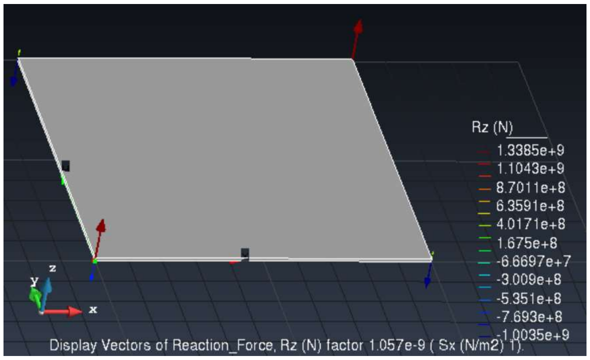


Figure 6   reaction forces. The larges values are in the order of 1.4E9N!

The impact of self weight is not apparent in the displacement field above, as the deformation caused by weight is small. The plate is being submitted to high tension by being stretched. To test the effect of self weight, a simulation was run with prescribed displacements (0,0,0) in all corners. As can be appreciated in the next figure, the displacements are negligible when compared to the -2m and +2m prescribed in the problem and this is why they can almost be neglected.

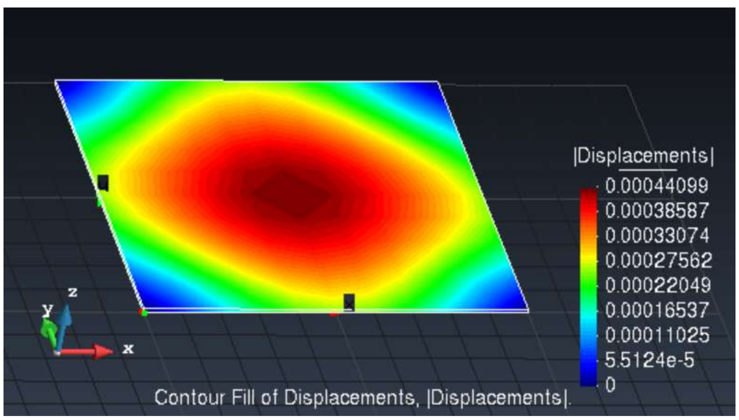


Figure 7   effect of self-weight only. Notice how small the displacements are relative to the prescribed +2m, -2m on the corners

However, if we were to reduce Young's Modulus in the simulation by a factor of 100, the-self weight effects become clearly visible. As the material is weaker, the center experiences a downward displacement:

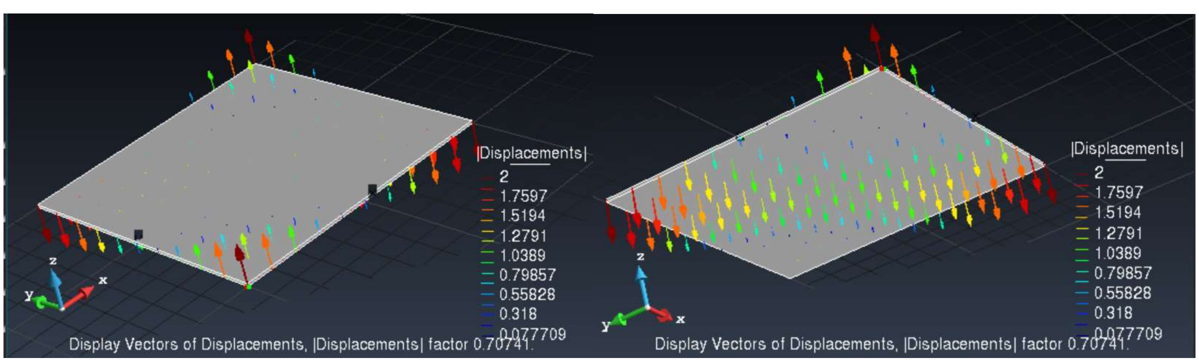


Figure 8 same displacement conditions and loads, but with E=2.1E^9. Notice now the displacements in the negative z direction due to self-weight become visible