Master's Degree Numerical Methods in Engineering

Computational Structural Mechanics and Dynamics

Assignment 8: Shells

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1 Shells

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

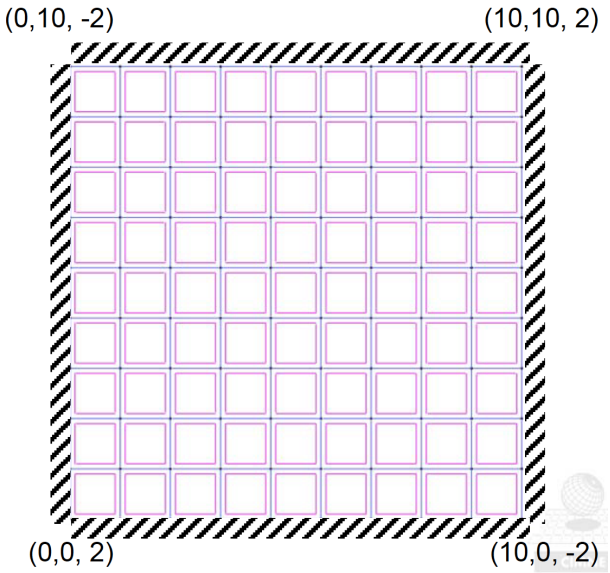

Figure 1: Geometry of the concrete plate

As the previous assignments it is needed to model this concrete plate in GID and use the input file created in the MATFEM programs in order to generate the outputs of the simulation and visualize the outputs in the GID post-process. All the displacements and rotations were closed on the boundaries and no forces were applies to the plate. Concrete was assigned as material to the plate with young's modulus of $3.00e^{+10}$, poissons ratio of 0.2 and as assigned in the problem thickness of 0.1m. A mesh size of 0.2 with triangular linear elements was assigned to the geometry. The mesh was chosen by a mesh convergence for the maximum value of the z-direction displacement because for different mesh sizes. The z-displacement was chosen as the convergence parameter because of the importance of it for the self weight problem that we were analyzing. In the chart below we can see that for a mesh size of smaller than 0.3 the difference between the maximum value of the z-displacements are very small so the 0.2 size was chosen for the analysis.

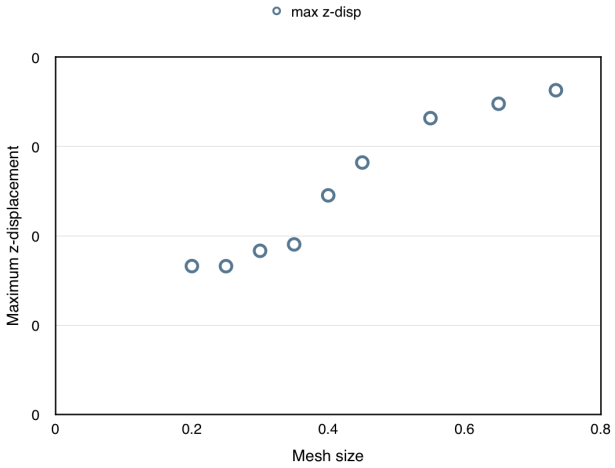

Figure 2: Mesh convergence with mesh size and maximum z-displacement

The z-direction displacements were obtained as:

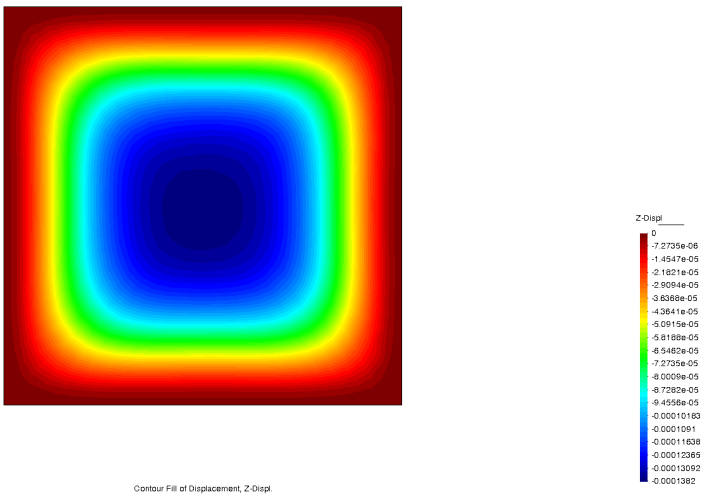

Figure 3: Z-displacement

As expected we can see that the maximum z-displacement is obtained in the middle point of the plate because of the zero displacement condition on the boundaries. The effect of the self-weight cause displacements on the x and y directions too but relative to the z-direction they are very small. The general displacement of the plate is shown below:

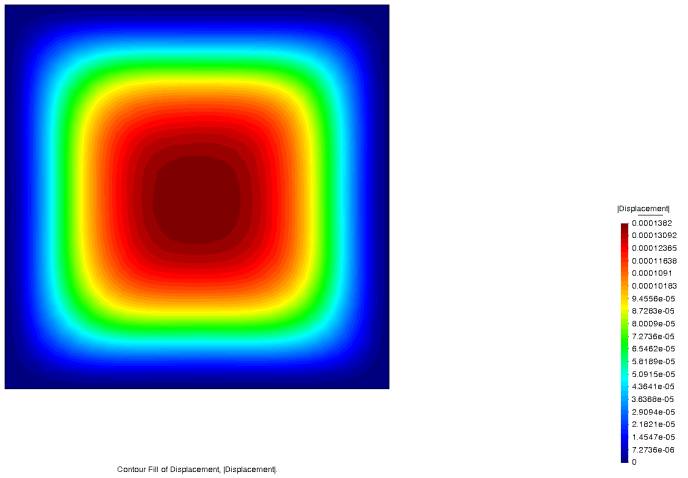

Figure 4: General displacements caused by the self weight

The stresses created in the plate have 3 directions for of the main Cartesian axis. We know that the stresses obtained for the each direction and its opposite are the same with opposite signs, for example the stresses in the XY are the opposite values of the YX, so only one direction of the stresses was shown for each combination. The stresses created in the XX direction as seen below, change in parallel lines to the x-axis and the same applies for the YY direction. We know that the maximum displacements are caused in the middle of the plate because of the self-weight and for each one the maximum moments are in the middle of the boundaries perpendicular to the axis so the maximum streching happens in the middle of the plate and because of the moments in the same direction we can see that the values for the stresses change parallel to each axis.

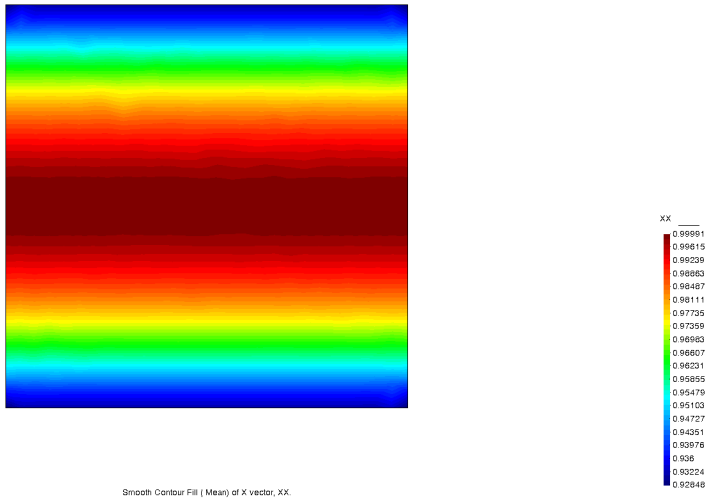

Figure 5: The xx direction stresses

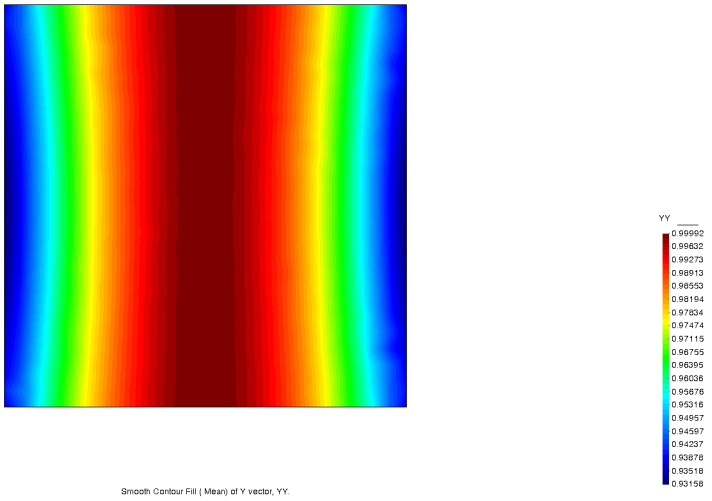

Figure 6: The yy direction stresses

The stresses created in the XY direction has the maximum and the minimum values in the corners because the main stresses created in the XY direction are caused by the membrane forces which as seen have the maximum and minimums in the corners. the reason is the self weight acting in the middle and causing the displacement. The reason for the positive and negative membranes is the form of the plate so when we have negative z-displacements in the plate the lower corners create positive and the upper corners creates negative membrane forces.

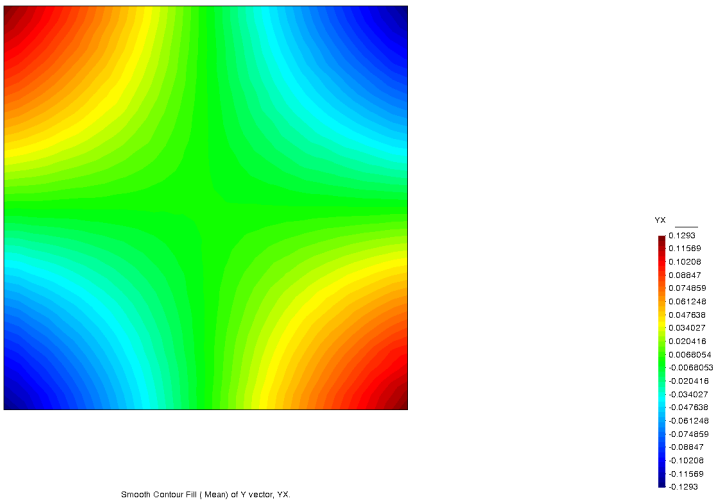

Figure 7: The yx direction stresses

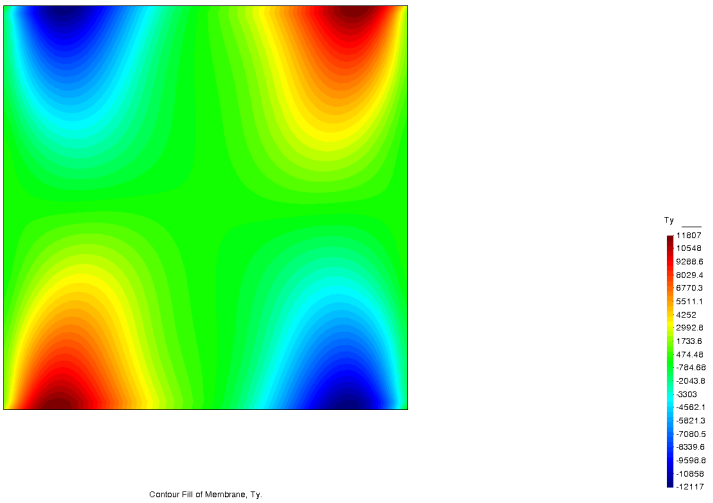

Figure 8: The membrane of y-direction

The stresses in the XZ and YZ directions as seen change in parallel lines with each axis. There is a neutral point in the middle of the plane where the XZ and YZ component of the stresses is zero. The reason of the stresses is because of the opposite slopes that the parallel edges have with respect to each other.

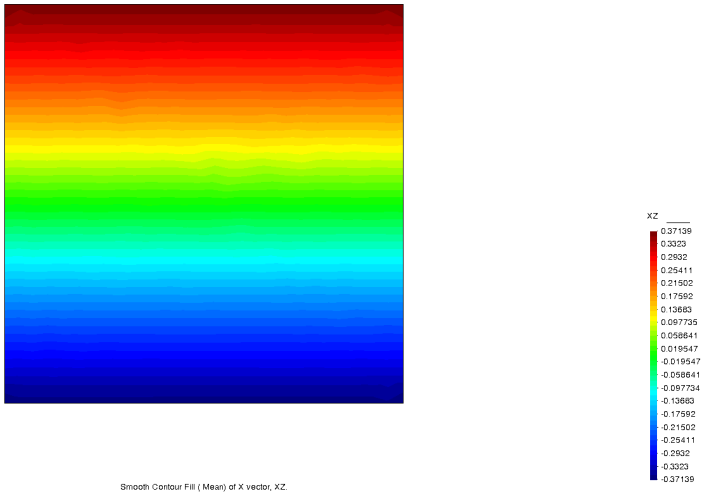

Figure 9: The xz direction stresses

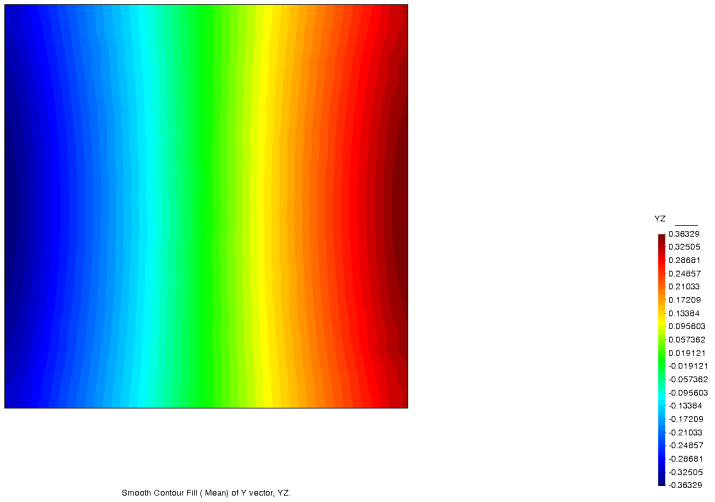

Figure 10: The yz direction tresses

The stresses created in the ZZ direction are the direct result of the z-direction displacements caused by the self-weight and as the displacement we can see that the maximum stresses are created in the middle of the plane.

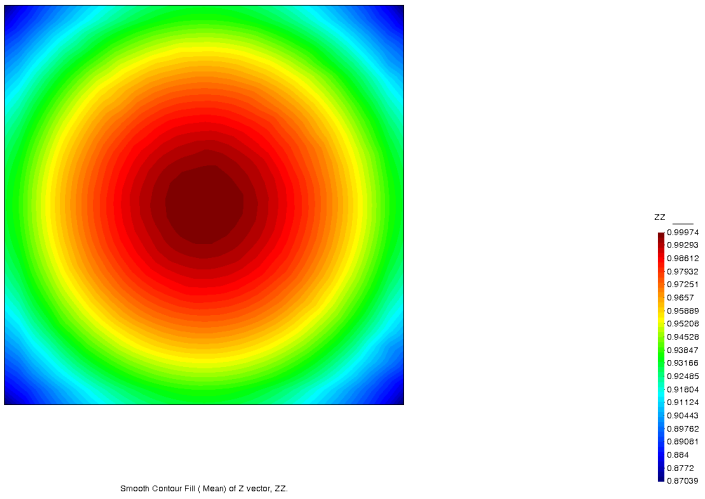

Figure 11: The zz direction stresses