Computational Structural Mechanics and Dynamics

Masters in Numerical Methods

Assignment 8

Analysis of shells with plate elements

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Contents

1 Task

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

The material properties for concrete were as follows : $E = 3x10^{10}$ Pa , $\nu = 0.2$ $\rho = 25000kg/m^3$.

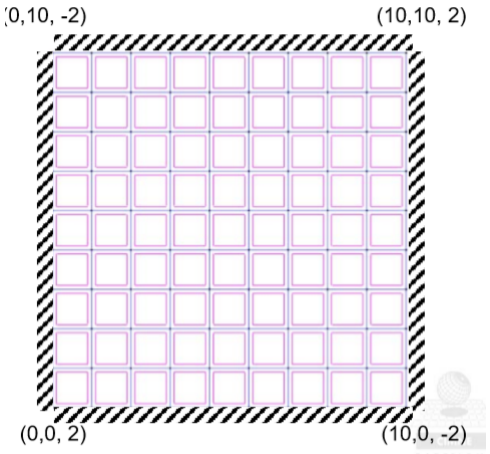


Figure 1: Problem Definition

2 Modelling

The analysis was performed using MATFEM Shell_T_RM version 1.1 module. The geometry was constructed as asked in the problem, self weight was considered. A triangular mesh of 208 elements and 125 nodes was created. No loading was considered either UDL or point loads. All the nodes on the boundary were constrained with zero displacement in all directions and zero rotations.

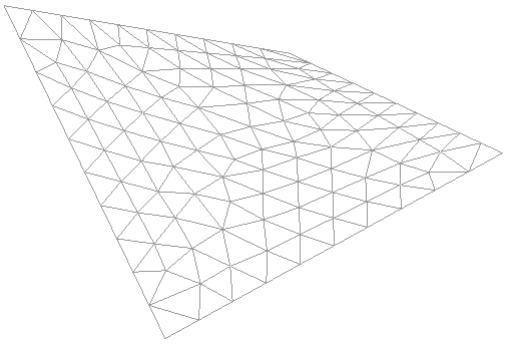


Figure 2: Mesh

3 Results

3.1 Displacements

Due to the effect of self weight it is expected that the maximum displacements be visible in the z direction, this can be observed in the figure 3. The z displacement is maximum at the center and it's value is around 0.1 mm in the negative z direction. Due to the geometry, the gravity load does not act perpendicularly on the membrane.

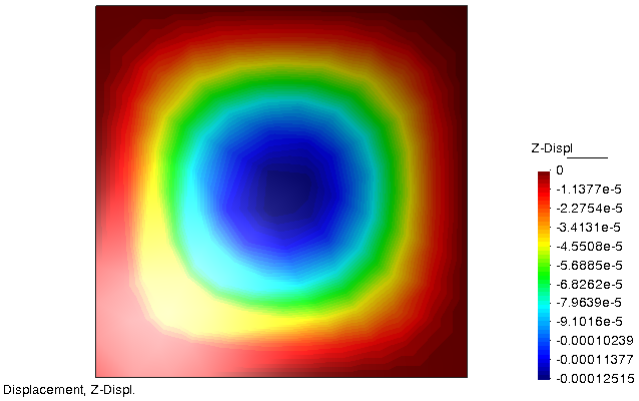
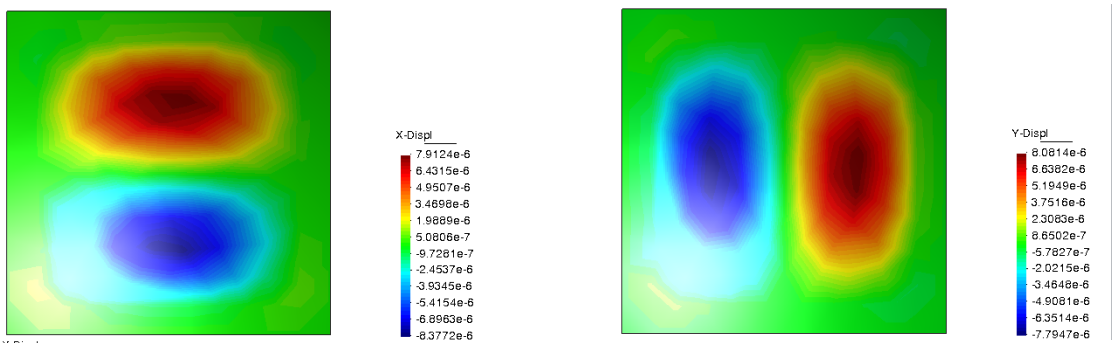


Figure 3: Displacement in the Z direction

In the planar directions, figure 4 we can see that there is a positive and negative displacements with two different peaks. There exists a saddle point at the center of the plate. These displacements are also around 100 times smaller in magnitude as compared to the z displacements.

3.2 Membrane Stresses

The stresses corresponding to membrane strains are looked at in figure 5 and figure 6. We can see that both for T_x and T_y stresses the maxima for tension and compression occurs at the edges. The center of the shell has almost zero stresses in both X and directions. The T_{xy} are maximum at the center because of geometry and the redistribution of stresses.



(a) Displacement in the X direction (b) Displacement in the Y direction

Figure 4: Displacements in the planar directions

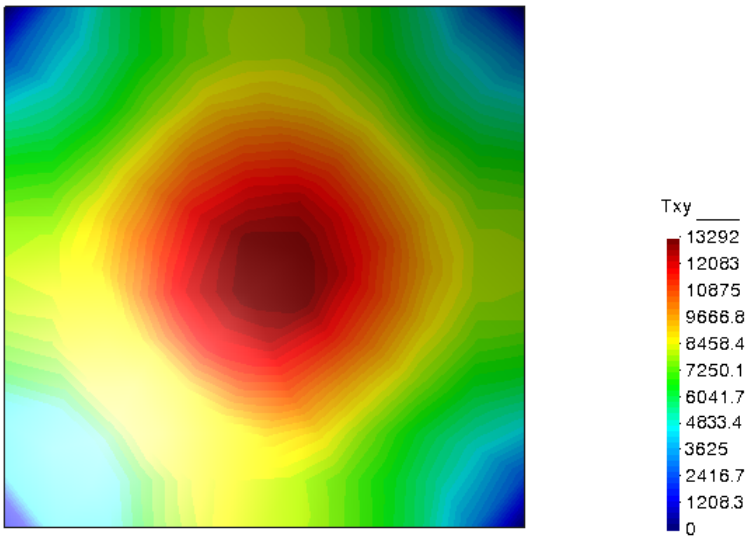
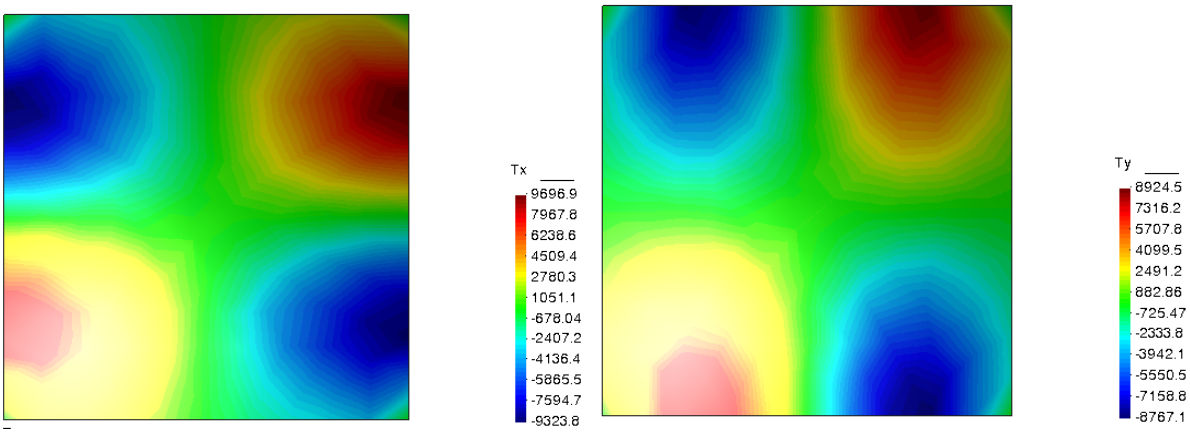


Figure 5: Txy Stresses

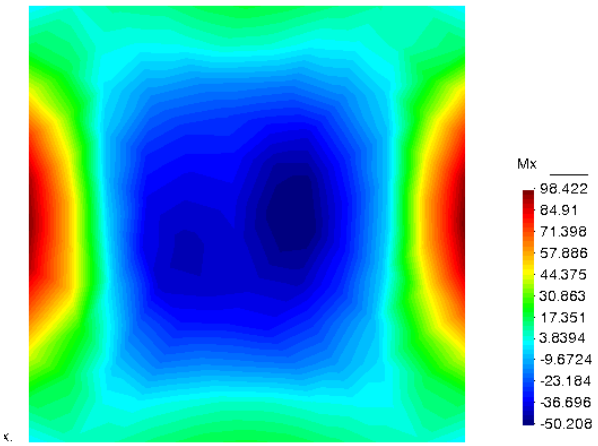


(a) T_X stress (b) T_Y stress

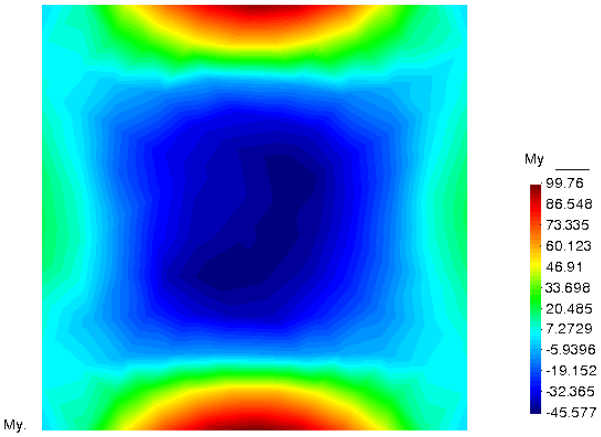
Figure 6: Membrane Stresses in the planar direction

3.3 Moments

The maximum positive bending occurs in the X and Y directions on the respective edges as seen in figure 7, there is negative bending moment at the center of the shell



(a) X moment



(b) Y moment

Figure 7: Bending Moments in the planar direction

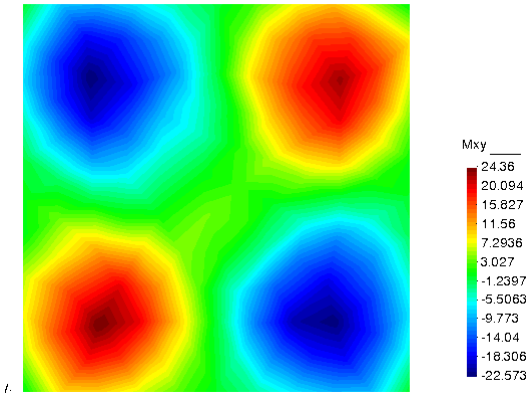
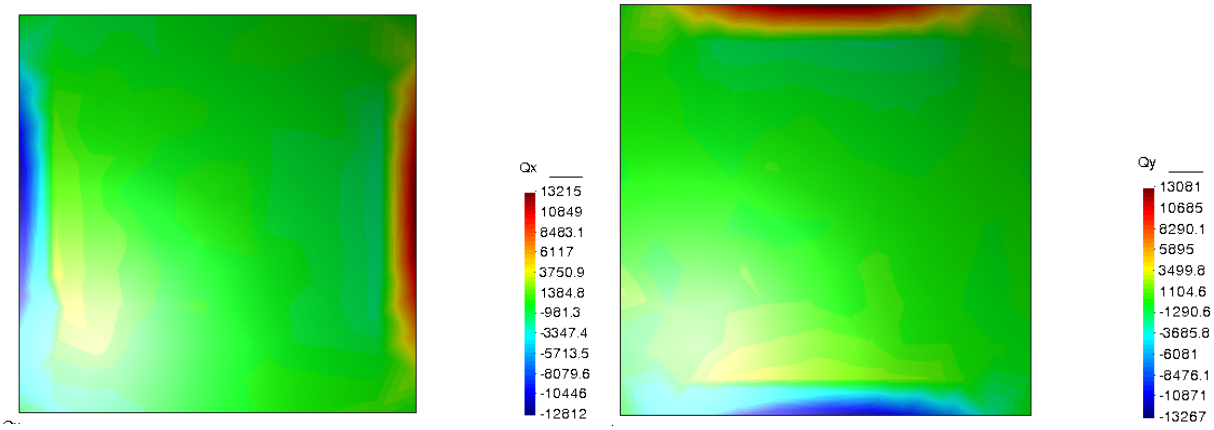


Figure 8: XY Moment

3.4 Shear Force

The shear forces are presented in figure 9a and 9b, owing to the symmetry of the problem the shear forces are almost the same in X and Y directions with opposite signs. This response is a result of the hyperbolic shape of the shell, the fixed edges and the self-weight load



(a) X shear force

(b) Y Shear Force

Figure 9: Shear Forces in the planar direction

4 Discussion

- The Reissner-Mindlin flat shell theory is an effective tool for computing deformation in shells as it considers plane stress states and the effect plate bending with internal shear effects.
- The maximum observed displacement was in the negative z with a magnitude of 0.11mm under self weight.
- The shear stresses were concentrated very close to the edge, and their concentrations presented an anti-symmetric behavior.
- The membrane stresses are present in zones near the edge of the shell with their maxima at the edges, they also exhibit anti-symmetric behaviour.