SHELLS ASSIGNMENT

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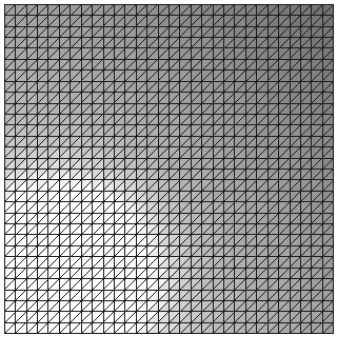
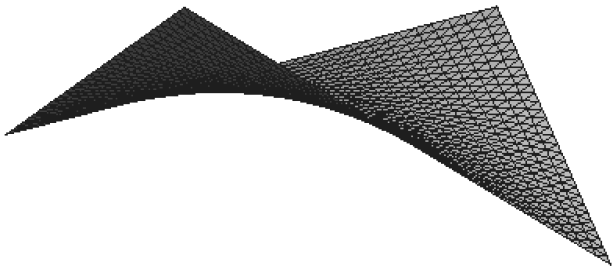
Msc in Computational Mechanics

Shells can be seen as the extension of a plate to a normal planar surface. In addition to bending and shear forces, axial forces (membrane) are introduced due to the non-coplanarity, providing a higher strength. Considering the shell as formed by a group of folded plates, the formulation of flat shell elements is obtained as a direct extension of Reissner-Mindlin thick plate theory.

A fixed concrete hyperbolic shell under self-weight is studied using triangular Reissner-Mindlin elements. Then, different stresses types will be analyzed in order to obtain the right conclusions.

(0, 10, -2) (10, 10, 2)





(0, 0, 2) (10, 0, -2)

Problem Data

$E = 3e10\ N/m^2$, $\nu = 0.2$, $\rho = 2.5e4\ kg/m^3$, $t = 0.1\ m$

DISPLACEMENTS

To start the analysis, displacements in the z direction and final deformation results are studied in order to obtain the firs conclusions. Remark that the z-direction has been chosen due to the fact that just self-weight is acting on the shell.

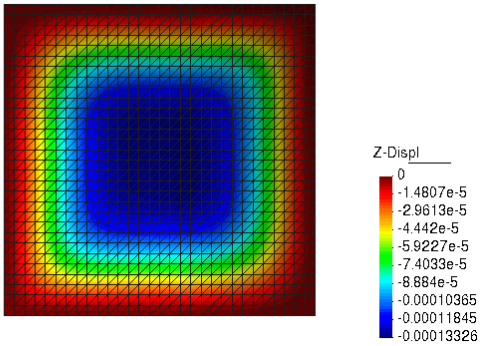


Figure 1. Z-displacements chart

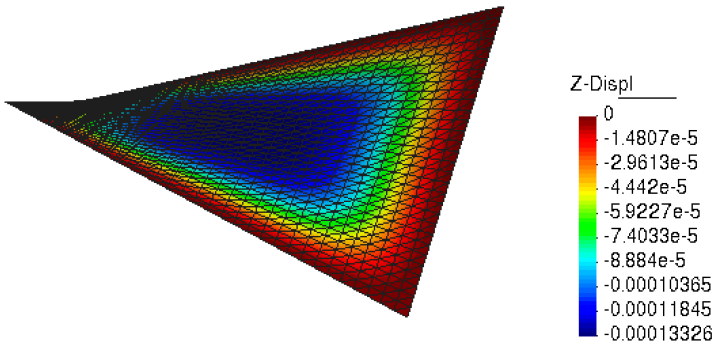


Figure 2. Z-displacements initial shape

As expected, as the forth sides are fixed, together with the self-weight load acting uniformly everywhere, the highest negative displacement is achieved in the middle point of the shell. Moreover, the displacements are symmetric respect both axis, x and y. In the figures below, the real

appearance of the shell after deformation is showed, look in the l.h.s that the results are symmetric too.

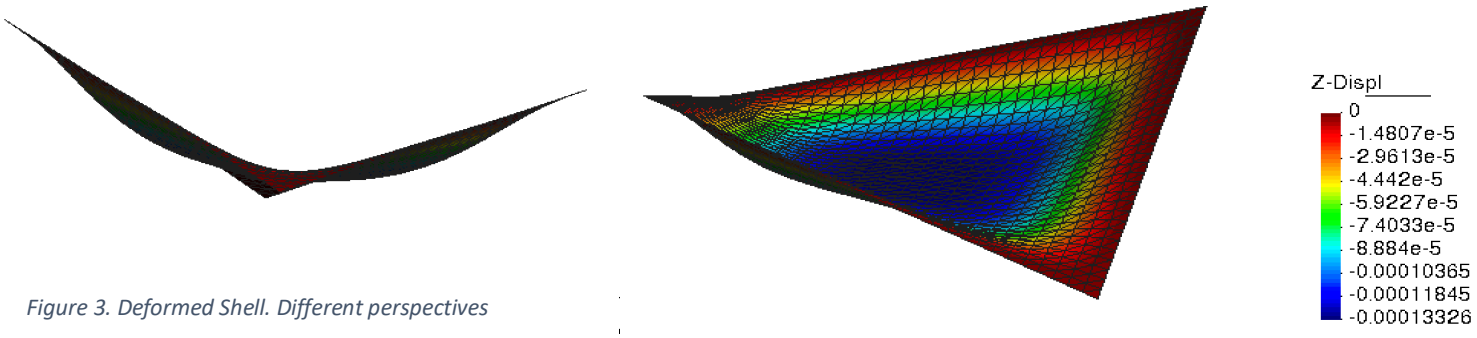


Figure 3. Deformed Shell. Different perspectives

RESULTANT STRESSES

1. Membrane effects - Axial forces

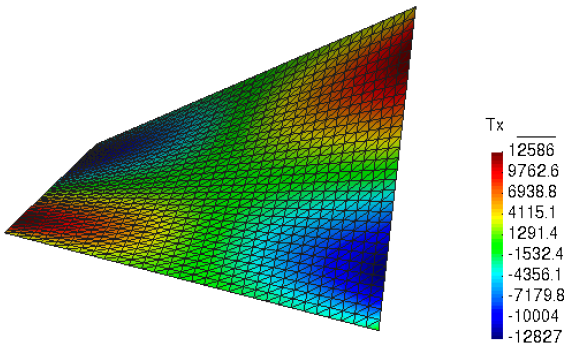


Figure 4. Membrane effec – Axial force x-direction

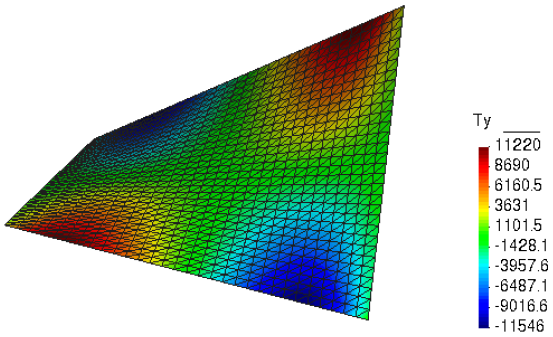


Figure 5. Membrane effec – Axial force y-direction

Figures above shows the axial forces acting on the shear. With higher values, as positive as negative, in the x-direction, a resemblance between both directions is seen. Around those corners with negative z-coordinate, negative T_x and T_y values are concentrated. In the same way, the highest values are achieved around those corners where $z = 0$.
At next figure, the final deformated shell is seen under membrane effect.

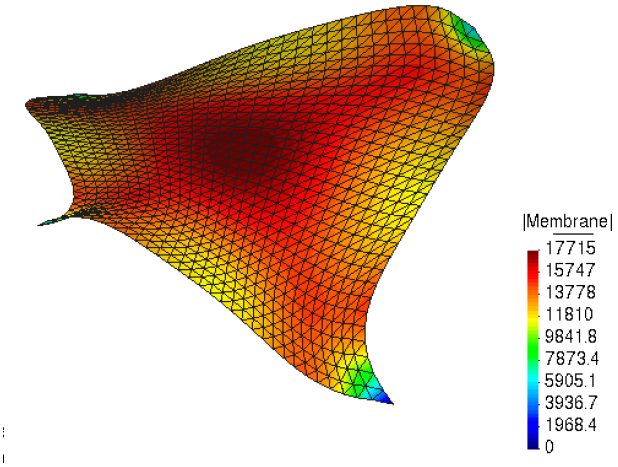


Figure 6. Deformed shell – Membrane effect

2. Bending effects – Bending moments

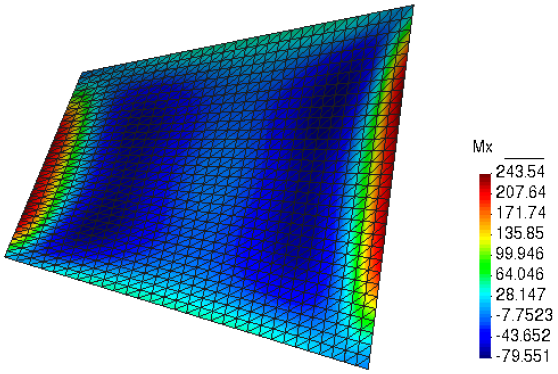


Figure 7. Bending effect – Moment in x direction

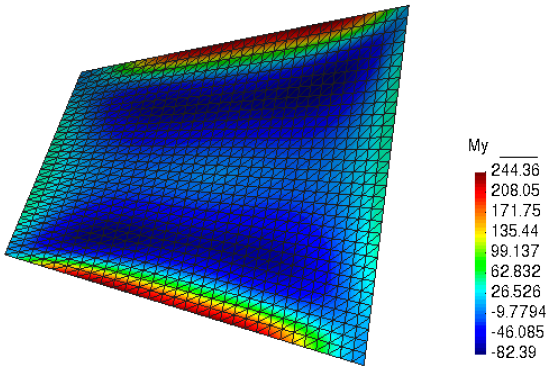


Figure 8. Bending effect – Moment in y direction

Now bending moment, related with rotations are showed. As expected, the higher results are obtained in the normal direction extreme sides, y-directions sides for x and x-directions sides for y. Moreover, due to the fact that just a vertical load (z-direction) is applied, positive and negative maximum values are almost the same.

The deformed shape shows a completed different aspect compared with the previous one (Figure 6). That is a clear way to understand that they represent different phenomenons.

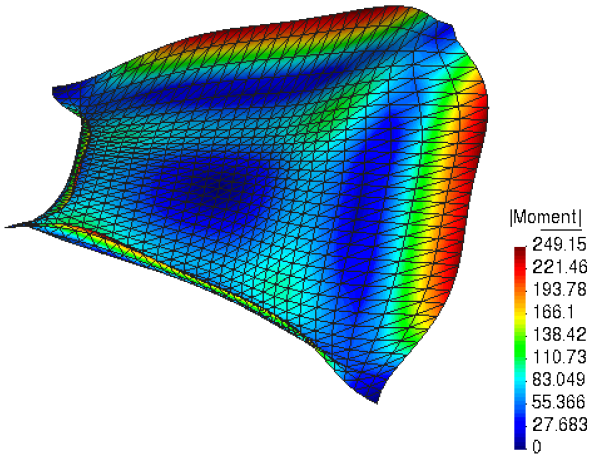


Figure 9. Deformed Shell – Bending effect

3. Shear effect – Transverse shear forces

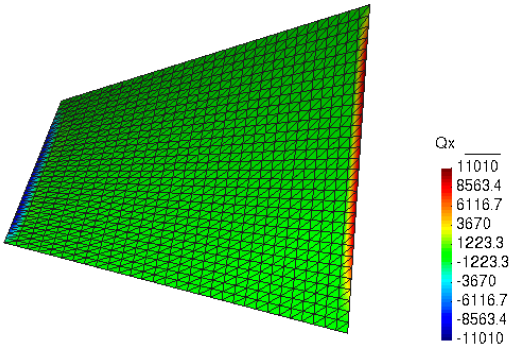


Figure 10. Shear effect – X shear force

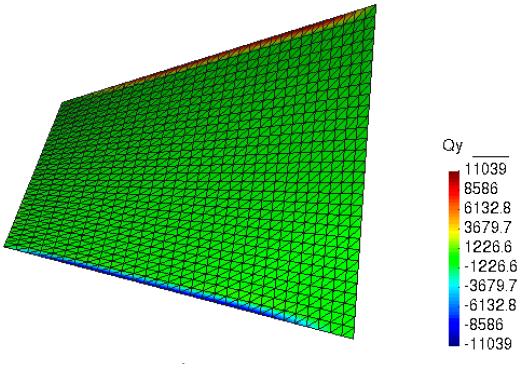


Figure 11. Shear effect – Y shear force

Regarding to shear stresses, once again the highest values for each direction are obtained in the normal shell sides. For x as well as for y, equal absolute value is obtained for maximum positive and negative force as expected. Along the shell surface, the forces remain quite constant modifying their value abruptly in the extremes.
Finally, the deformed shape for shear effects is show. Once again a complete new picture appears.

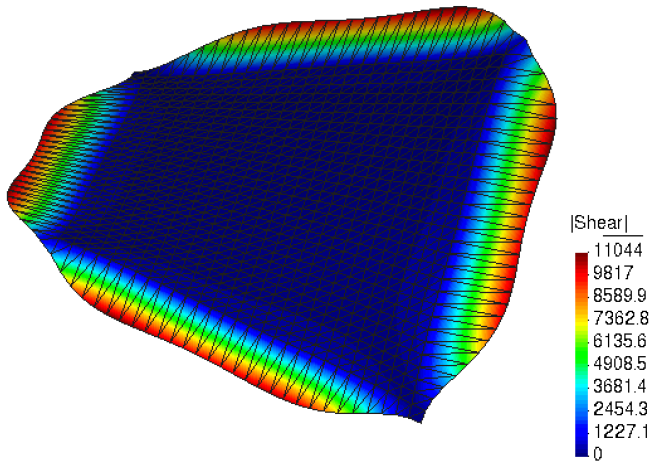


Figure 12. Deformed Shell – Shear effect