SHELL ASSIGNMENT.
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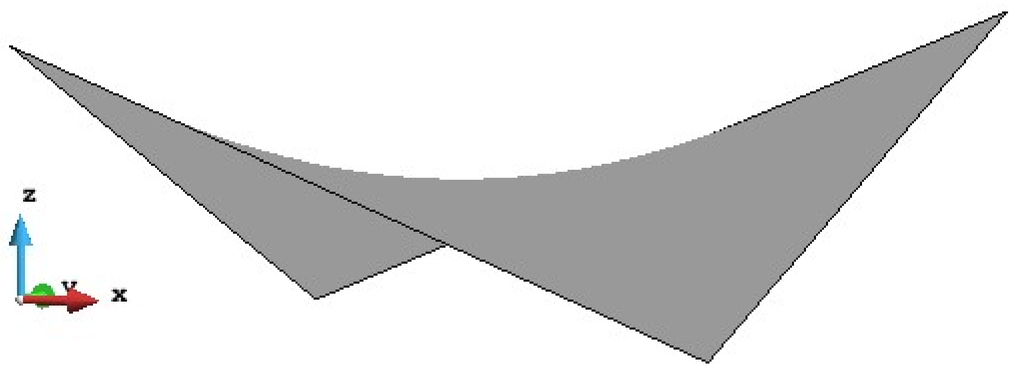
We have a Matlab code to analyze a concrete hyperbolic shell.

Its vertices are fixed in the coordinates: (0, 10, -2,), (10, 10, 2), (10, 0, -2) and (0, 0, 2).

We can see the spatial perspective of the hyperbolic shape in this figure:



The shell is under its self weight and it has a thickness of 0.1 m. So Kirchhoff plate theory can be used here.

Then, we will mesh it.

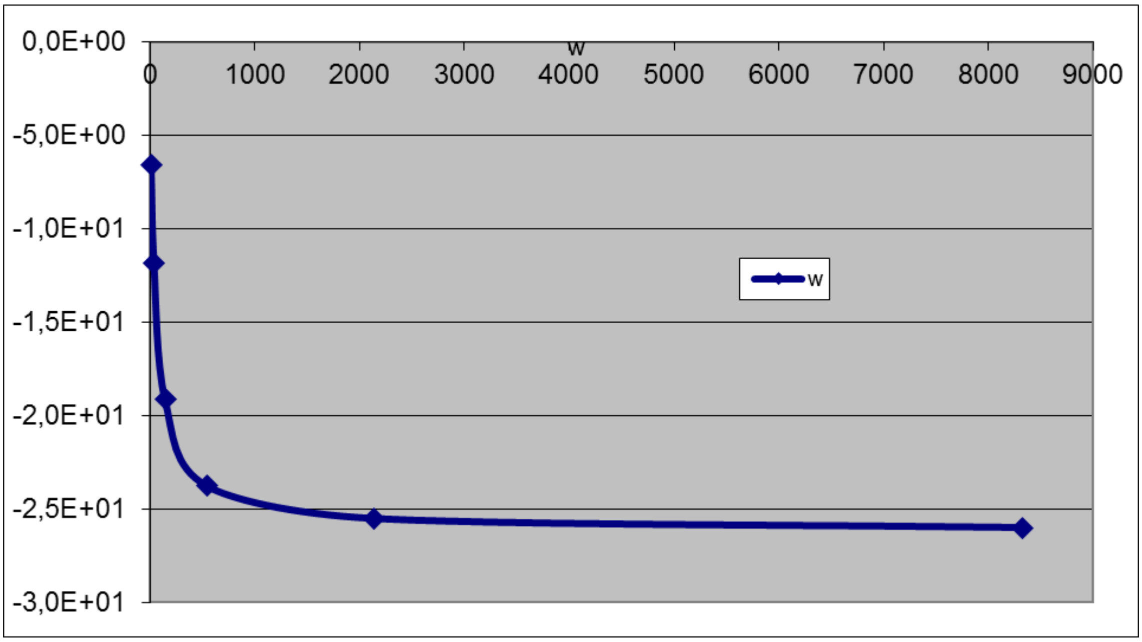
We can do this with Matlab code, just selecting the appropriate input file given: cubierta2.m, cubierta4.m, cubierta8.m, cubierta2.m, cubierta16.m, cubierta32.m and cubierta64.m which divide the shell into 2x2, 4x4, 8x8, 16x16, 32x32 or 64x64 pieces**.** Or we can mesh it before drawing the figure with GID program.

We know that as more elements (and nodes) we take, relative errors decreases, as we can see in next table:

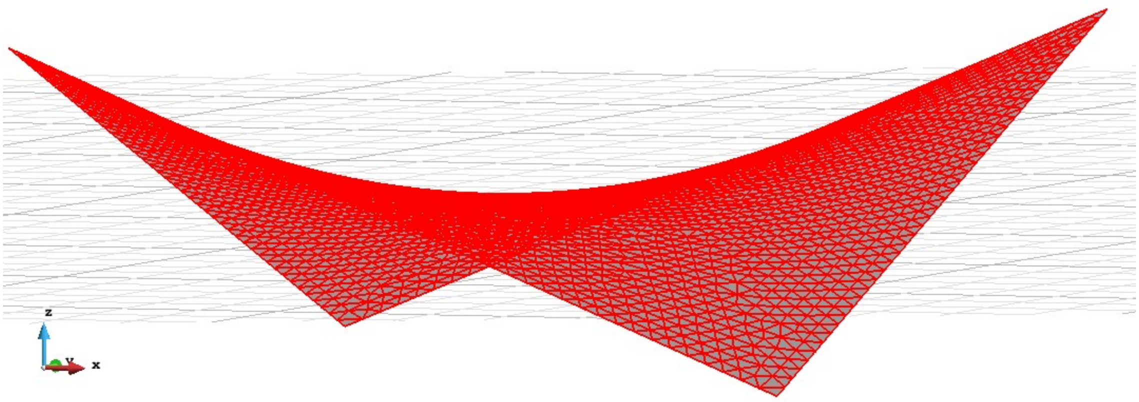
Pieces	Elements	Nodes	w	Total running time (s) (*)
2x2	16	13	-6,5893E+00	0.089893
4x4	64	41	-1,1854E+01	0.138535
8x8	256	145	-1,9106E+01	0.430448
16x16	1024	546	-2,3768E+01	2.697431
32x32	4096	2133	-2,5499E+01	78.980543
64x64	16384	8321	-2,5994E+01	1061.272698

(* all timed with the same computer)

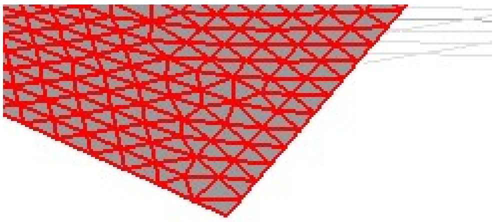
With around 4000 elements, running time is 79 seconds and with 16384, we have to wait more than 17 minutes. So, around 4000 elements is accurate enough without huge running time.



Then, we mesh with linear triangle elements. The number of elements in the mesh are 4120 and we have 2147 nodes.

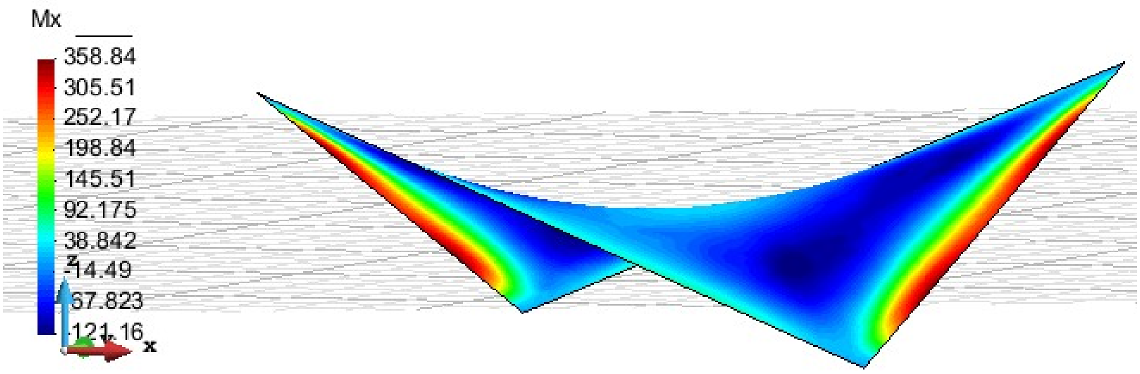


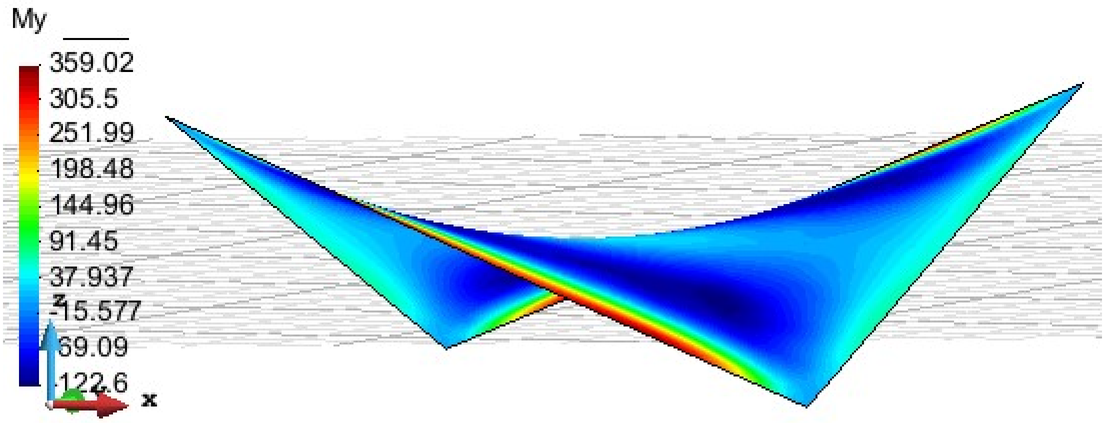
Mesh detail:

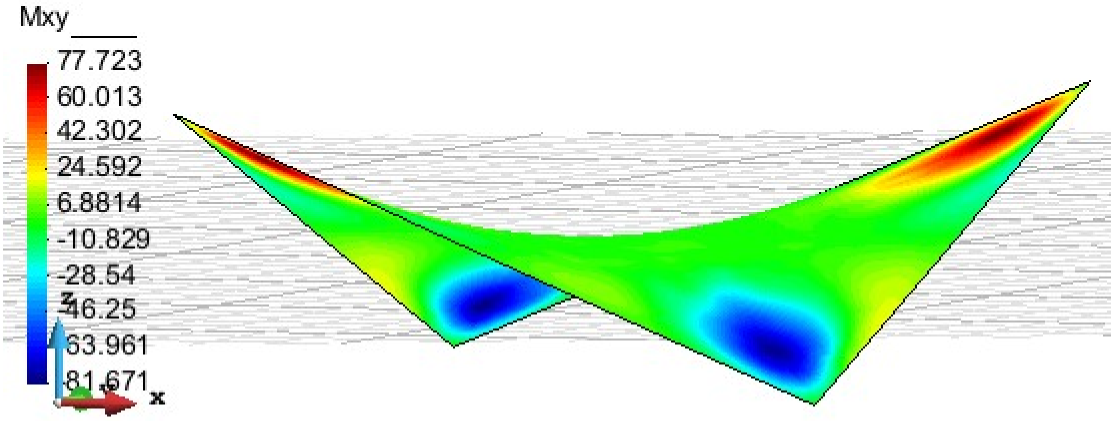


Plot figures. What do we get?

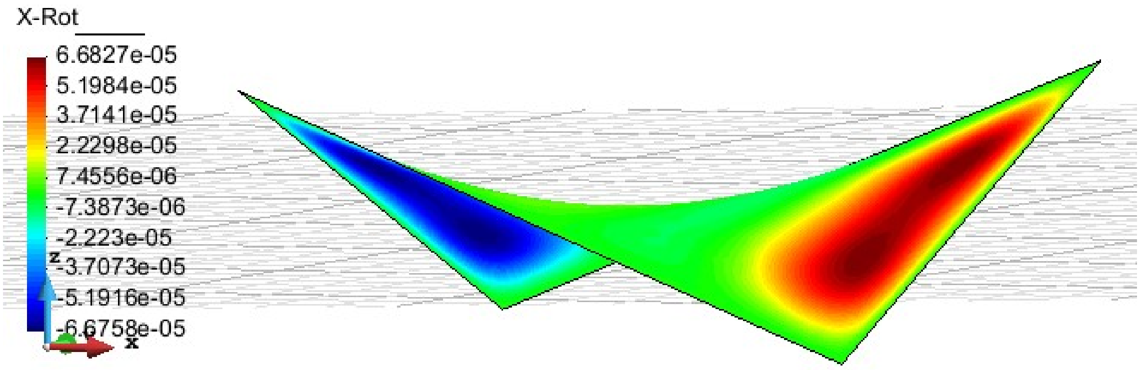
Moments:

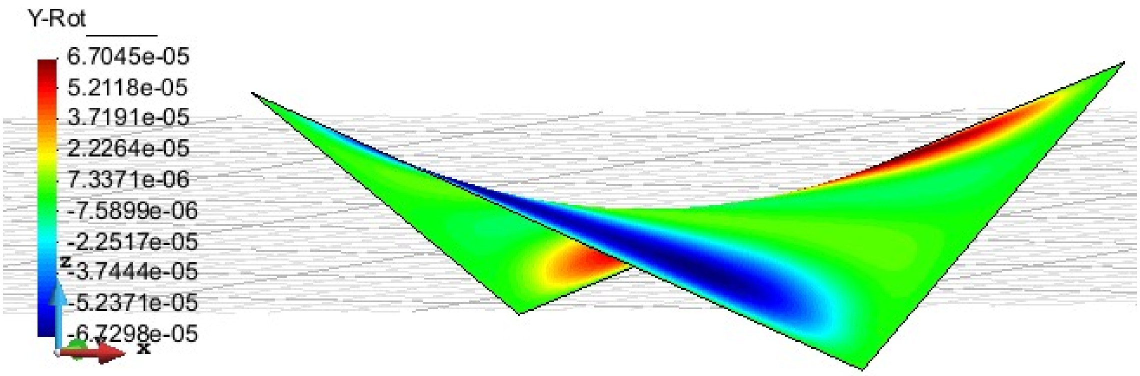




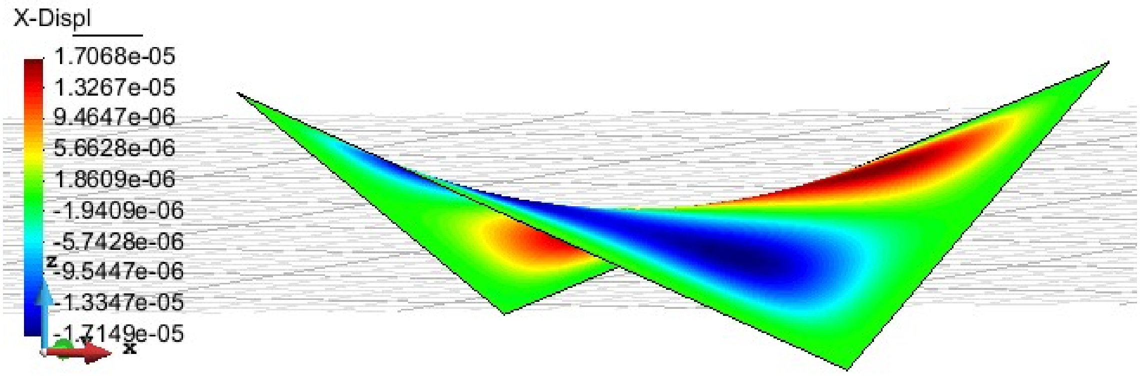

Mxy
77.723
60.013
42.302
24.592
6.8814
-10.829
-28.54
-46.25
-63.961
-81.671
z
x

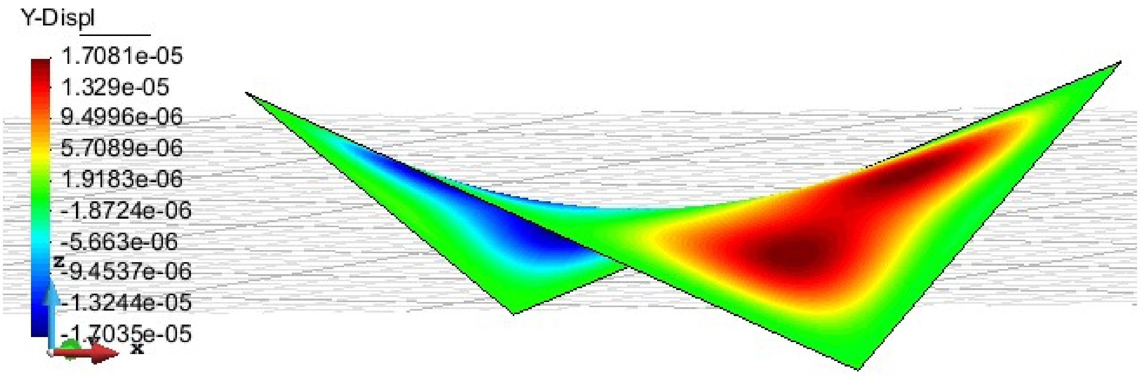
Rx, Ry:

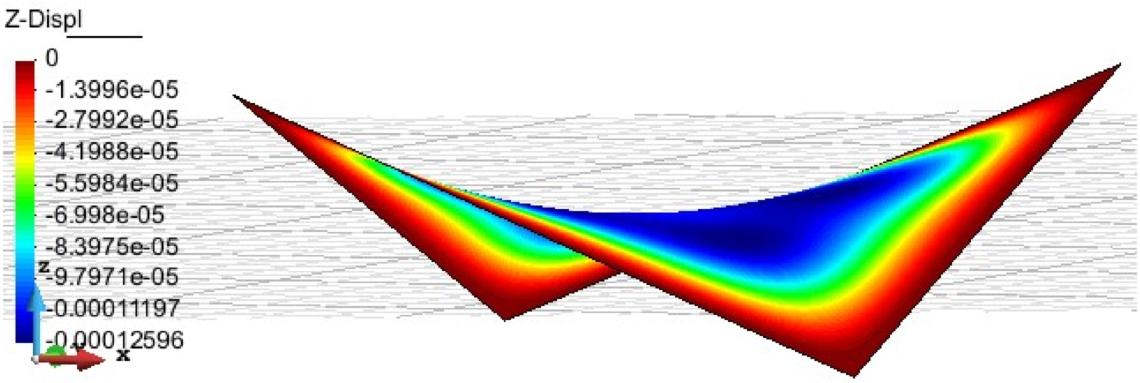

X-Rot
6.6827e-05
5.1984e-05
3.7141e-05
2.2298e-05
7.4556e-06
-7.3873e-06
-2.223e-05
-3.7073e-05
-5.1916e-05
-6.6758e-05
z
x


Y-Rot
6.7045e-05
5.2118e-05
3.7191e-05
2.2264e-05
7.3371e-06
-7.5899e-06
-2.2517e-05
-3.7444e-05
-5.2371e-05
-6.7298e-05
z
x

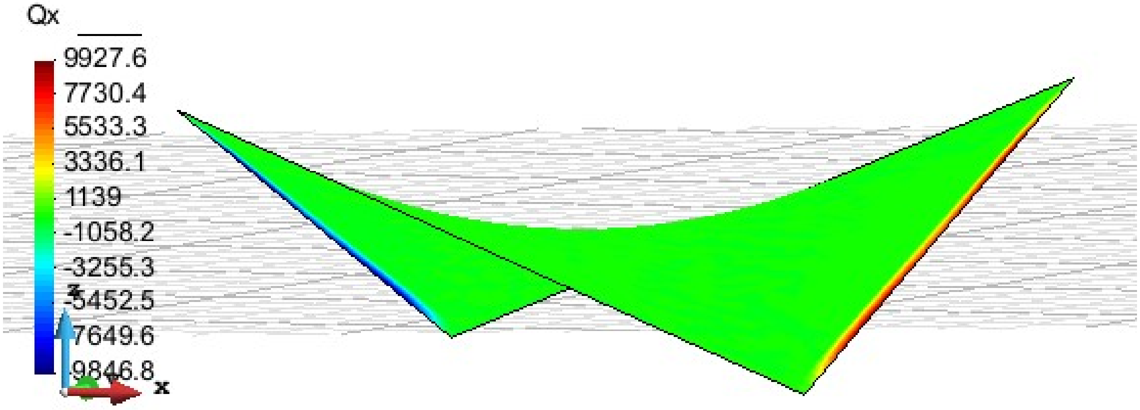
Displacements:

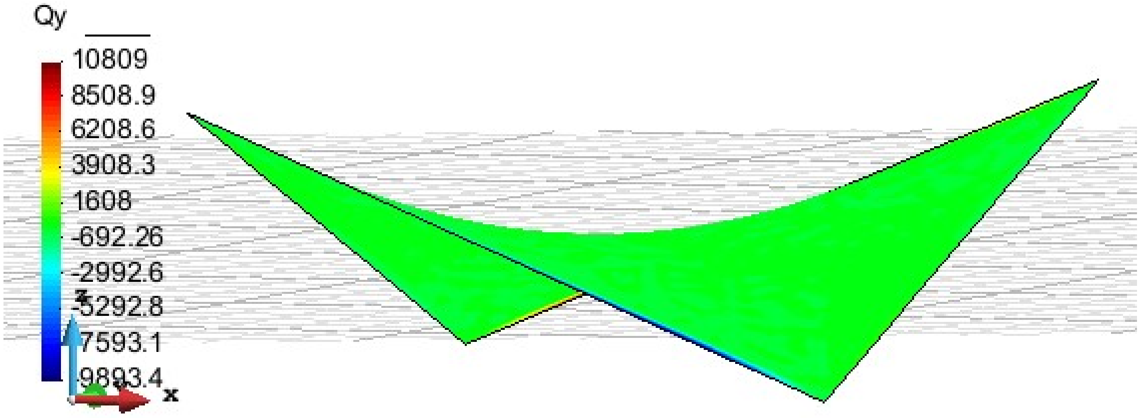




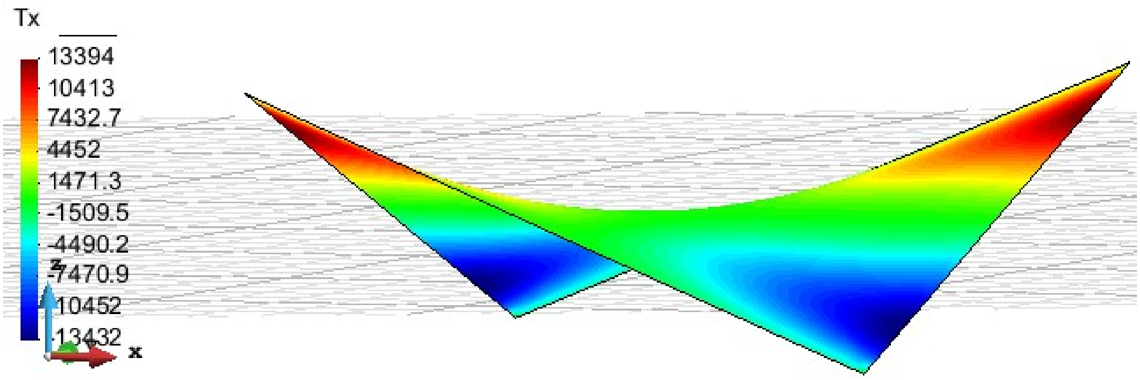


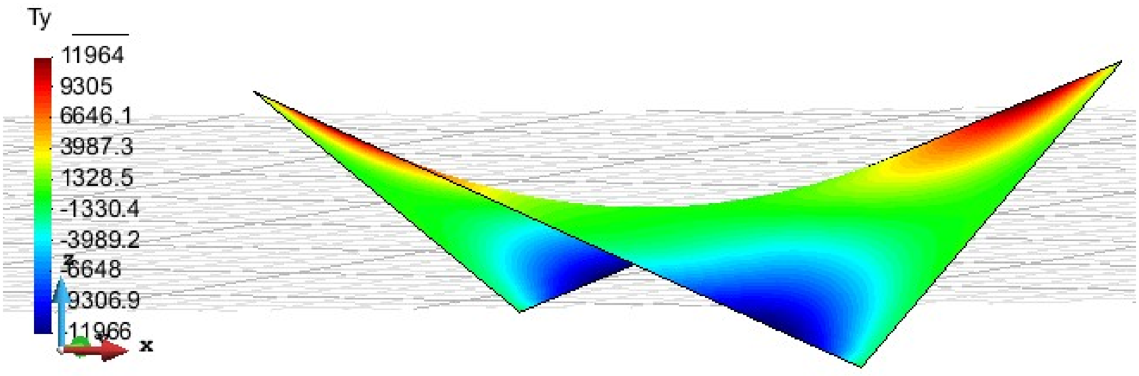
Shear:

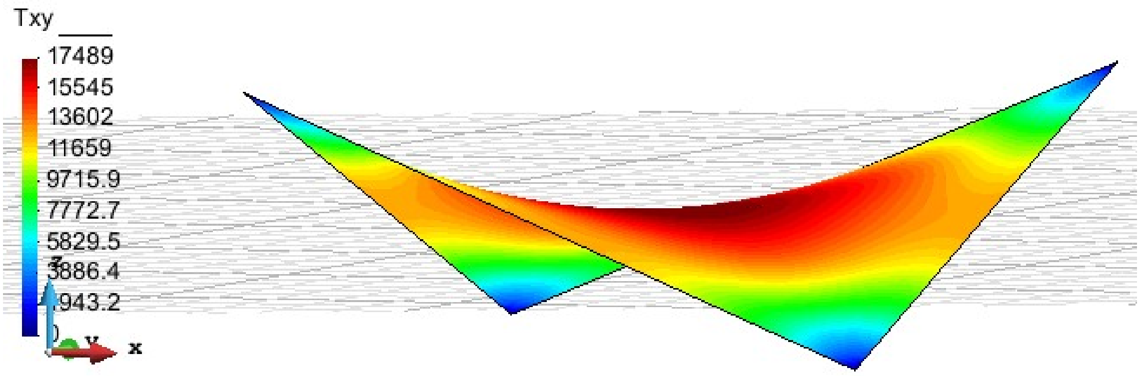




Membrane:







Behavior:

Displacements in x and y directions are very small, from -1,7e-5 m to 1,7e-05 m (and close to 0 in the borders, which are clamped and they does not allow displacements) and from 0 (in the borders) to -0,0001 m in z direction, in the middle (its center of gravity). Just what we expected because of its geometry and the clamped borders.

Mx and My takes values from -122 to 159 (Nm/m) (maximums are in the borders). Minimum are in the surface which less deformation. Similar situation for rotations in x and y: Rx and Ry takes values from -6,7e-05 to 6,7e-05 (rads). Maximums and minimums are near the borders and values are closer to zero in its middle top. There is no rotation in z direction (just displacements in this direction).

Transverse shear forces Qx and Qy takes maximum and minimum values on its borders (from 10000 N/m to -10000 N/m, where the boundary conditions are imposed). But most of the surface takes values around 1000 N/m.

Tx takes values 13400 and -13400 near the corners. The rest of the surface takes values from -1500 to 1500 .

Tx takes values 12000 and -12000 near the corners. The rest of the surface takes values from -1300 to 1300