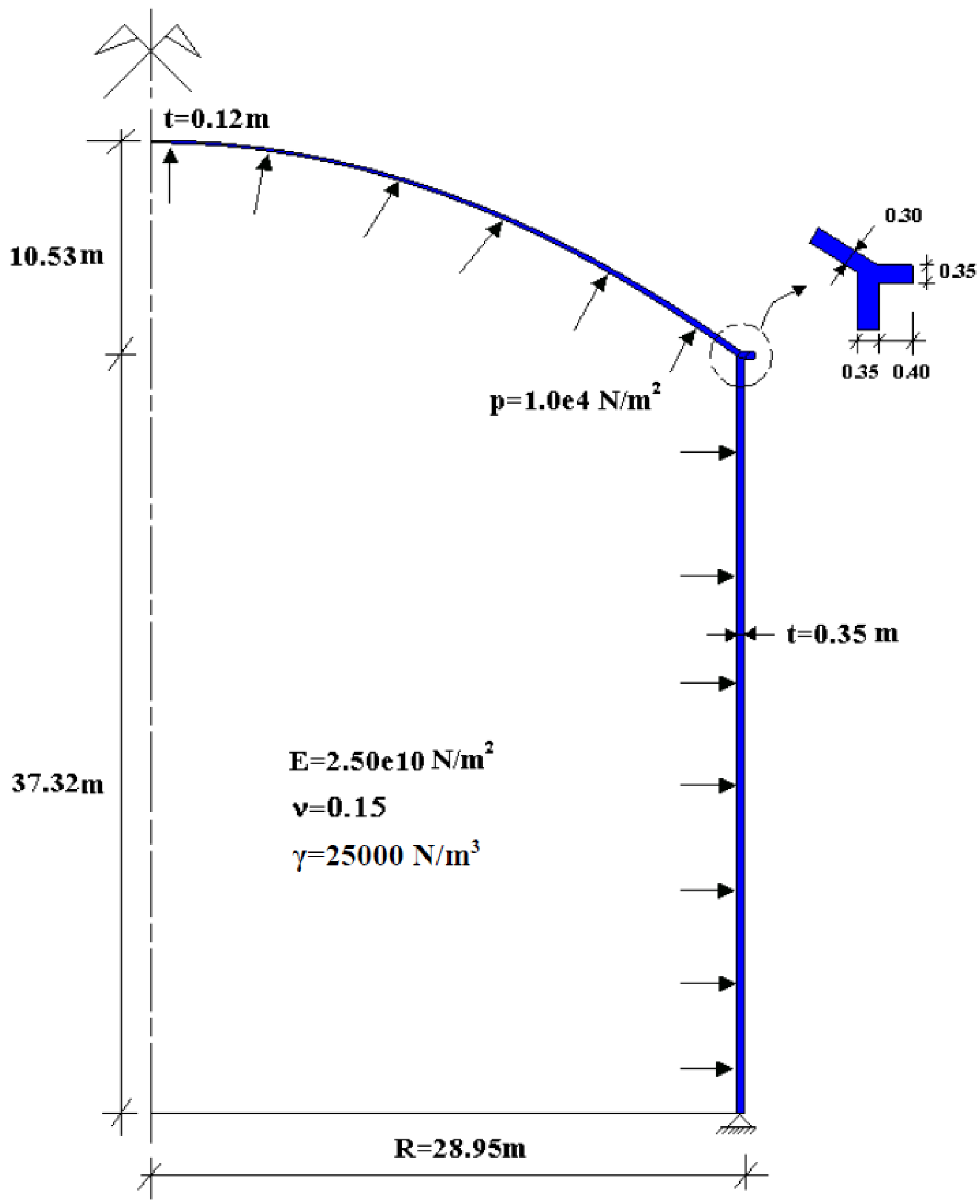
Computational Structural Mechanics and Dynamics

Practice 4

Jose Andino Saint Antonin

Analyze the state of stress of the tank shown in the figure, which is submitted to an internal pressure. Suppose a continuous variation of the thickness of the spherical cupola. Use revolutions shell elements with two nodes and 3D shells elements with three nodes.



Solution:

We are asked to analyze the stresses on the tank described above by modeling it as a revolution shell and as a 3D object. It should be pointed out that given the fact that the tank has axial symmetry over the y axis and the loads & constraints are also axisymmetric, both solutions should be the same

We begin by drawing the geometry of the half cross section of the tank in GID.

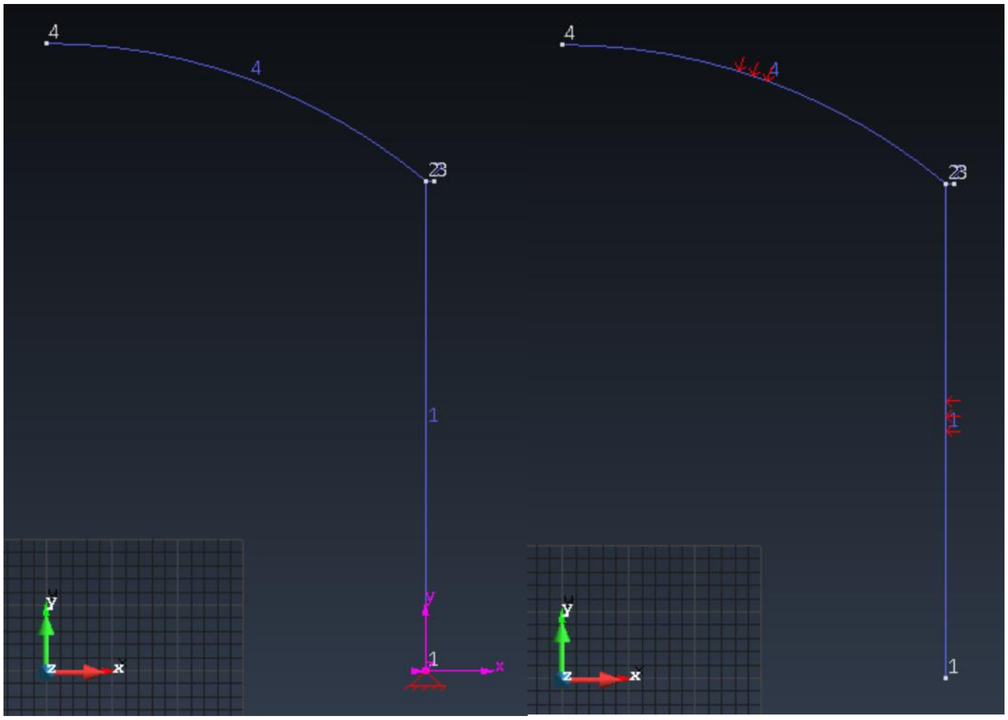


Figure 1 prescribed displacements (left) and loads (right)

The boundary conditions are:

- Zero displacement on the base of the tank wall
- Internal pressure (distributed load normal to the tank wall and roof)

The revolution shell simulation was done using ramseries 2D.

The displacements are shown below. Notice how the effect of the pressure displacing the roof up and the well out. Only the corner is being sucked in (the tank would tend to adopt the shape of a sphere) and the tangential stresses in this location are very large. We see details about stresses in the 3D model.

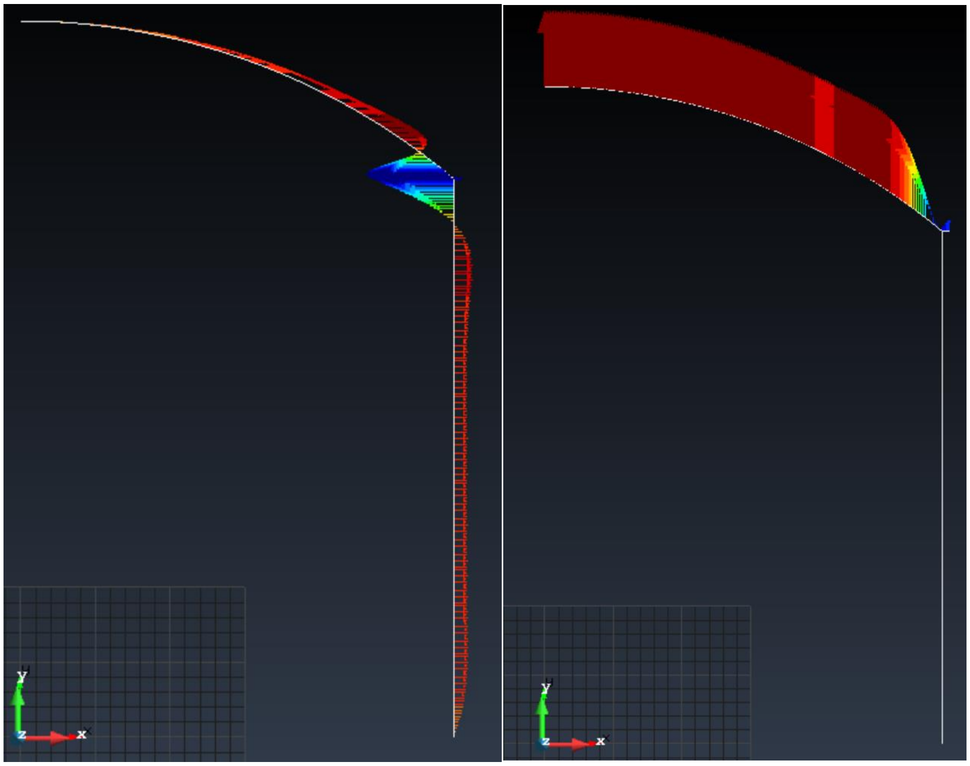


Figure 2   X and Y displacements, exaggerated 550X. Notice how the effect of the pressure trying to push the roof up and the well out. Only the corner is being sucked in (the tank would tend to adopt the shape of a sphere)

The reaction forces are mostly downward (meaning the wall is in tension, keeping the roof from flying up) but also inward (there is shear stress on the base of the wall, as it keeps the wall from being pushed out radially).

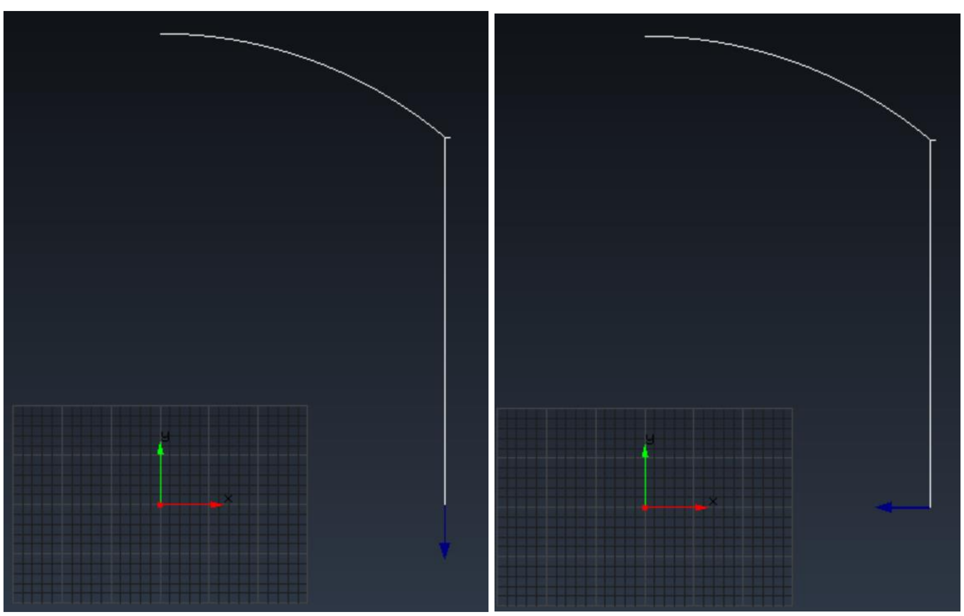


Figure 3   Downward and inner reaction forces at the base of the tank

Full 3D model

The 3D model cannot be done with Ramseries educations 2D, so it was done with Ramseries professional. The model was constructed using triangular linear elements as shown below.

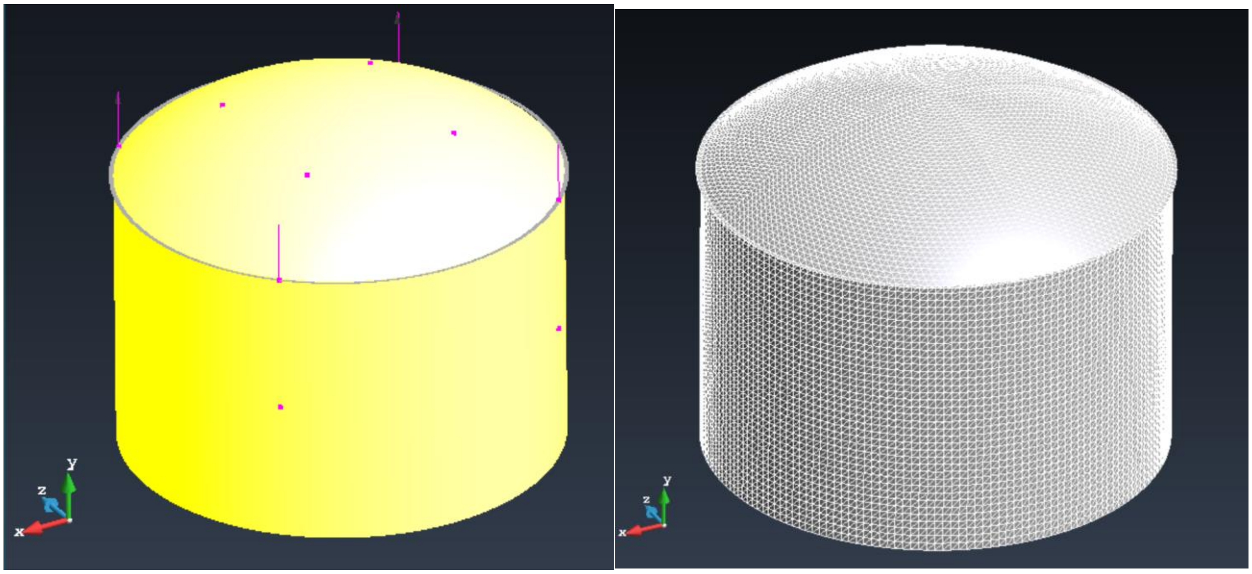


Figure 4   Num. of Triangle elements=22.448, Num. of nodes=11.317

Analysis is as follows:

1. the direction of the displacements is outward (on the wall) or upward (on the roof). The exception is the joint between roof and wall being pulled in. Maximum displacement is experienced by the roof, and it is upwards due to the pressure.
2. The roof and wall are on tension, with the largest stresses being experience at the highest part of the roof where the wall thickness is thinnest. Stresses around the joint between the wall and the roof are also high due to the sharp corner.
3. Regarding moments, the highest values concentrated in the corner at the union between the roof and the wall (as we see in the rotation figure below).
4. Reaction forces are mostly downward, but also have an inner radial component.

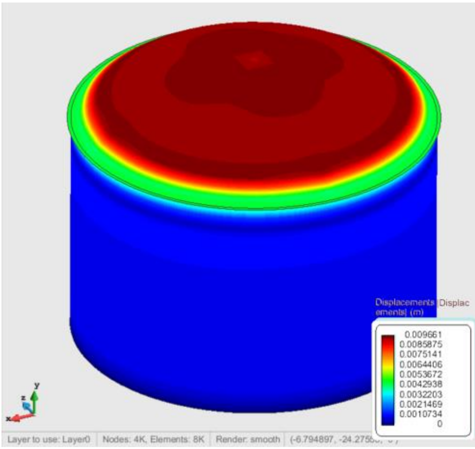


Figure 5 magnitude of displacement vectors

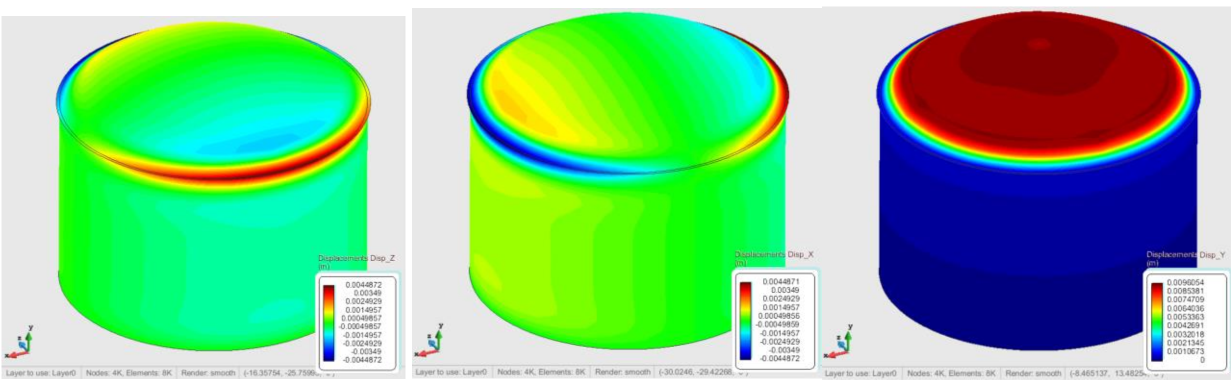


Figure 6 displacement in x, z and y direction (left to right). X and z displacement are the same except they are rotated 90 degrees on the y axis. Vertical displacements dominate. The lid of the tank is being pushed up be the fluid pressure inside.

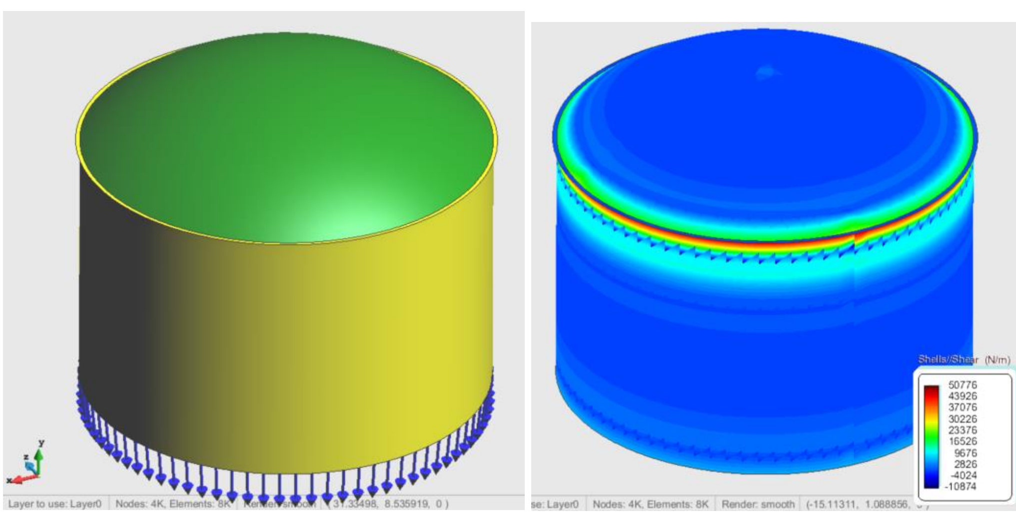


Figure 7 reaction forces. The tank floor is preventing the tank wall from being lifted (left). Shear stress, maximum on the ring where the wall and the roof join.

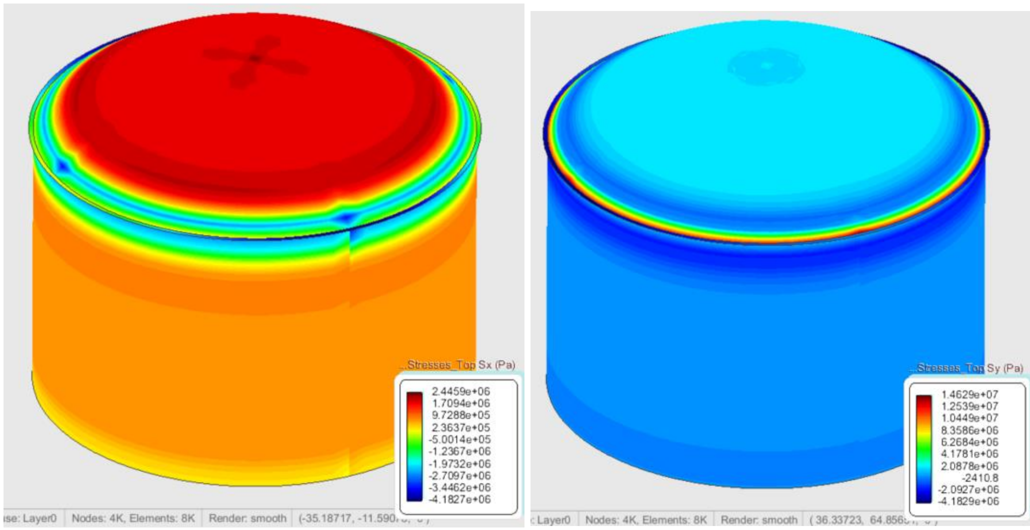


Figure 8   x and y stresses.

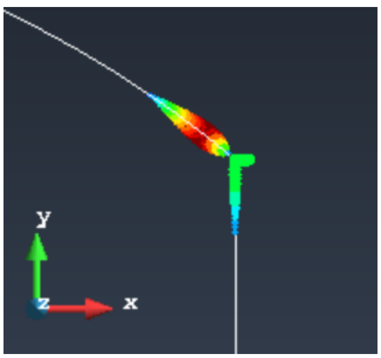


Figure 9   rotations in the joint between the wall and the roof

<u>Conclusion</u>

Both models with 3D shell and revolution shell elements delivered very similar results. The displacements, forces and the moments have almost identical distribution and values. Given that the revolution shell is so much faster and simpler to run, it seems like the right choice for this type of problem. Only when non axisymmetric loads or other boundary conditions need to be modeled should we resort to full 3D modelling.