

MASTER OF SCIENCE IN COMPUTATIONAL MECHANICS

HOMEWORK 2

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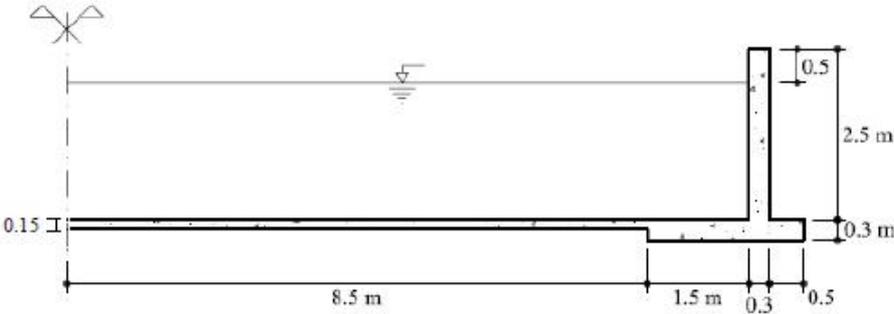
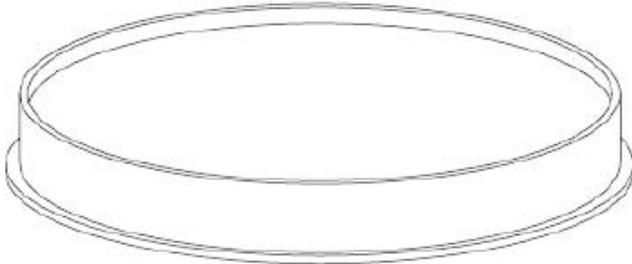
Exercise 1

The figure shows a circular tank made of reinforced concrete. It is used for the storage of water in a water purification plant. Analyze the structural behavior of the tank. Use quadrilateral elements with four nodes.

Data

Concrete $\left\{ \begin{array}{l} E = 3.0 \times 10^{10} \frac{N}{m^2} \\ \nu = 0.2 \end{array} \right.$

Floor $\left\{ \begin{array}{l} \text{Ballast coefficient} = 50 \frac{N}{cm^3} \end{array} \right.$



In order to compute 3D tank as 2D model, we consider it as a structure of revolution. We apply a constraint in X direction at the left edge, using the given cross section. The water pressure is considered a constant load at the base line and a linear load at the right edge of the tank. We calculate the value using the following expression:

$$p = \rho \cdot g \cdot h$$

Then, we find that:

$$p = \rho \cdot g \cdot h = 1000 \left(\frac{kg}{m^3}\right) * 10 \left(\frac{m}{s^2}\right) * 2(m) * 1(m) = 20kN / m$$

We use the Rev_Solids problem type and create the mesh. We divide the structure into several surfaces as it shown in Figure 1, and assign the cells to the different lines using a concrete material.

(E=30.000 MN/m² and v=0,2).

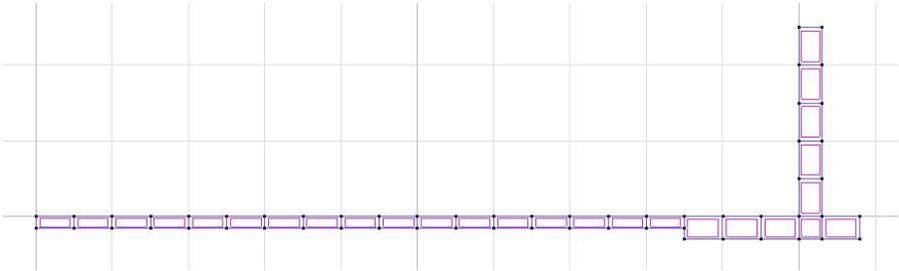


Figure 1.

Now, we choose quadrilateral element with 4 nodes. The mesh is presented in Figure 2.

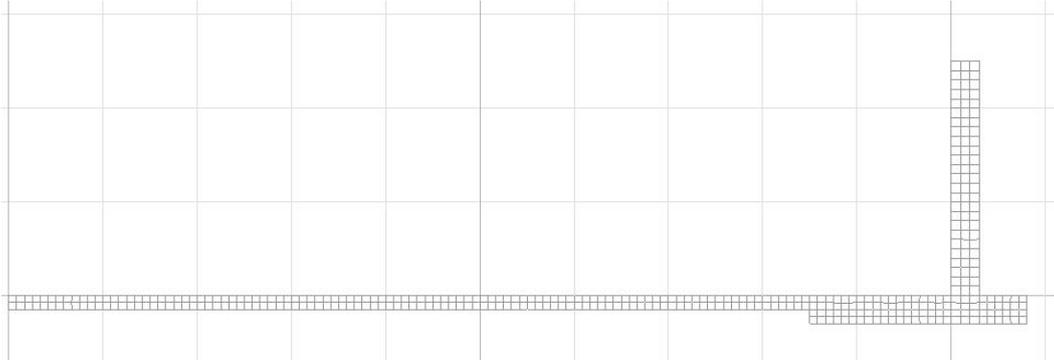


Figure 2. The mesh of the tank

Results for displacements in x and y directions are presented in Figure 3 and Figure 4..

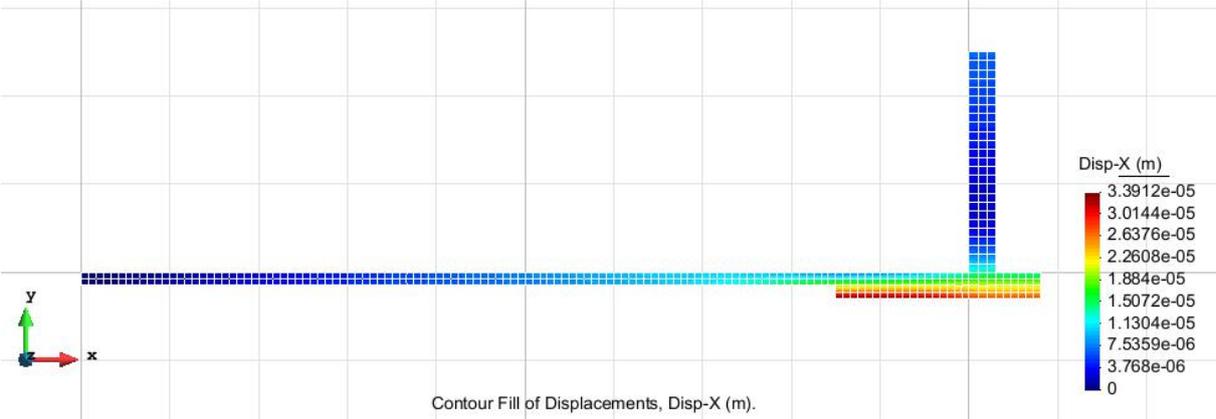


Figure 3. Displacement X direction

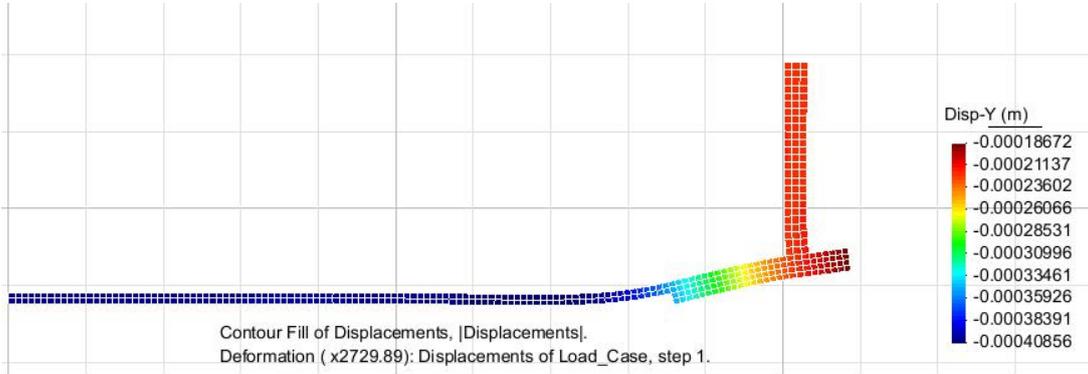


Figure 4. Displacement Y direction

→Analysis of result:

- We clearly see that the displacement in x direction is the the highest at the bottom of the structure. On the other hand, it is constraint at the left side due to the symmetry of the model.
- We observe that the displacement in y direction due to the water pressure is higher at the left side. We can say that this is because the stiffness for this side is lower because of the thickness of the base slab.

Results for stresses are presented in Figure 5, Figure 6 and Figure 7.



Figure 5. Stresses X Direction

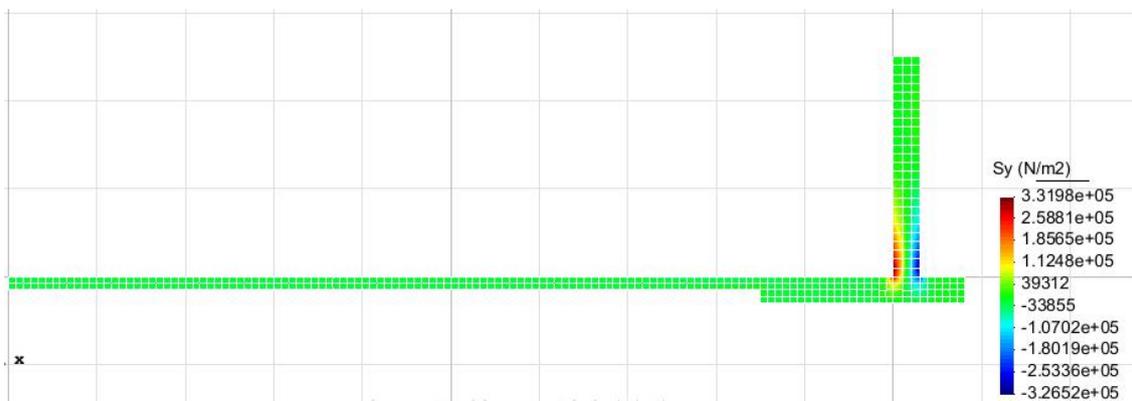


Figure 6. Stresses Y Direction



Figure 7. Stresses in XY Direction

→Analysis of results:

- We observed that the highest stresses occur around the corner. Moreover we have high tensions at the inner part of the tank.

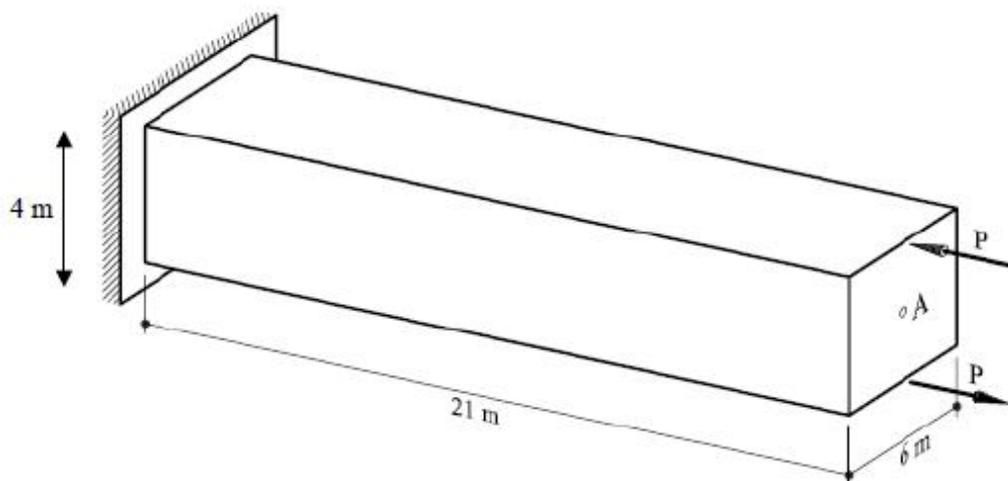
Exercise 2

Analyze the cantilever shown in the figure, submitted to the action of a moment at the far end. Compare the results obtained with the beam theory. Use hexahedra elements with 8 and 20 nodes.

Data

$$\text{Material} \begin{cases} E = 2.1e11 \frac{\text{N}}{\text{m}^2} \\ \nu = 0.20 \end{cases}$$

$$P = 10000\text{N}$$



The given cantilever consists steel (i.e. $E=210000 \text{ MN/m}^2$ and $\nu=0,2$). First we model the geometry and assign the mesh of hexahedra elements with 8 nodes. The mesh is presented in Figure 8.

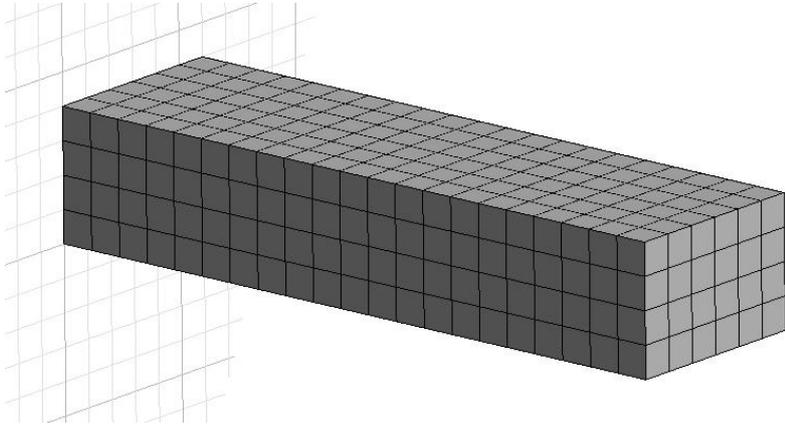


Figure 8.The mesh of cantilever

Results of FEM are presented in Figure 9, Figure 10 and Figure 11.

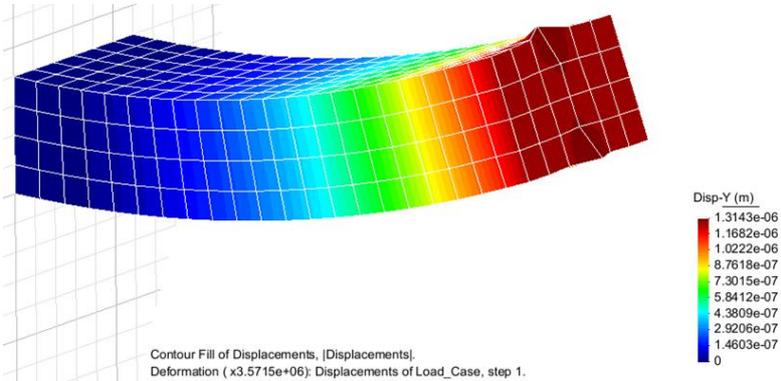


Figure 9.The displacement of cantilever

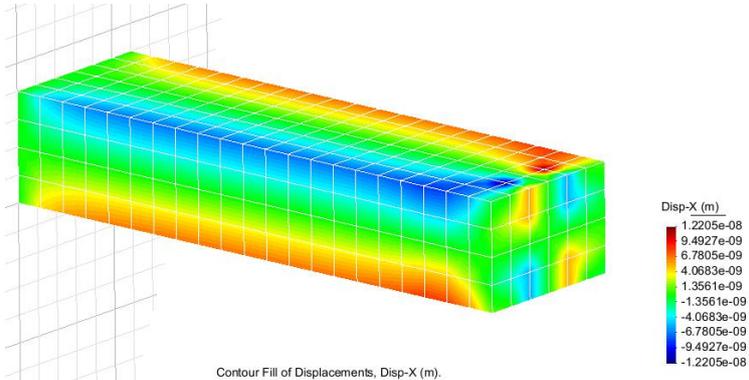


Figure 10.The displacement of cantilever with 8 nodes in x direction

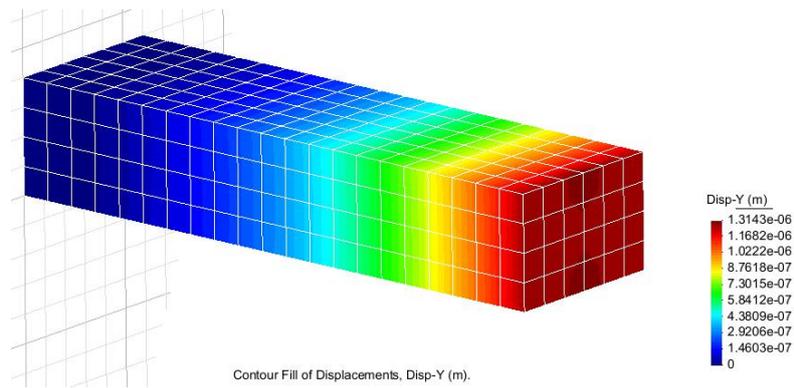


Figure 11.The displacement of cantilever with 8 nodes in y direction

In order to check the results of FEM, we compare them with the displacement calculated using the beam theory.

The displacement can be computed using the following expression:

$$I = \frac{b.h^3}{12} = \frac{6.4^3}{12} = 32m^4$$

$$d = \frac{M.l^2}{2.E.I} = \frac{40000.21^2}{2.2,1.10^{11}.32} = 1,31.10^{-6} m$$

→Results

- The result of FEM for displacement is $1,3146.10^{-6} m$. On the other hand, we find $1,31.10^{-6} m$ as a result of a hand calculation. Therefore, we got the similar results.
- The maximum displacements are observed at the end of the cantilever.

Results for stresses are given in Figure 12, Figure 13 and Figure 14.

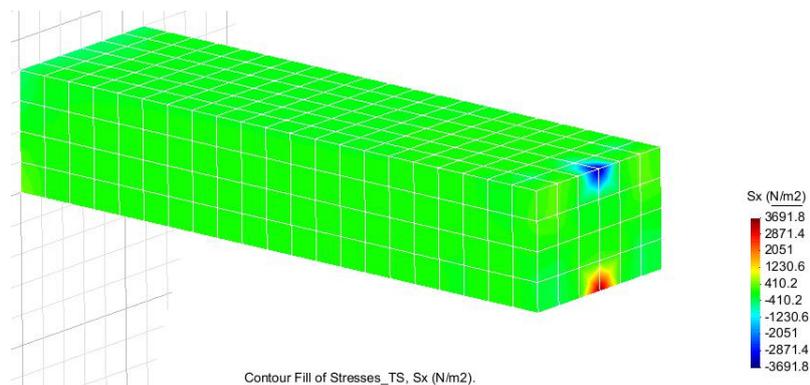


Figure 12.Stresses in x direction

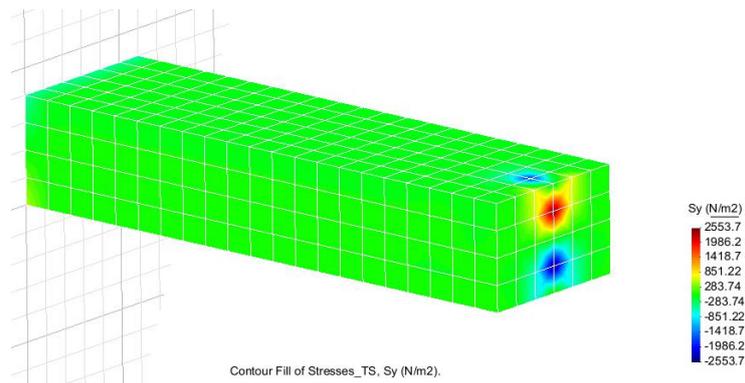


Figure 13. Stresses in y direction

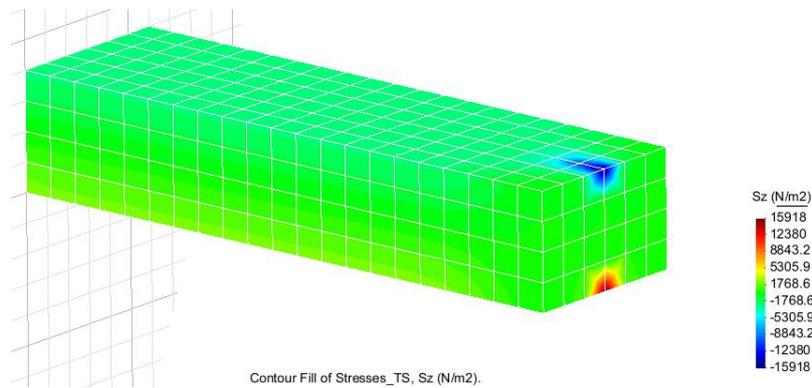


Figure 14. Stresses in xy direction

→Analysis of results

We observed that we have a constant stress throughout the whole cantilever. The only difference occurs at the points where the forces attack. We observed higher stresses at these points.

In order to reduce this appearance, we can distribute the force to a line.

Now, we compute the cantilever using the same mesh but with 20 nodes. The results are presented in the following figures.

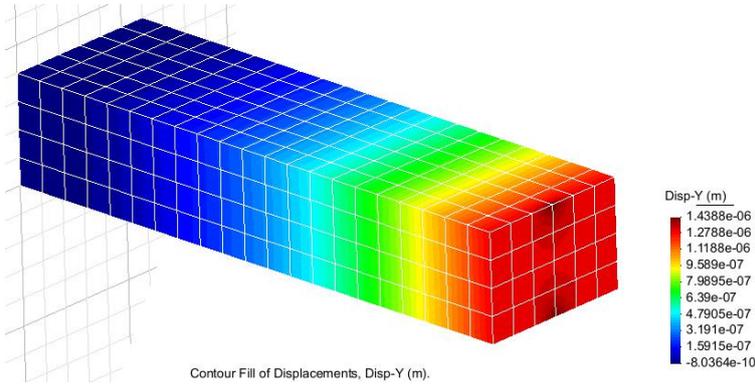


Figure 15. Displacement in y direction

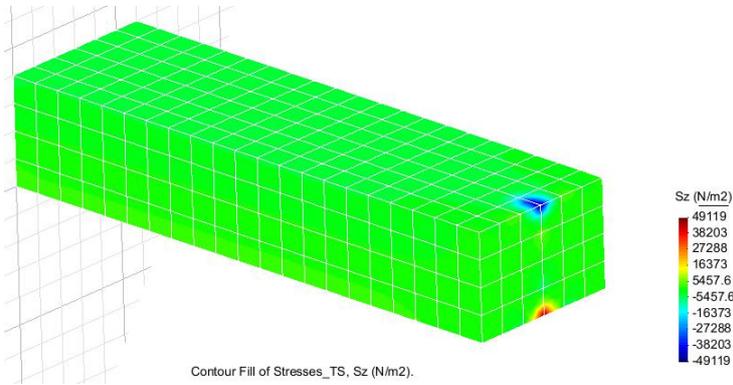


Figure 16. Stresses in z direction

→Analysis of results

We observed that the results for displacements are closer. On the other hand we got very different results for stresses. We see that the stresses increases at the point where the load is assigned.