Computational Structural Mechanics and Dynamics

GID Practice 1
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Exercise 1: Thin plate under dead weight

1. Three and six noded triangular elements and four, eight and nine noded quadrilateral elements were used for this analysis. The chosen variable was the maximum vertical displacement. The geometry of the structure is shown in the figure below.

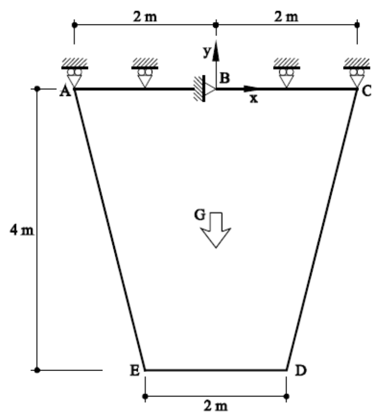

Figure 1: Geometry of the model

2. Material properties:

$$E = 2.1\ 10^5\ MPa \quad (1)$$
$$\nu = 0.30 \quad (2)$$
$$\gamma = 7000\ \frac{kg}{m^3} \quad (3)$$
$$thickness = 0.1\ m \quad (4)$$

3. 2 show the different meshes used

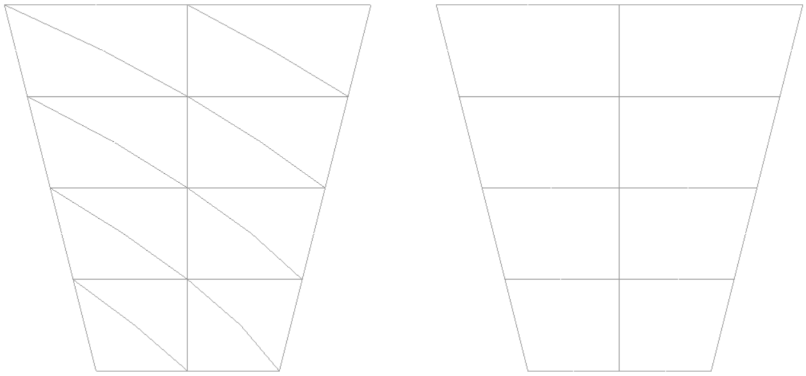

Figure 2: Triangular and quadrilateral mesh

4. The problem was modelled as a 2D plane stress problem. The only applied load was the self-weight.

5. It can be shown that while the mesh is refined, the numerical solution converge to the exact solution.

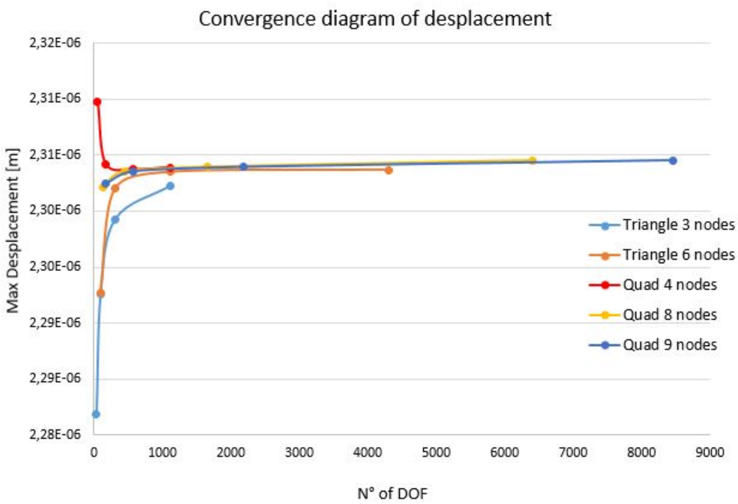

Figure 3: Convergence of the different meshes

Excersice 2: Plate with ventilation hole

1. The structure in the figure presents a reinforced concrete plate with two holes, supported by three columns. The geometry is shown in the next figure

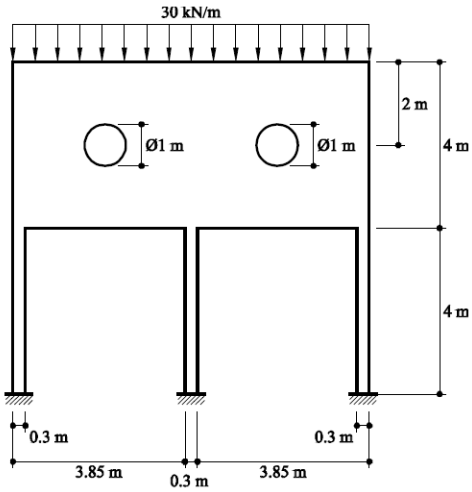

Figure 4: Problem geometry

2. The problem was modelled as a 2D plane stress problem. The data of the material and the thickness of the plate are the following:

$$E = 3.0 \; 10^{10} \; \frac{N}{m^2} \tag{5}$$

$$\nu = 0.2 \tag{6}$$

$$t = 0.20 \; m \tag{7}$$

3. The next figure shows the mesh used to process the model. 3 nodes triangular elements were used, with a total of 7855 elements and 4229 nodes.

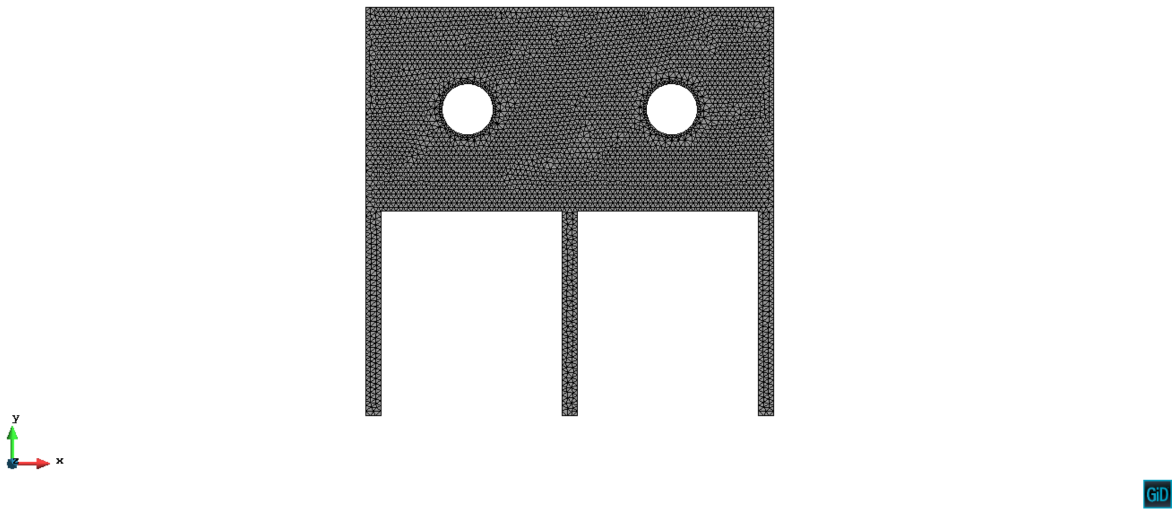

Figure 5: Triangular mesh

4. We are going to compare 2 cases: with and without a 10 cm displacement (or drop) in the central column. Comparing the resultant displacements fields:

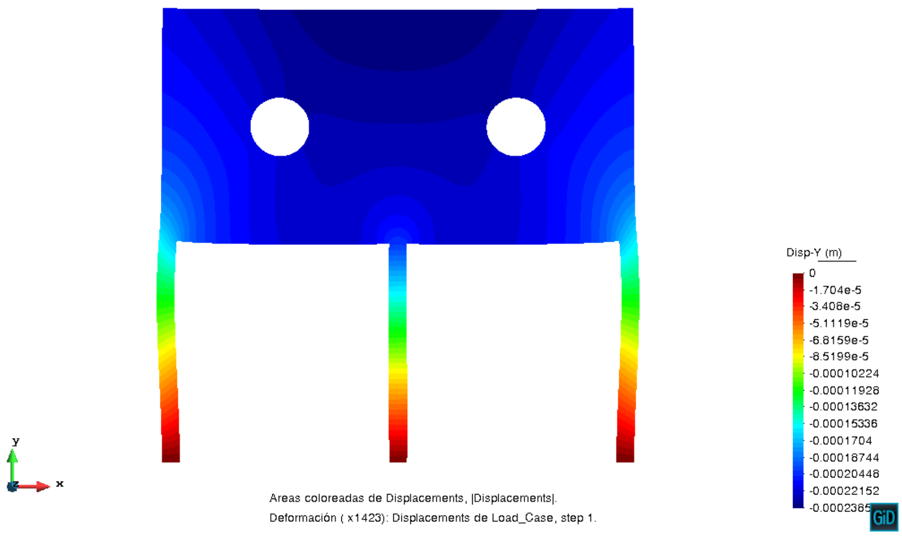

Figure 6: Vertical displacements for the undropped case

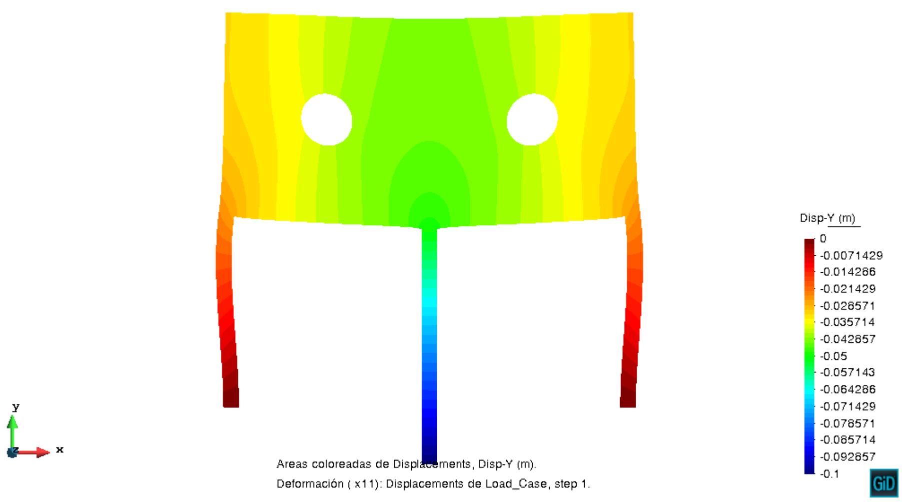

Figure 7: Vertical displacements for the dropped case

5. And the stress fields obtained

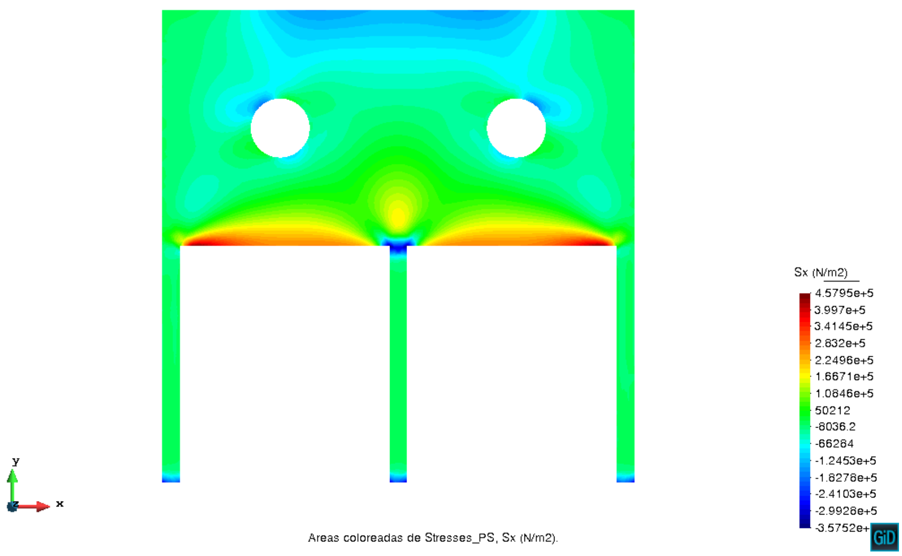

Figure 8: σ_x for undropped case

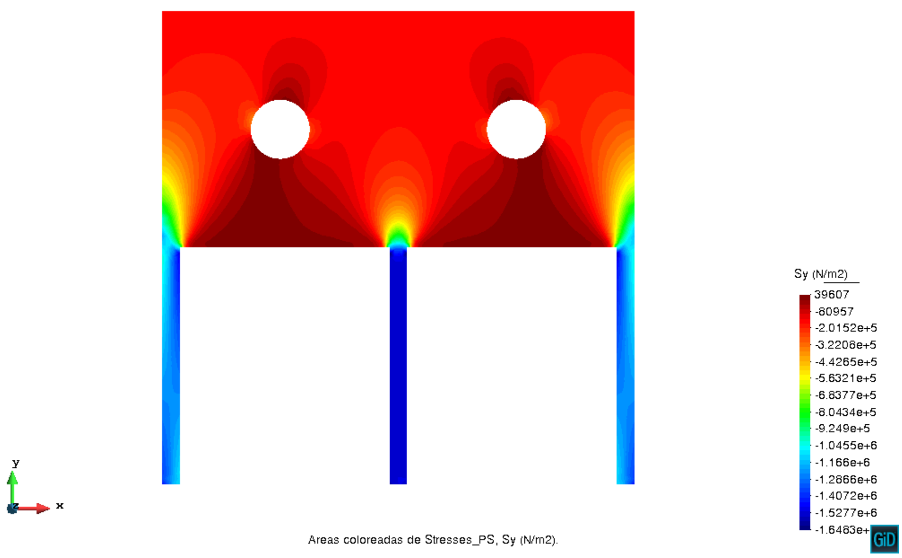

Figure 9: σ_y for undropped case

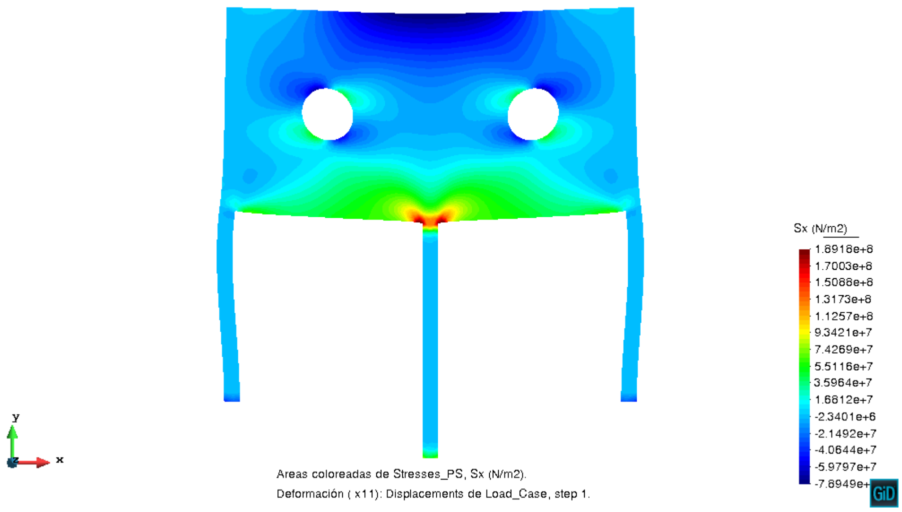

Figure 10: σ_x for dropped case

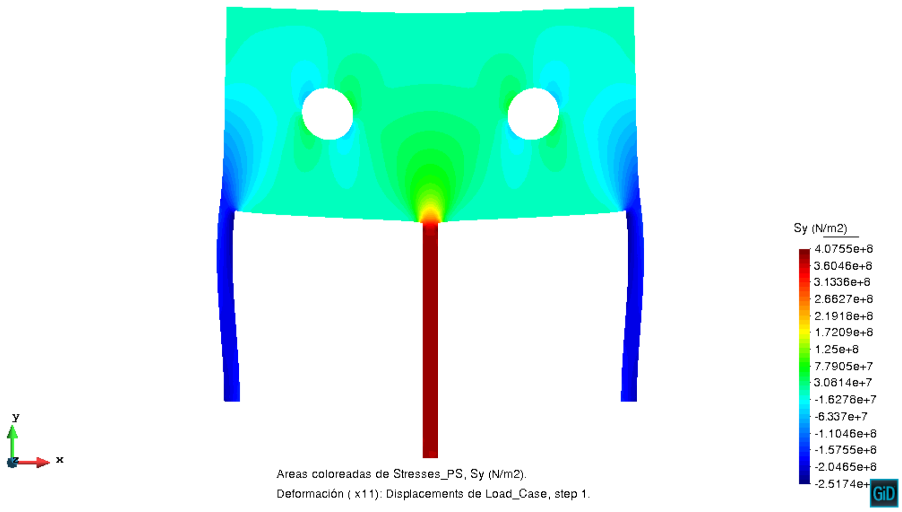

Figure 11: σ_y for dropped case

6. We can see how in the first case the deep beam is supported by the 3 columns, the central being the most compressed. On the other hand, when the descent occurs in the central column, due to its great rigidity, the beam tends to prevent it and a state of traction is generated along the entire central column, overloading the outer columns.

Exercise 3:Plate with two sections

1. The problem has been modelled with two separate set of surfaces, one for the concrete beam and another for the steel plate. In order to ensure that the steel plate is stuck into the beam, their surfaces in GiD were defined using the same set of nodes and lines. The beam supports were modelled as fixed, imposing zero horizontal and vertical displacements (in x and y directions, respectively). The applied load was 'Normal pressure' with the given value of 25.0 kN/m. No self-weight was considered.

   Material properties (c stands for concrete, s for steel)

$$\begin{aligned} E_c &= 3.0\ 10^4\ MPa; \quad E_s = 2.1\ 10^5\ MPa & (8)\\ \nu_c &= 0.2; \qquad\qquad \nu_s = 0.3 & (9)\\ thickness_c &= 0.25\ m;\ thickness_s = 0.016\ m & (10) \end{aligned}$$

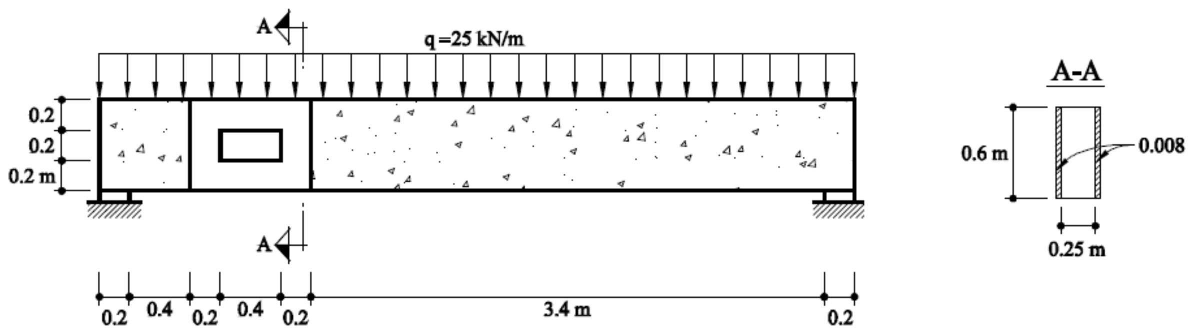

Figure 12: Problem data

2. The geometry was meshed using structured four node quadrilaterals. In order to ensure a good approach of the solution, and to keep a good aspect ratio, we used a total of 8710 and 8300 elements (0.2 m sided squares). Next figure shows the number of elements per line.

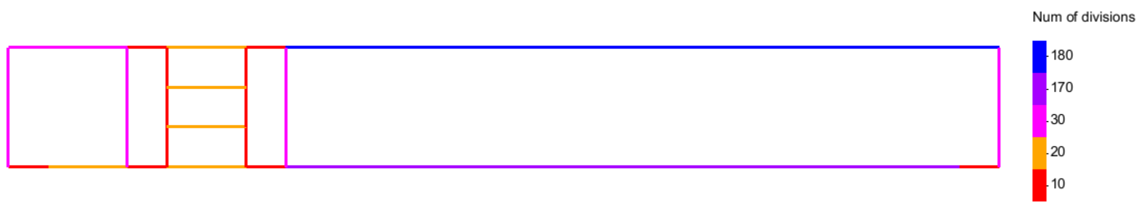

Figure 13: Number of elements in the structure mesh. All elements are squares of 0.2 m sides.

3. The results can be seen in 14 to 17. The reinforced beam is deforming simetrically (except for the hole, of course) with a maximum deflection of 0. 53 mm. Most of the tension is located at the inner corners of the steel plate. However, the concrete beam is not particularly experiencing high gradients of tension (except at the vicinity of the supports). We can see here that the steel is increasing the stiffness locally, avoiding an excesive deformation. In the table the different values for these points can be found. Tension in steel is around 10-7 times higher for σ_x and σ_y and 6-8 for τ_{xy} than in concrete.

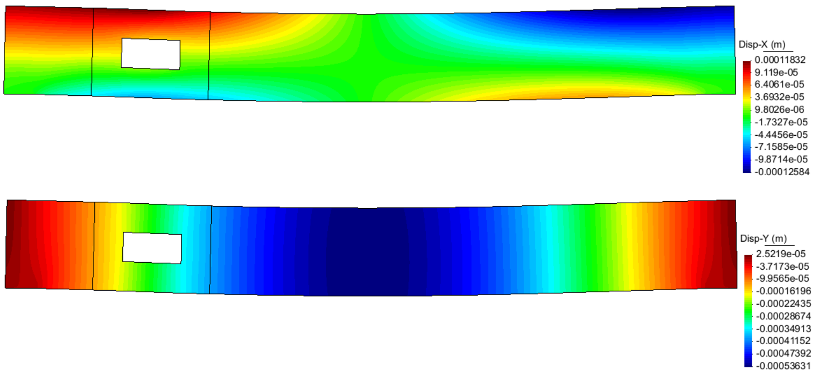

Figure 14: Disp-X and Disp-Y over deformed mesh [mm]

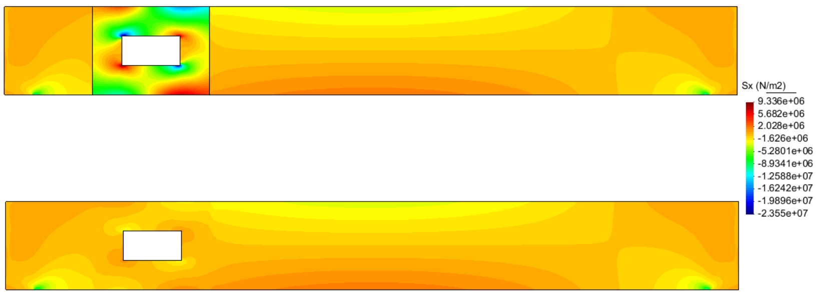

Figure 15: σ_x in beam and beam with plate[MPa]

Figure 16: σ_y in beam and beam with plate[MPa]

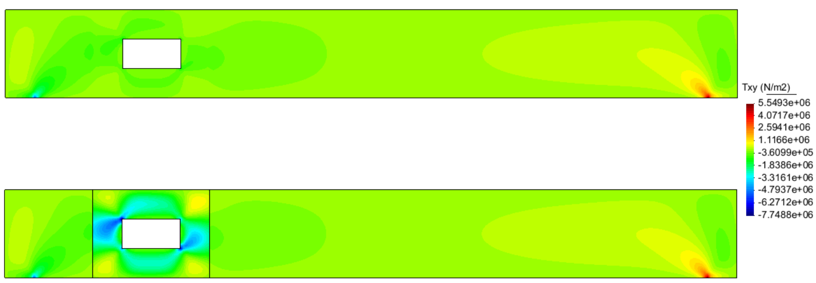

Figure 17: τ_{xy} in beam and beam with plate[MPa]

Node X [m]	Node Y [m]	Surface	σ_x [MPa]	σ_y [MPa]	σ_{xy} [MPa]
0.8	0.2	steel	9.337	11.7	-4.53
1.2	0.2	steel	-18.7	-13.2	-6.74
0.8	0.4	steel	-21.5	-14.9	-7.75
1.2	0.4	steel	6.94	9.977	-3.65
0.8	0.2	concrete	1.25	1.53	-0.697
1.2	0.2	concrete	-2.54	-1.60	-1.05
0.8	0.4	concrete	-2.91	-1.82	-1.22
1.2	0.4	concrete	0.929	1.33	-0.546

Exercise 4:Prismatic water tank

1. The reaction of the ground was modelled using elastic constraints and a constraint on the X direction as a roller support was imposed. The load produced by the weight of the water was modeled using a uniform load over the bottom of the tank and and a linear distribution over the wall of the tank. Finally, the tank weight was considered. The boundary conditions described before are shown in the figure below.

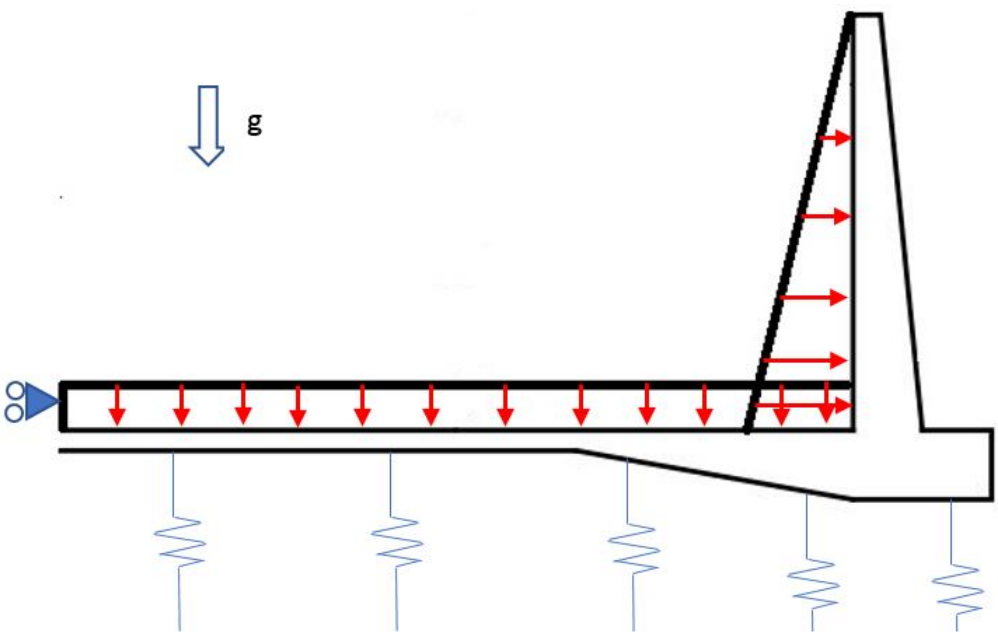

Figure 18: Boundary conditions

2. Displacement: 19 shows the X and Y displacements. It can be seen that they are in accordance with the applied loads.

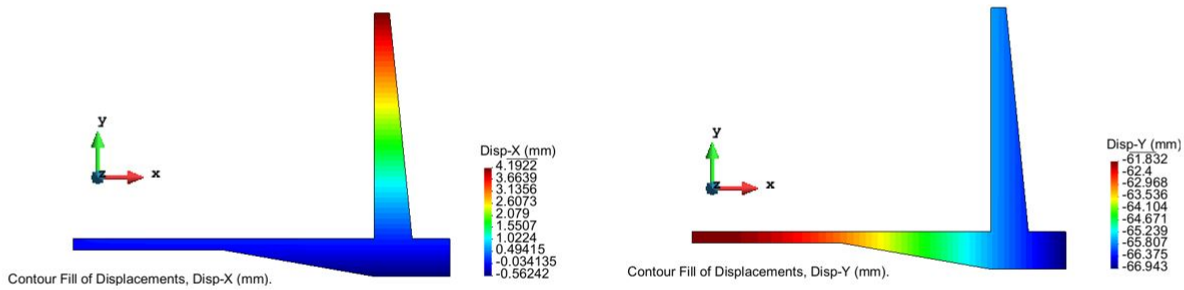

Figure 19: Horizontal and vertical displacements

The maximum displacement was around -67mm in Y direction. This value is in accordance with the total applied load.

3. Stresses: **??** shows σ_x and σ_y stresses.

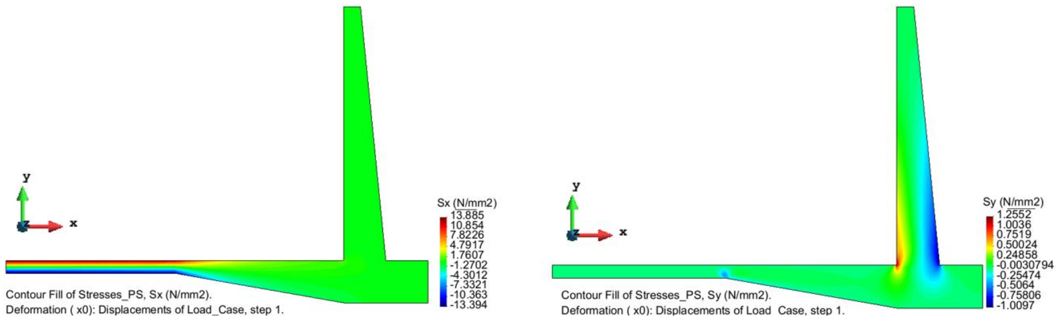

Figure 20: σ and σ_y stresses in the tank

The figures on both sides show that the stresses were in accordance with the applied load. It can be seen on the left that the traction and compression stresses were located on top and bottom of the tank floor respectively. The behaviour of the tank wall showed a similar behaviour of a cantilever beam where the traction stress was on the internal face of the wall and the compression stress was on the external face of the wall.

Finally, **??** shows that the Von Mises stress level was less than the yield stress of the concrete ($\sigma_Y = 28MPa$ of concrete). Max $\sigma_{VM} = 13MPa$

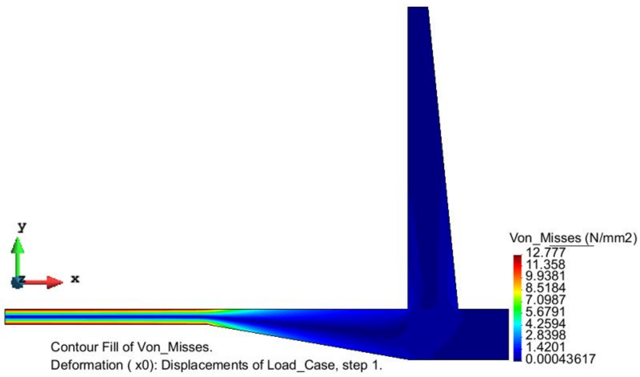

Figure 21: Von Mises stress