Computational Structural Mechanics and Dynamics

Practice 1

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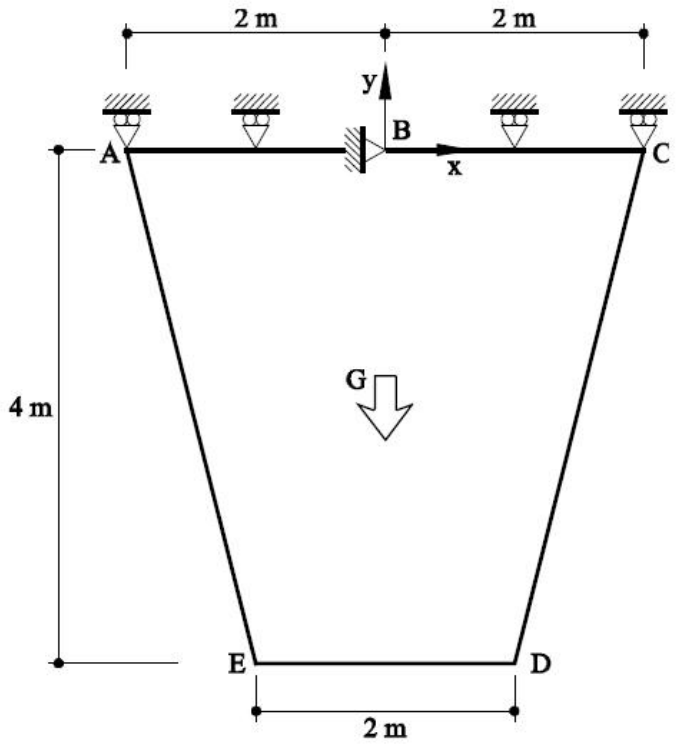
Exercise 1

Analyze the thin plate shown in the figure, which is submitted to its self weight. Compare the obtained results with the solution that is obtained when refining the mesh.

Use triangular elements with 3 and 6 nodes and quadrilaterals with 4, 8 and 9 nodes.



Boundary conditions and geometry are presented in Figure 1 and Figure 2.

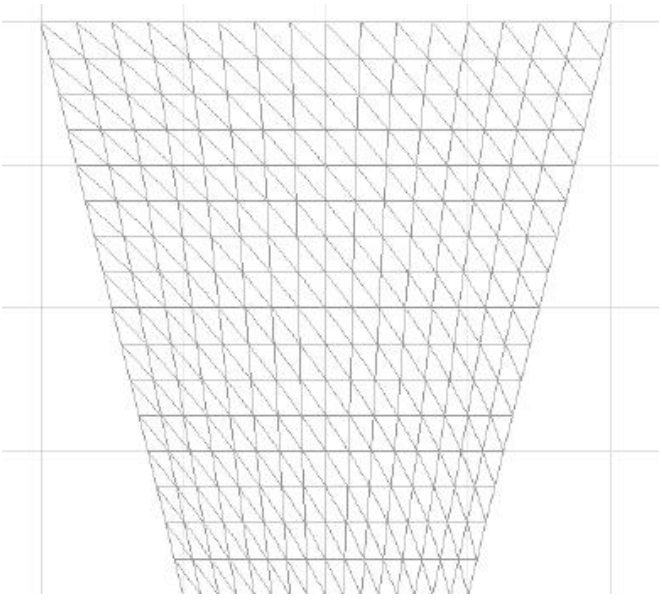


Figure 1. Mesh, Triangular

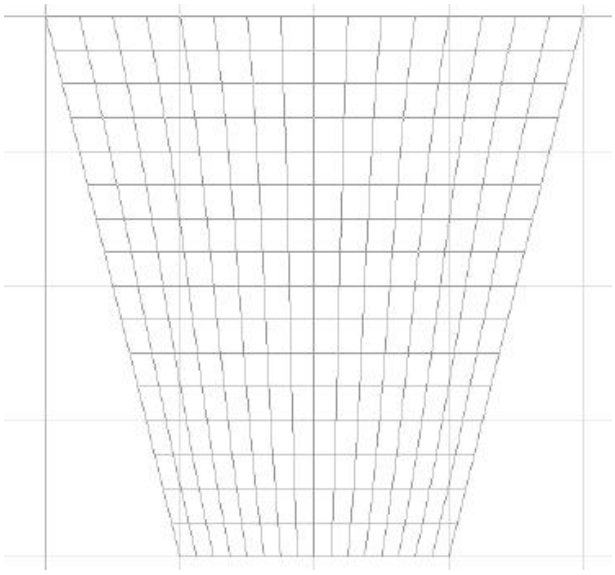


Figure 2. Mesh, Quadrilateral

In the following figures, Figure 3 and Figure 4, results for the triangular element with 3 nods are presented.

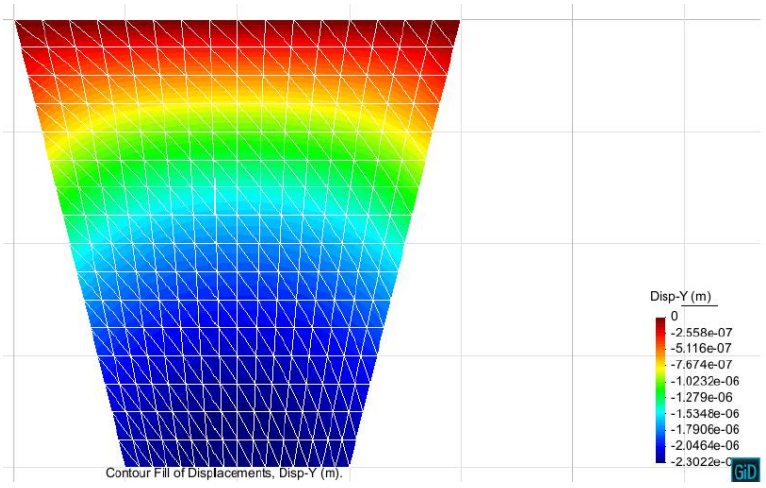


Figure 3. Displacement in Y-direction with triangular element with 3 nods

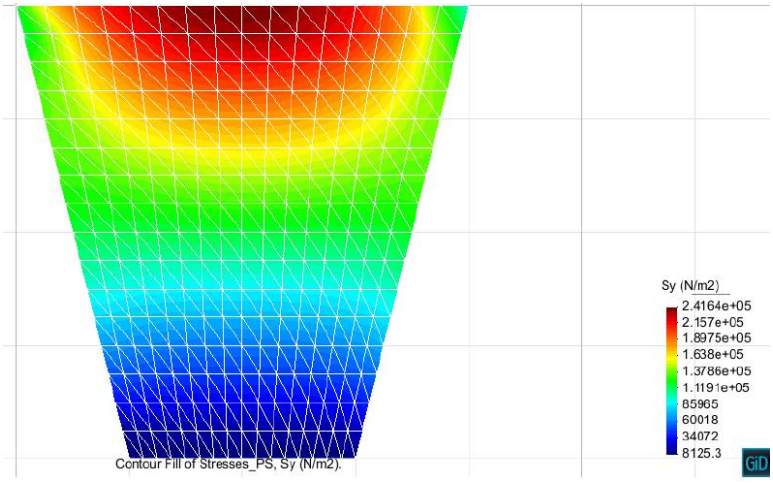


Figure 4. Stresses in Y-direction with triangular element with 3 nods

In the following figures, Figure 5 and Figure 6, results for quadrilateral element with 4 nods are presented.

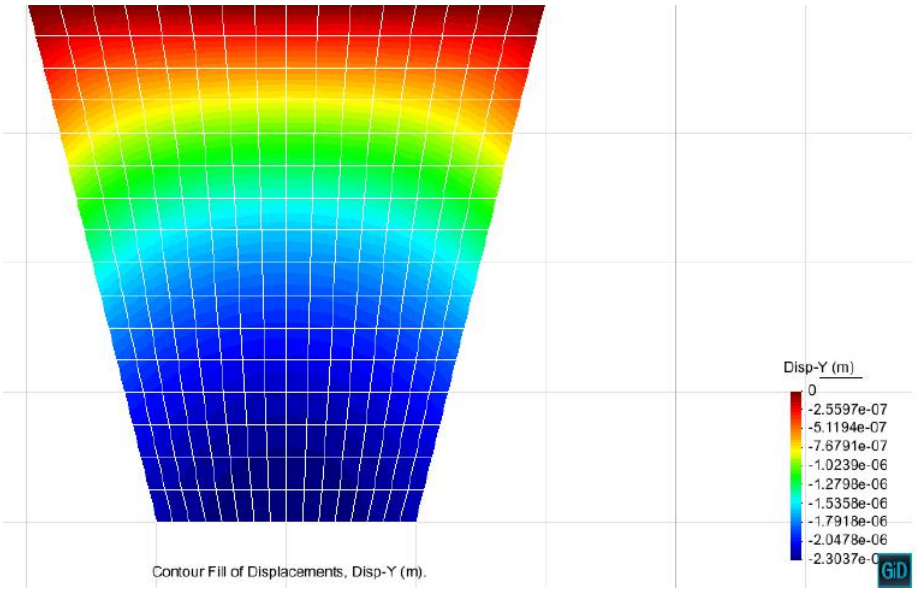


Figure 5. Displacement in Y-direction with quadrilateral element with 4 nods

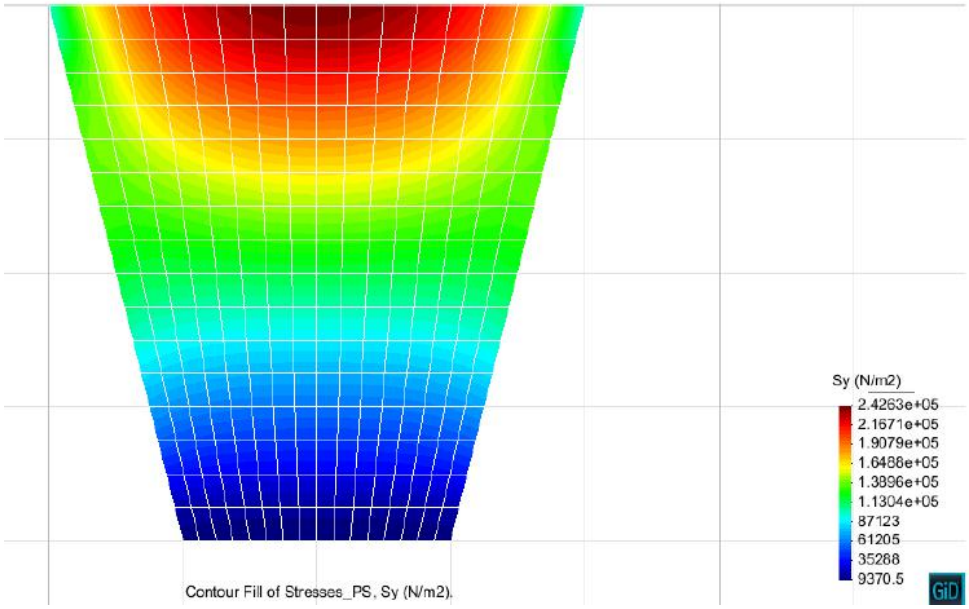


Figure 6. Stresses in Y-direction with quadrilateral element with 4 nods

All results for triangular element with 3 nodes and 6 nodes, quadrilateral element for 4, 8 and 9-nodes are presented in Table 1.

Element Type	Stress in point B in Y-direction (N/m2)	Displacement at the center of Edge ED in y-direction[m]
Triangular with 3-nodes	$2{,}4164*10^{5}$	$-2{,}3022*10^{-6}$
Triangular with 6-nodes	$2{,}4861*10^{5}$	$-2{,}3039*10^{-6}$
Quadrilateral with 4-nodes	$2{,}4263*10^{5}$	$-2{,}3037*10^{-6}$
Quadrilateral with 8-nodes	$2{,}4978*10^{5}$	$-2{,}3039*10^{-6}$
Quadrilateral with 9-nodes	$2{,}4977*10^{5}$	$-2{,}3039*10^{-6}$

Table 1

- **Analysis of the results**

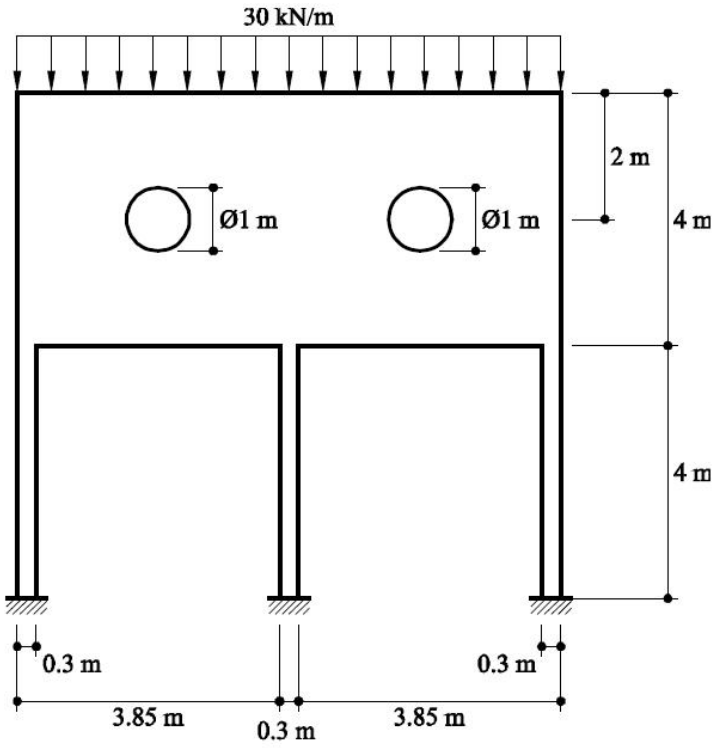
We see that there is small difference of displacement between different number of nodes.

On the other hand, there is a remarkable difference between different models. The stresses increase with high density mesh and the model that is one with a high density mesh is more accurate.

Exercise 2

The structure in the figure presents a reinforced concrete plate with two holes, supported by three columns. The central column undergoes a displacement δ due to sag of the foundation caused by a leakage in some pipes nearby.

Analyze the distribution of the stresses that the drop of the central column produces. Assume the hypothesis of plane stress. Use triangular elements with 3 nodes for the analysis.



Boundary conditions and geometry are presented in Figure 7.

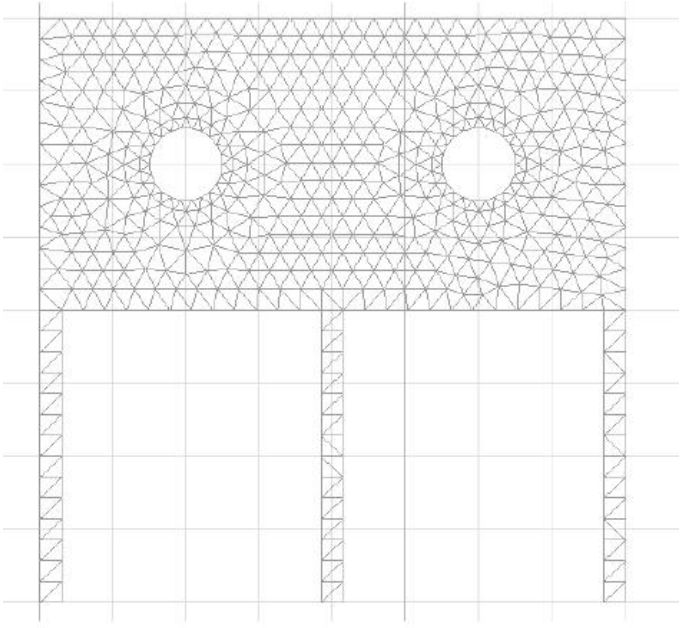


Figure 7

Results for the structure with no displacement in X, Y, and XY directions are presented in Figure 8, Figure 9 and Figure 10.

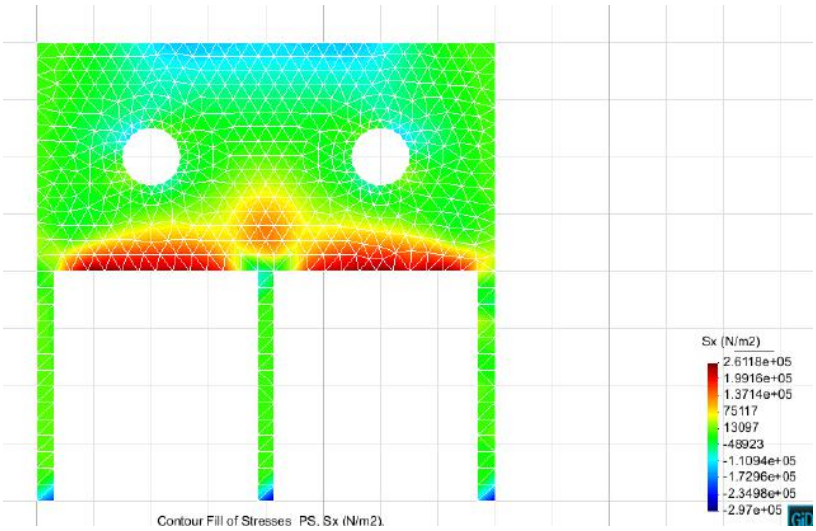


Figure 8. Structure with no displacement in X-direction

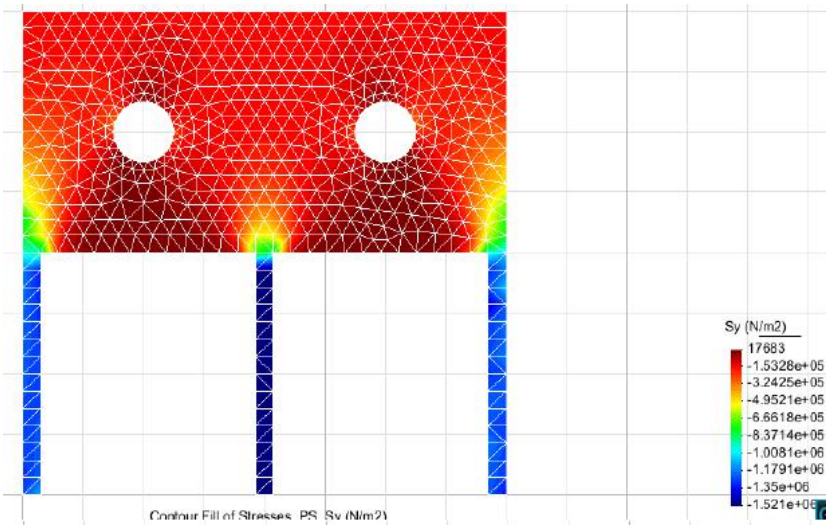


Figure 9. Structure with no displacement in Y-direction

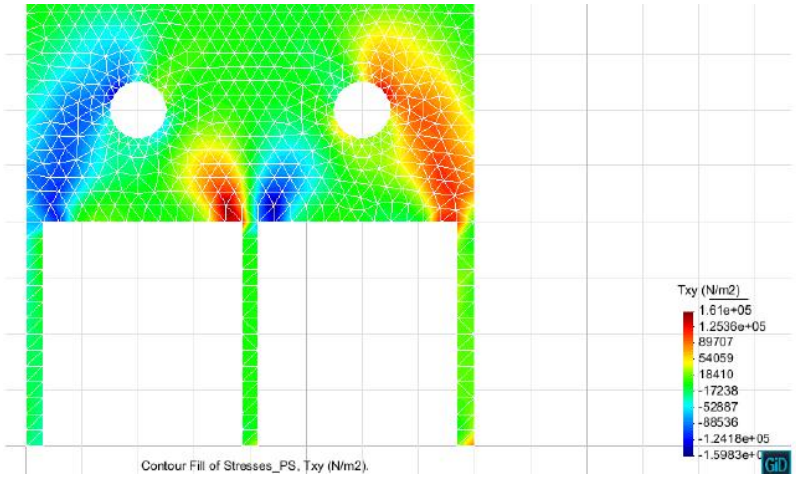


Figure 9. Structure with no displacement in XY-direction

Results for stresses in X direction caused by different amount of displacements are presented in the following figures.

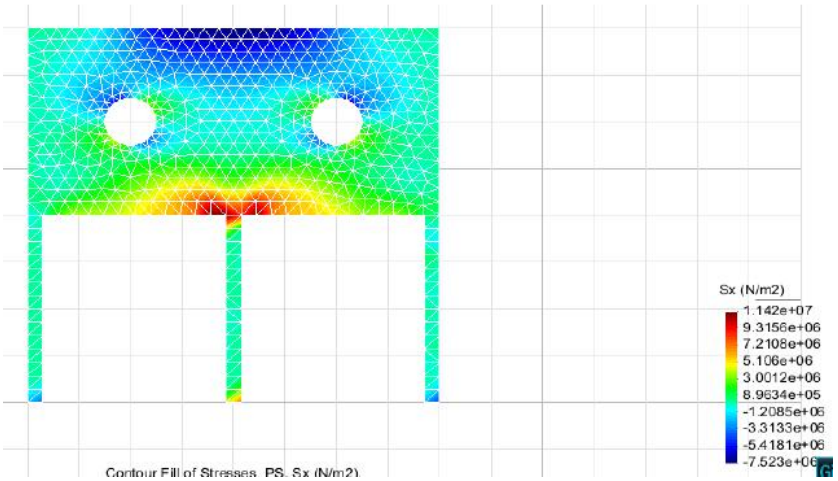


Figure 10. Structure with 1 cm displacement

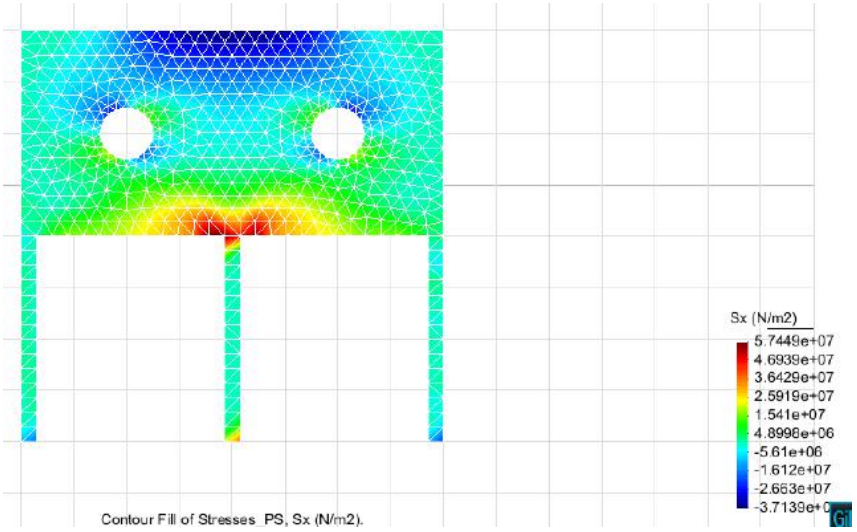


Figure 11. Structure with 5 cm displacement

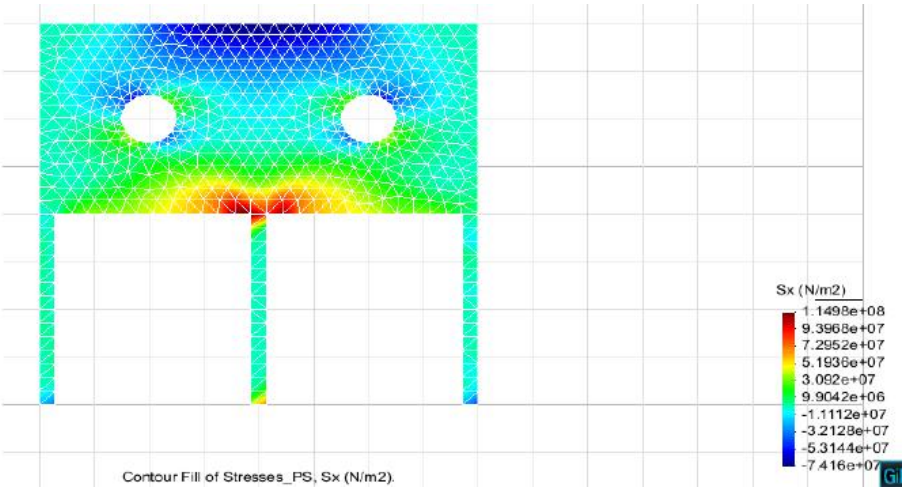


Figure 12. Structure with 10 cm displacement

Results for stresses in XY direction caused by different amount of displacements are presented in the following figures.

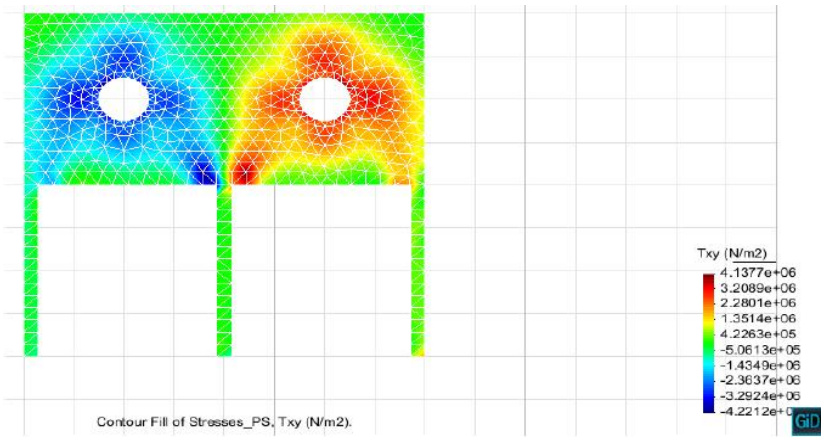


Figure 13. Structure with 1 cm displacement

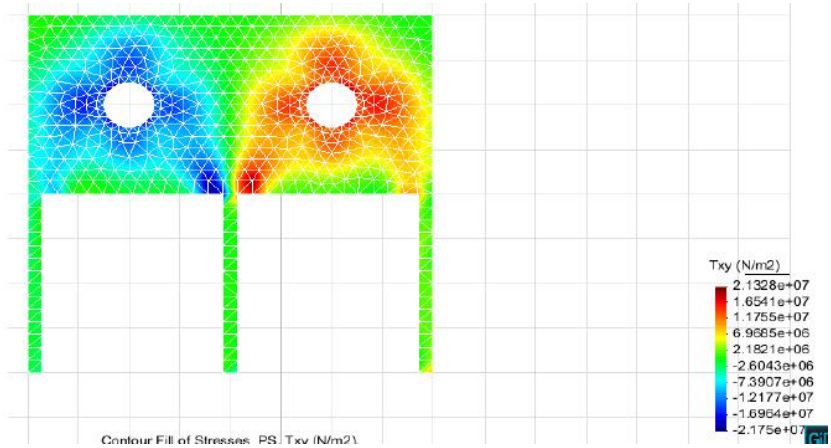


Figure 13. Structure with 5 cm displacement

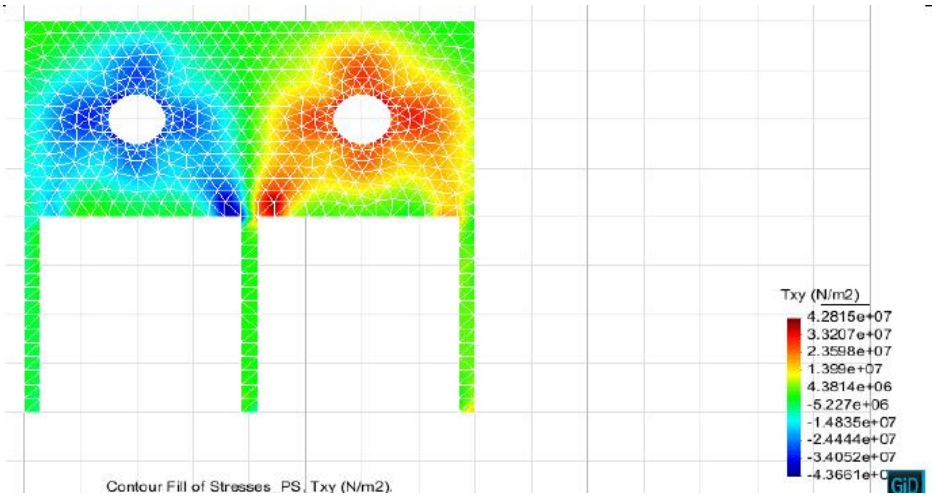


Figure 14. Structure with 10 cm displacement

Results for stresses in Y direction caused by different amount of displacements are presented in the following figures.

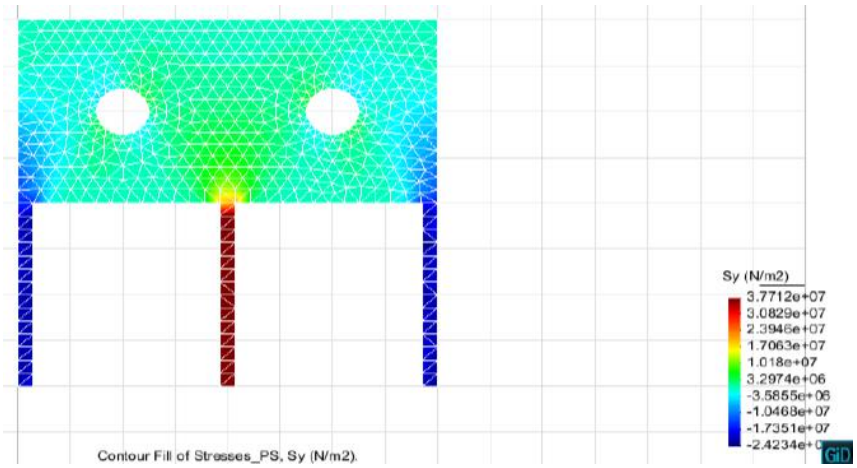


Figure 1. Structure with 1 cm displacement

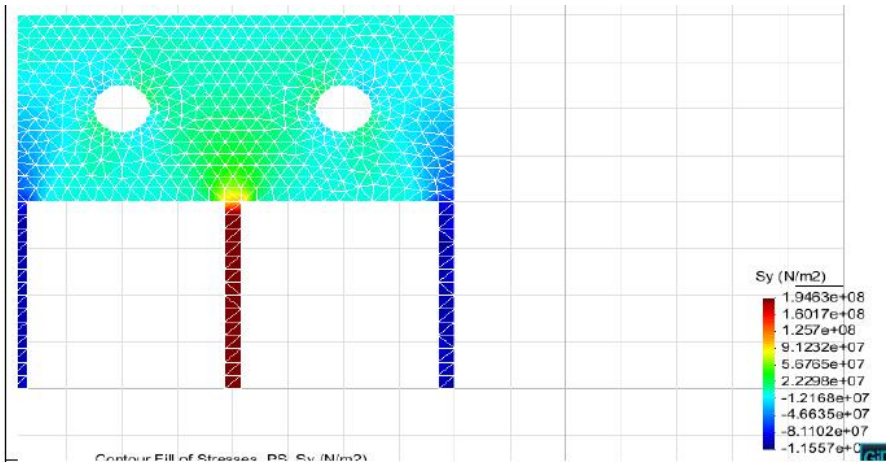


Figure 15. Structure with 5 cm displacement

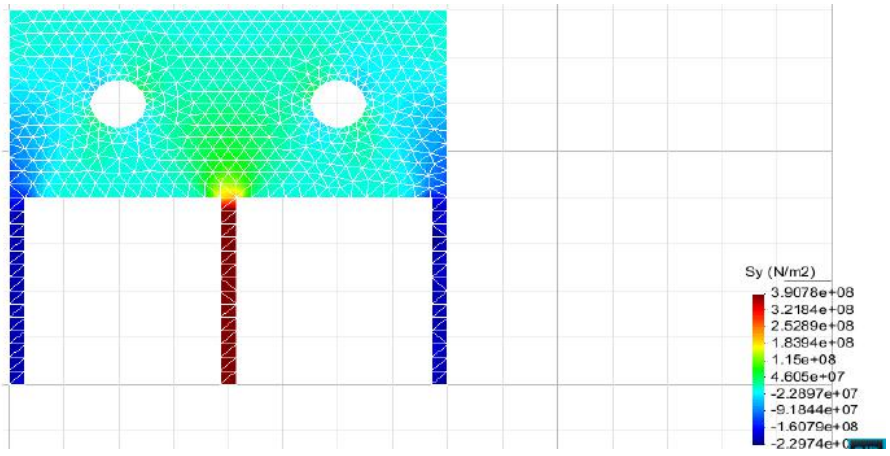


Figure 16. Structure with 10 cm displacement

Displacement (cm)	Range of stresses in X direction mPa	
0	-0.3	0.3
1	-7.5	11.4
5	-37.2	57.5
10	-74.2	114.9

Displacement (cm)	Range of stresses in Y direction mPa	
0	-1.5	0.2
1	-24.2	37.7
5	-115.6	194.4
10	--229.7	391.8

Displacement (cm)	Range of stresses in XY direction mPa	
0	-1.6	0.2
1	-4.2	4.1
5	-21.7	21.3
10	-43.6	42.6

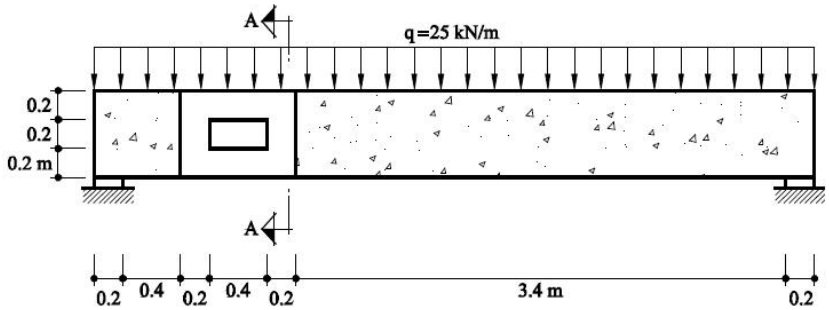
- **Analysis of the results**

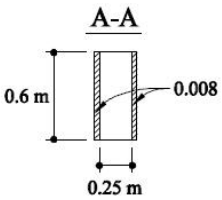
We observe that the stresses increase due to the settlement. For example, there is a significant increase of the tension in Y direction. We see that, for 1 cm displacement, approximately 25 times higher stresses we get.

We see that there are a couple of points with a high concentration of stress. The piles, the area over the piles. We can say that there should be reinforcing bars to support the concrete in the areas with high level of tension.

Moreover, the results are almost symmetric. We can say that this is due to not symmetric triangle mesh; because otherwise, if we had a symmetric mesh, the stresses would be exactly symmetric.

Exercise 3





The structure represents a reinforced concrete plate with simple supports. This plate possesses a hole for a ventilation pipe. Due to a change in the initial project, the design load for which the plate was calculated increased significantly. This motivated the placement of a metal reinforcement sheet on both sides of the plate in the area of the hole.

Analyze the state of stress in the plate and the metal reinforcement sheets. Assume the plane stress hypothesis. Use quadrilateral elements with four nodes.

Results for concrete at the top and steel at the bottom in X direction are presented in Figure 17 and Figure 18.

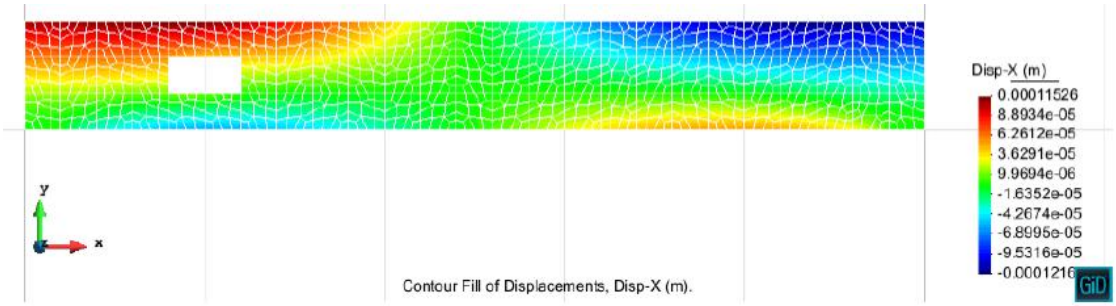


Figure 17

Figure 18

Results for concrete at the top and steel at the bottom in X direction are presented in Figure 19 and Figure 20.

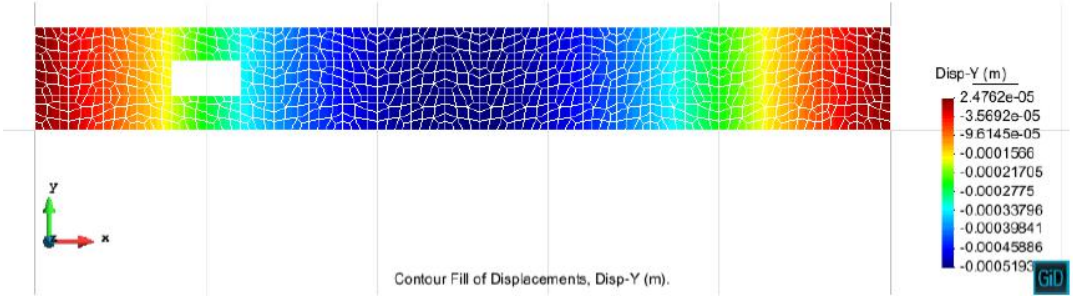


Figure 19

Figure 20

Results for stresses for concrete at the top and steel at the bottom in X direction are given in Figure 21 and Figure 22.

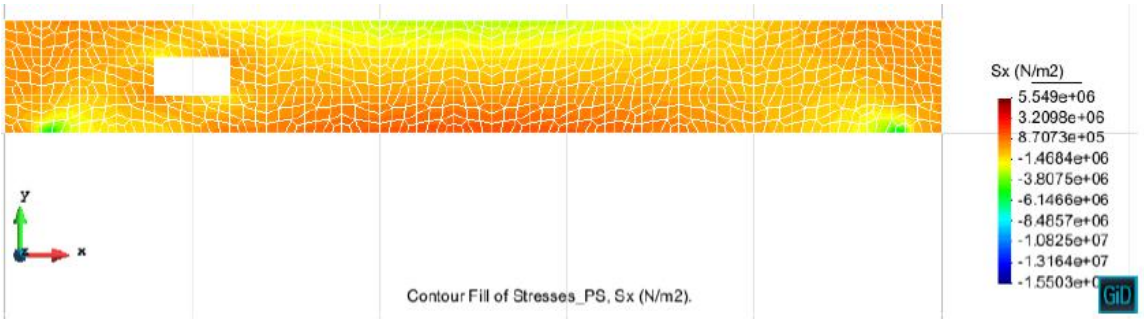


Figure 21

Figure 22

Results for stresses for concrete at the top and steel at the bottom in Y direction are given in Figure 23 and Figure 24.

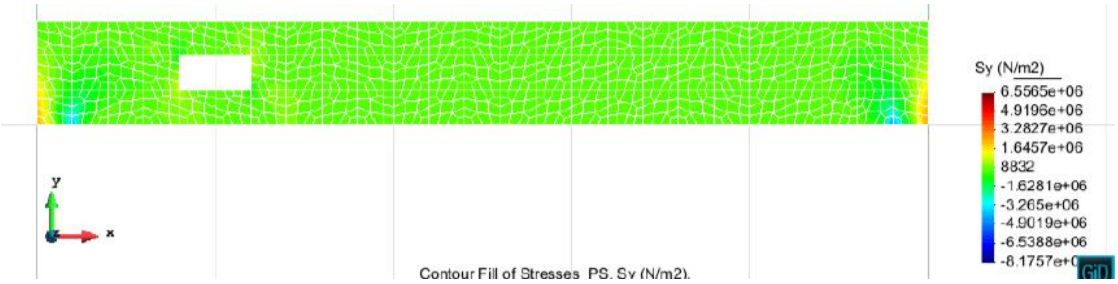


Figure 23

Figure 24

Results for stresses for concrete at the top and steel at the bottom in XY direction are given in Figure 25 and Figure 26.

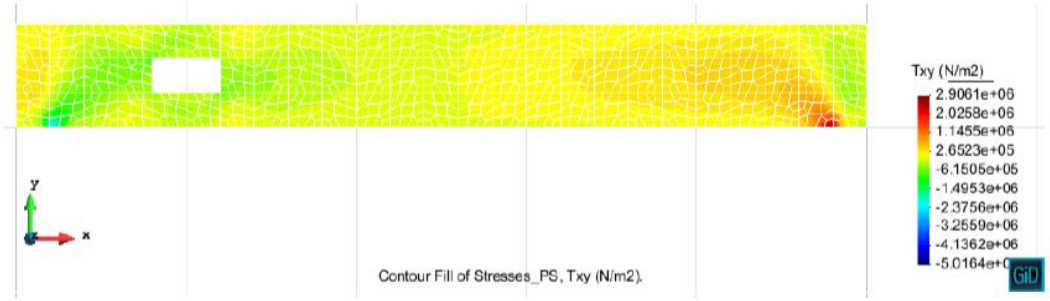


Figure 25

Figure 26

- **Analysis of the results**

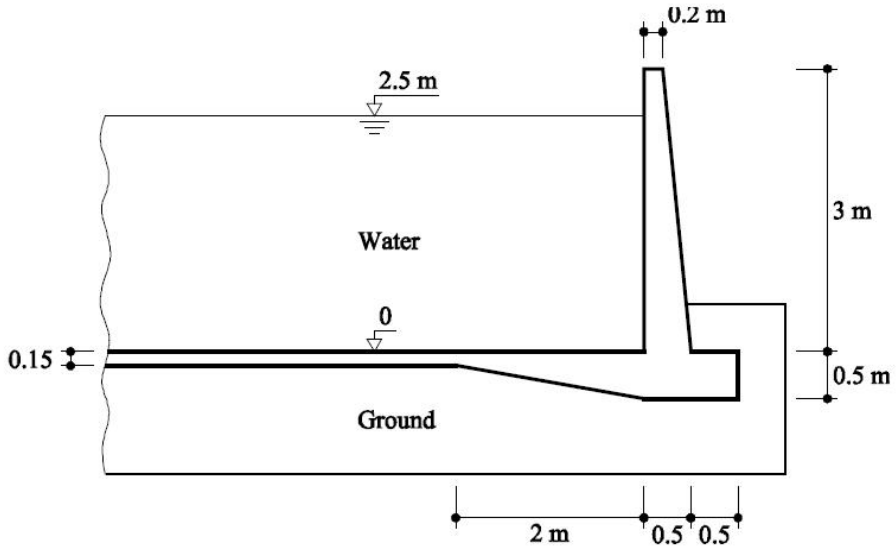
We see that the results for displacements of the steel and the concrete are same. Two materials, steel and concrete, are connected and their elements use the same nodes. Therefore, we get the same results.

On the other hand, we get different results for stresses. The reason of this that concrete and steel hace different E-modulus. The differen E modulus values lead to different stiffness and thus their behaviour are not same.

Exercise 4

The structure in the figure represents the cross-section of the wall of a rectangular water tank made of reinforced concrete. The tank is used to store drinking water.

Analyze the state of stress of the cross-section of the tank. Consider the base slab to be elastically supported by the ground. Use the hypothesis of planar deformation. Use quadrilateral elements with four nodes.



Results for displacement in X and Y direction are presented in Figure 27 and Figure 28.

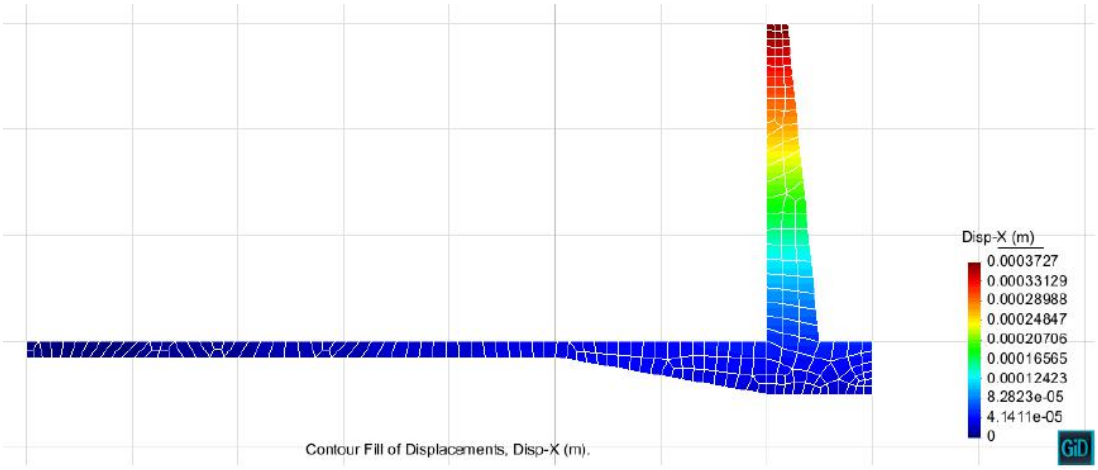


Figure 27. Displacement X direction

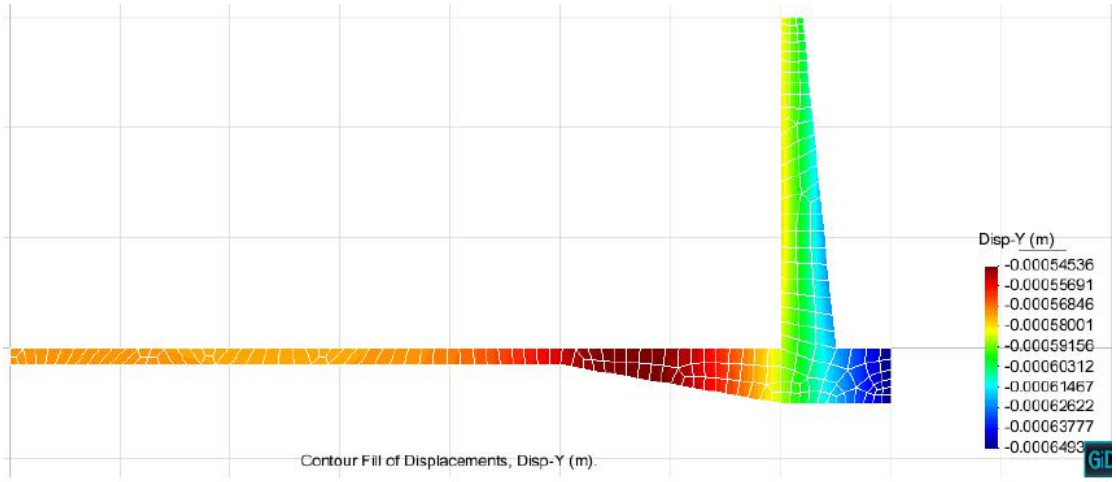


Figure 28. Displacement Y direction

Results for stressest in X,Y, XY direction are presented in Figure 29 and Figure 30 and Figure 31.

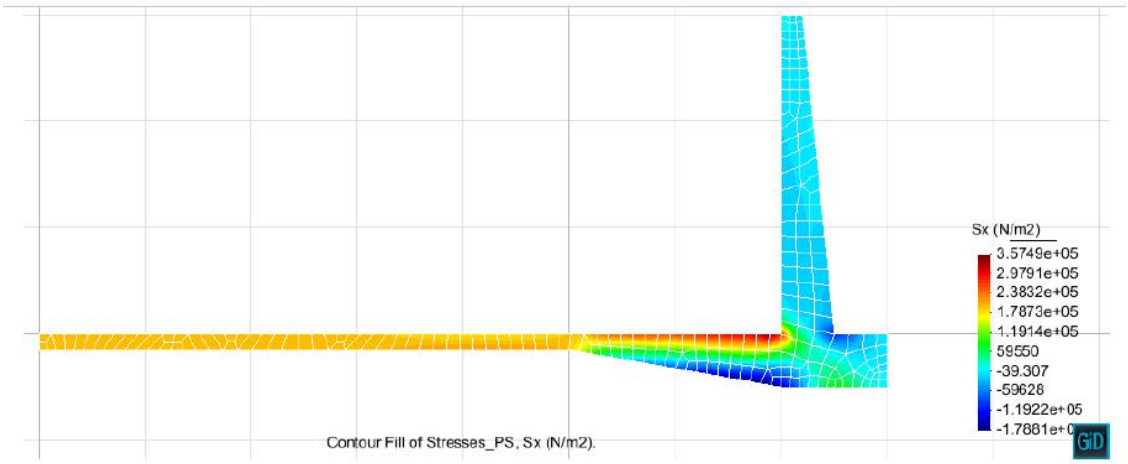


Figure 29.Stresses X direction

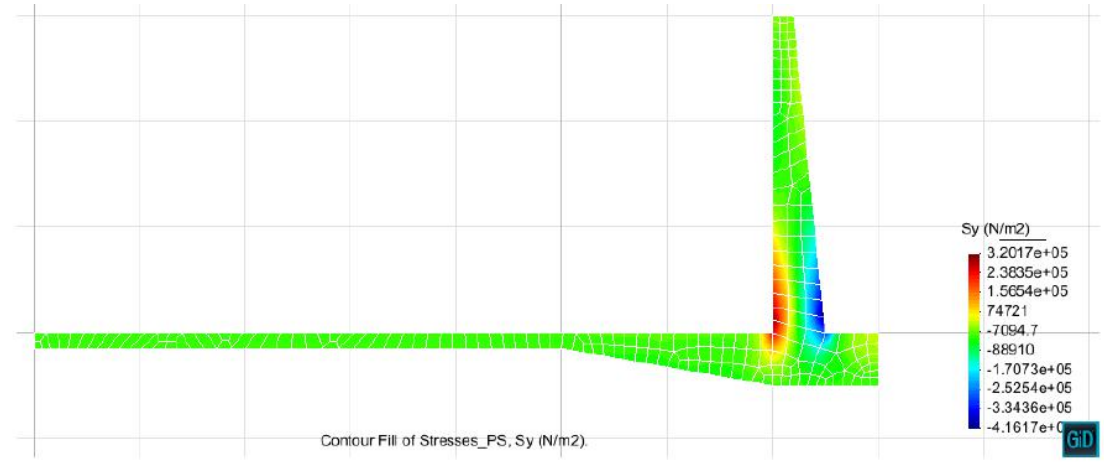


Figure 30.Stresses Y direction

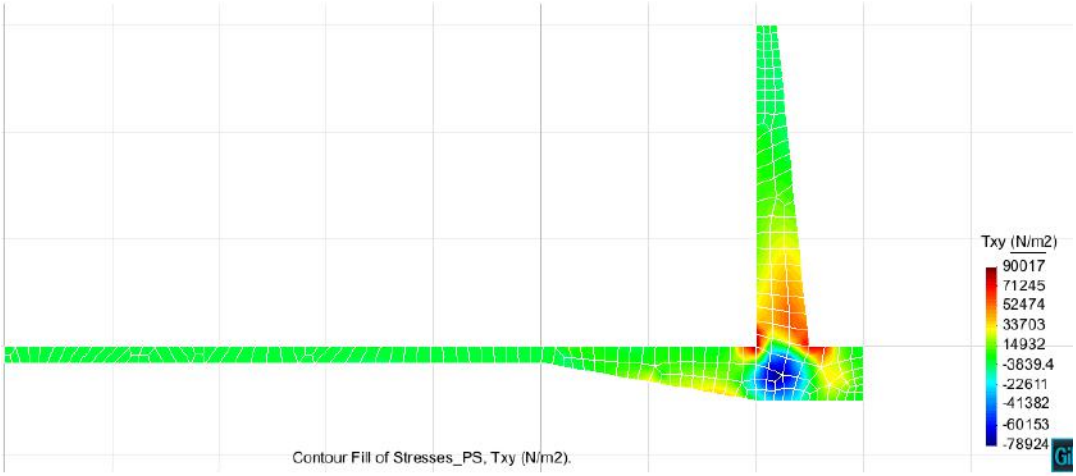


Figure 30.Stresses XY direction

- **Analysis of the results**

We observe that the points where the slab meets the wall have a high concentration of stresses. These points should be carefully anaylzed during designing process.

Settlements occur because of the elastic condition of the ground and these displacements change over the structure. Also these displacements lead to an additional stresses.