Computational Structural Mechanics and Dynamics

GID REPORT – PRACTICE 1

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Exercise 1: Thin Plate under dead weight

The analysis of the thin plate under deadweight shows higher stresses near the fixed joint. The displacements are highest at the lower part of the plate. The results are shown below for a 3 noded triangular element.

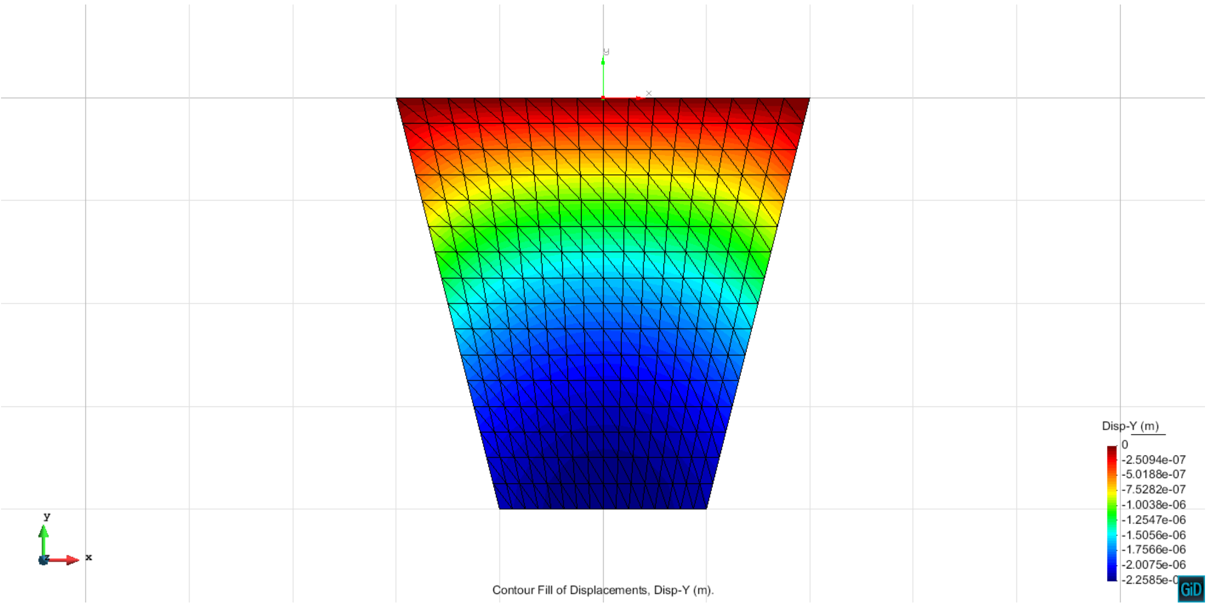

Fig.1.1: Y Displacement (m) for plate with 3 noded triangular elements

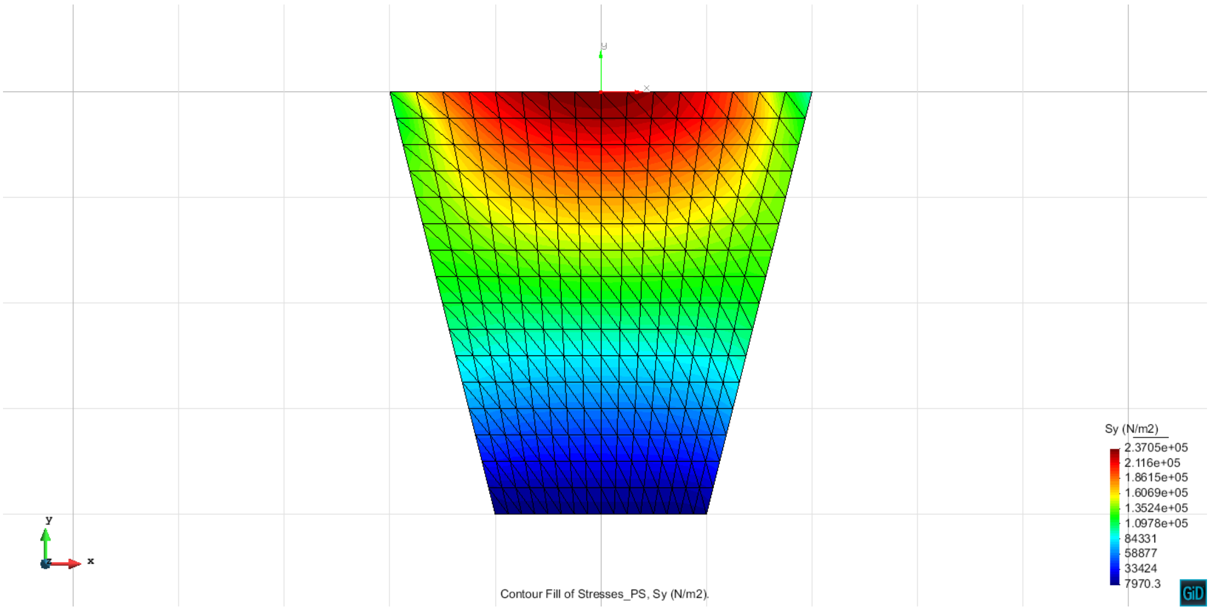

Fig.1.2: Stress (Sy) (N/m2) for plate with 3 noded triangular elements

The displacement at centre of side ED in the y direction is found to be = -2.2585 x 10^{-6} m.

The stress in y direction at point B = 2.3705 x 10^{5} N/m^{2}

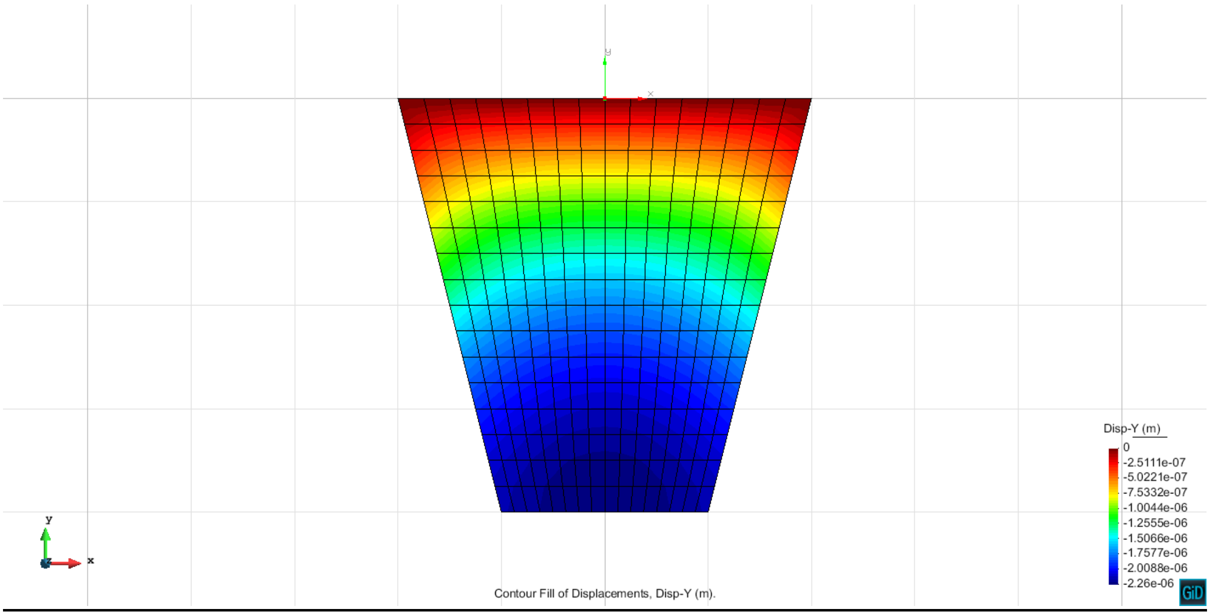

Fig.1.3: Y Displacement (m) for plate with 4 noded Quadrilateral elements

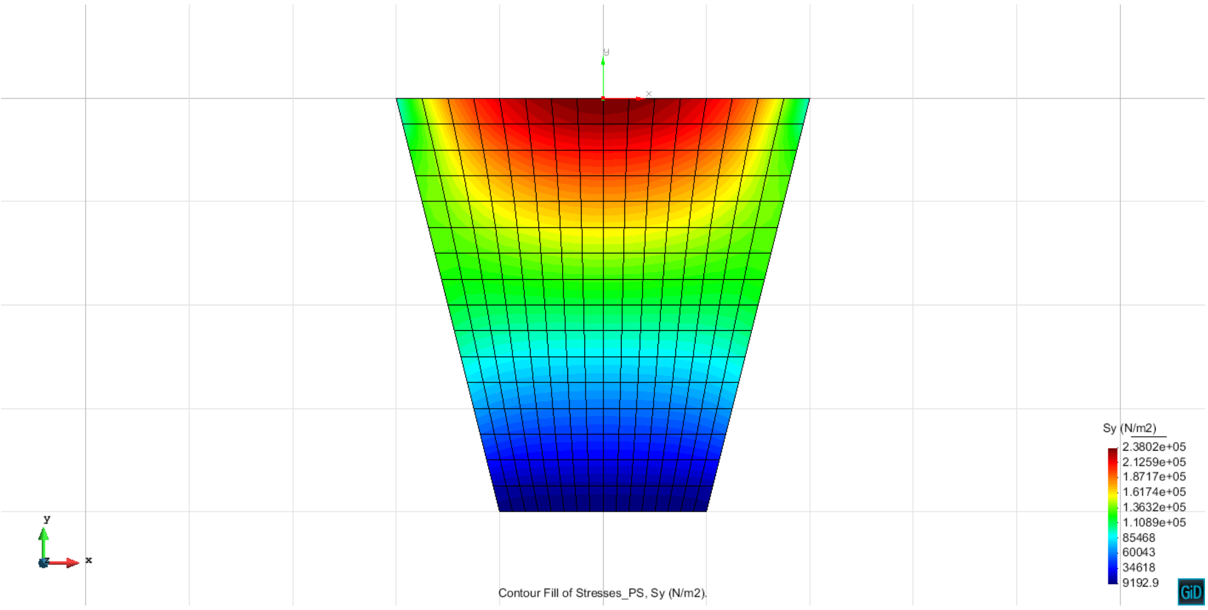

Fig.1.4: Stress (Sy) (N/m2) for plate with 4 noded Quadrilateral elements

Variation in Mesh size

A more refined mesh with the same 3 noded triangular elements gives a better approximation of the displacement and stresses.

Displacement Y = -2.2595x 10^{-6} m

The stress in y direction at point B = 2.4229 x 10^{5} N/m^2

<u>Variation in the element used</u>

Higher order triangular and quadrilateral elements with the same mesh size are used to analyse the variation and percentage error in the displacement and stress calculations.

Table 1 shows the result of the analysis with different elements.

Element Type	**Degrees of freedom**	**Stresses σy at B (MN/m2)**	**Displacement x in the centre of the side DE (x 10^{-6} m)**	**% error in Displacement**	**% error in Stress**
Triangle with 3 nodes	289	0.237	2.2585	0.066	4.04
Triangle with 6 nodes	1089	0.243	2.2599	0.004	1.61
Quadrilateral with 4 nodes	289	0.2380	2.26	0	3.6
Quadrilateral with 8 nodes	833	0.24503	2.2599	0.004	0.80
Quadrilateral with 9 nodes	1089	0.24503	2.2599	0.004	0.80

From the table we can see that the quadrilateral 8 and 9 node elements give better results in comparison to the other elements.

Exercise 2: Plate with two sections

The stress distribution in the y direction for the concrete plate in the initial state without any sag in the middle column is shown below.

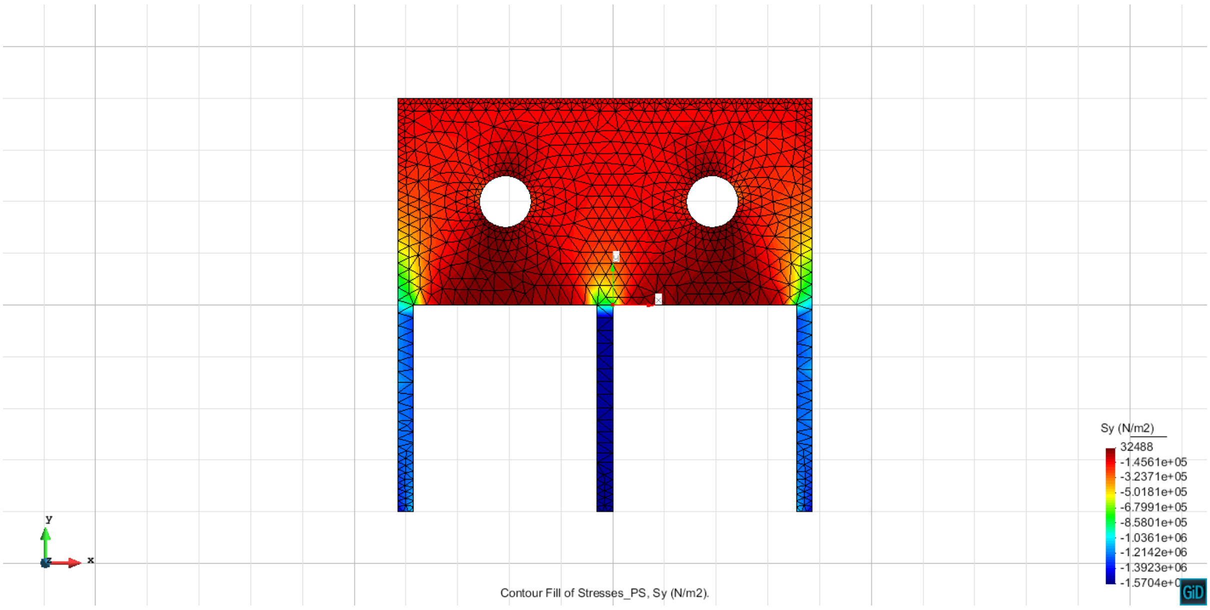

Fig.2.1: Stress (Sy) (N/m2)

The stresses are mostly compressive in the Plate.

3 cases of sag (δ) in the middle column are studied:

δ = 5 cm

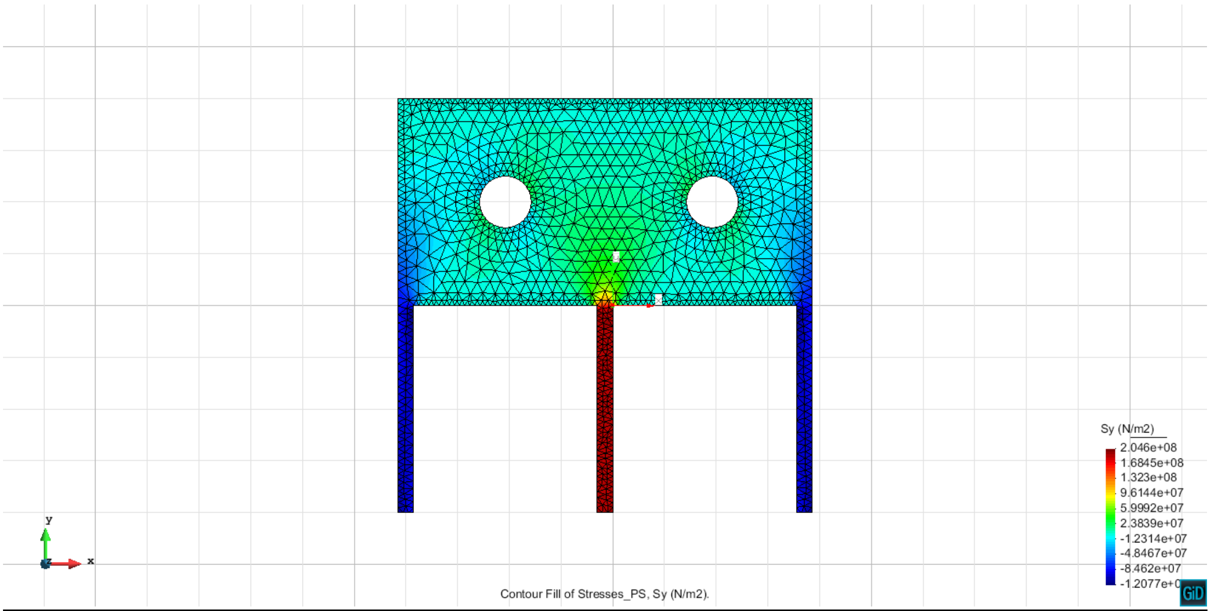

Fig.2.2: Stress (Sy) (N/m2)

δ = 10 cm

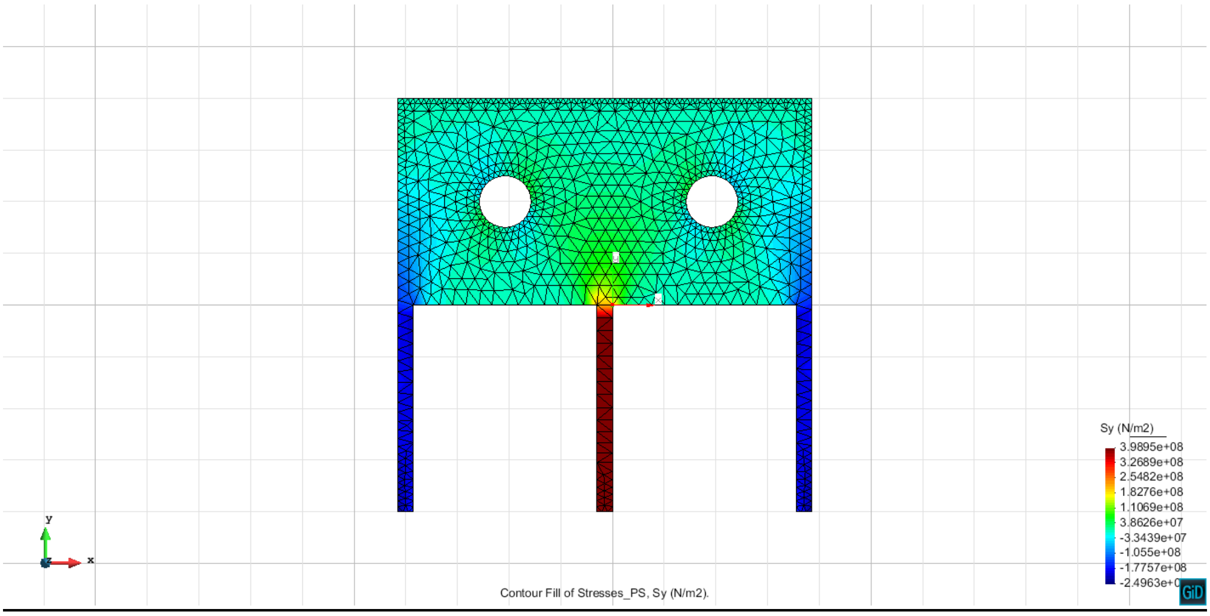

Fig.2.3: Stress (Sy) (N/m2)

δ = 15 cm

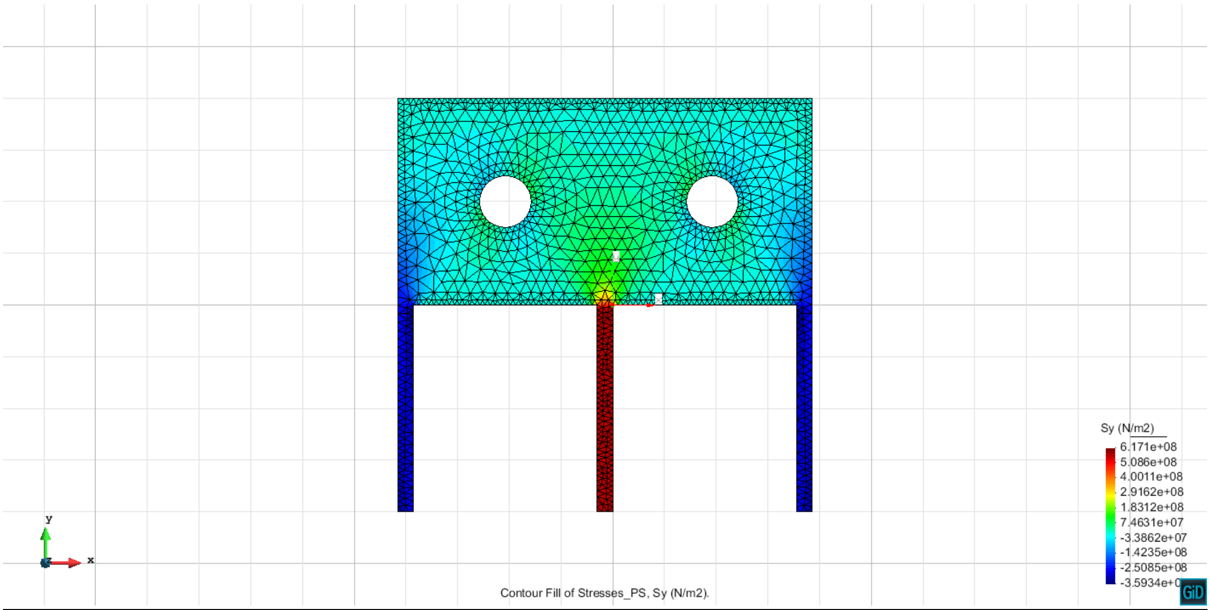

Fig.2.4: Stress (Sy) (N/m2)

As seen from the figures Fig. 2.2, 2.3 and 2.4, the sag induces very high tensile stresses in the middle column. The 2 side columns do not provide much support and there are high reaction forces at the bottom of middle column. The stress gradient in region of intersection of the middle column and the plate is quite high, which may lead to failure. The value of maximum tensile stress in the middle column increases as the sag increases.

Exercise 3: Plate with ventilation hole

Analysis of Stress distribution in the Concrete plate and metal sheets has the following results.

There is stress concentration in the corners of the hole for the ventilation pipe as seen in the figure below, which shows the stresses acting in the x and y direction. However, steel has better strength under tensile forces and so will be able to handle better the high tensile stresses at the corners.

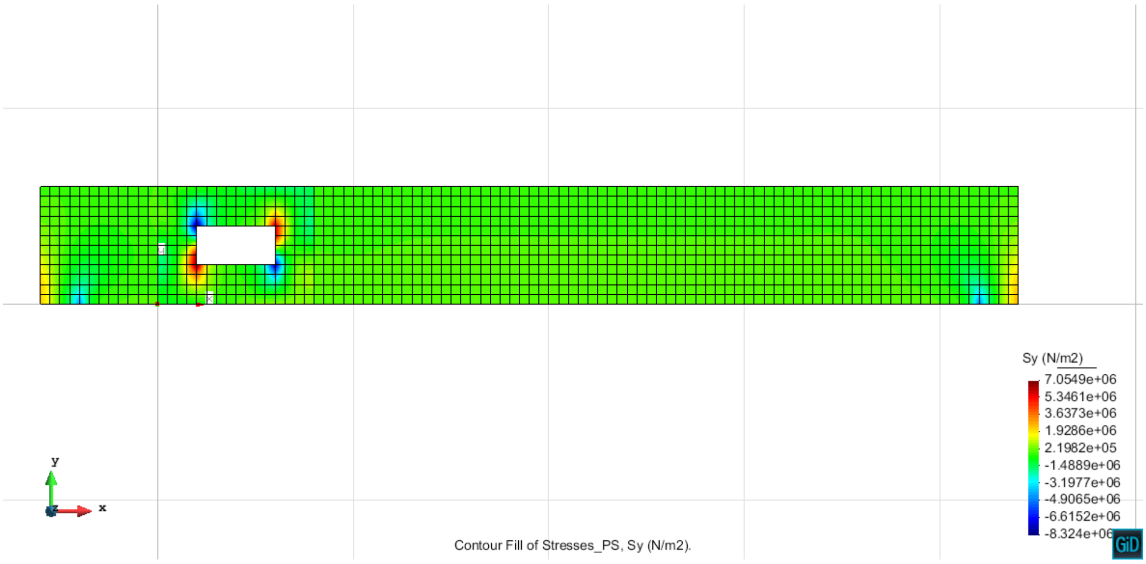

Fig.3.1: Stress (Sy) (N/m2) in the reinforced plate

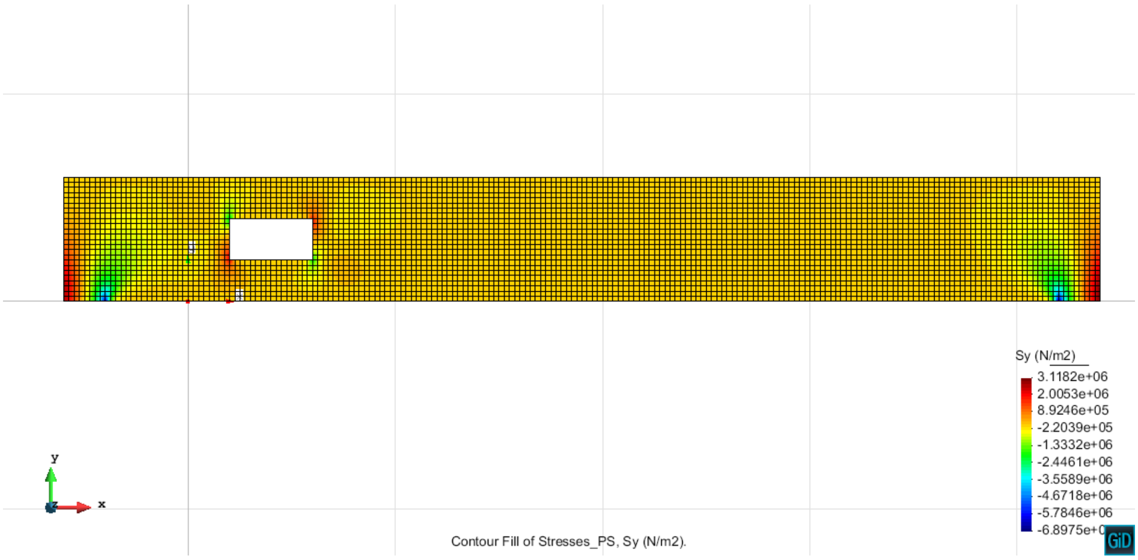

Fig.3.2: Stress (Sx) (N/m2) in the reinforced plate

But the rest of the plate has mostly uniformly distributed compressive stress acting on it, except for at the region where it is fixed to the ground.

On comparison with the concrete plate which has not been reinforced with metal sheets, the stresses in the x and y direction of which are given below,

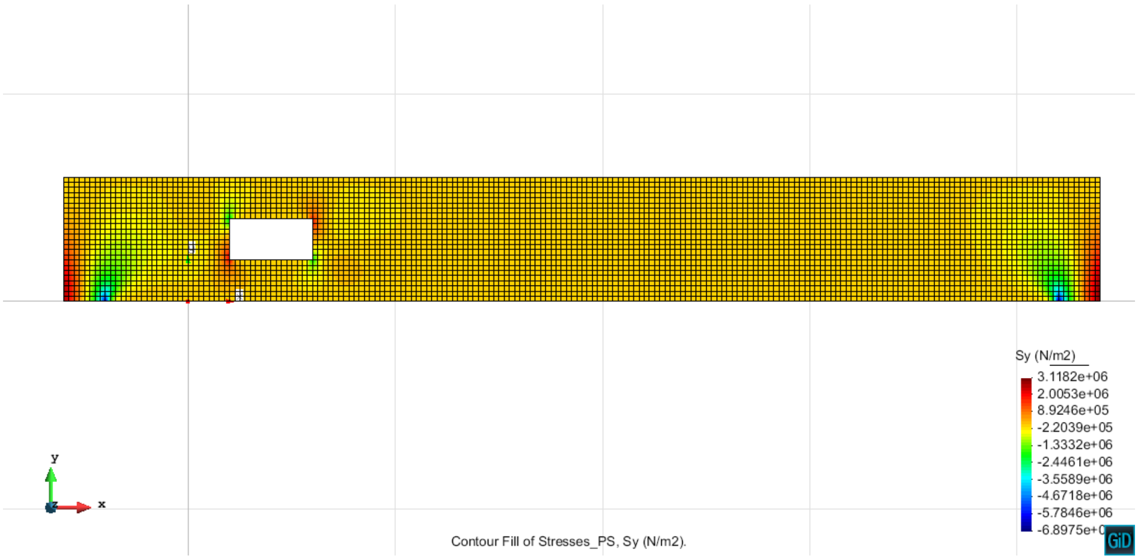

Fig.3.3: Stress (Sy) (N/m2) in the plate without steel reinforcement.

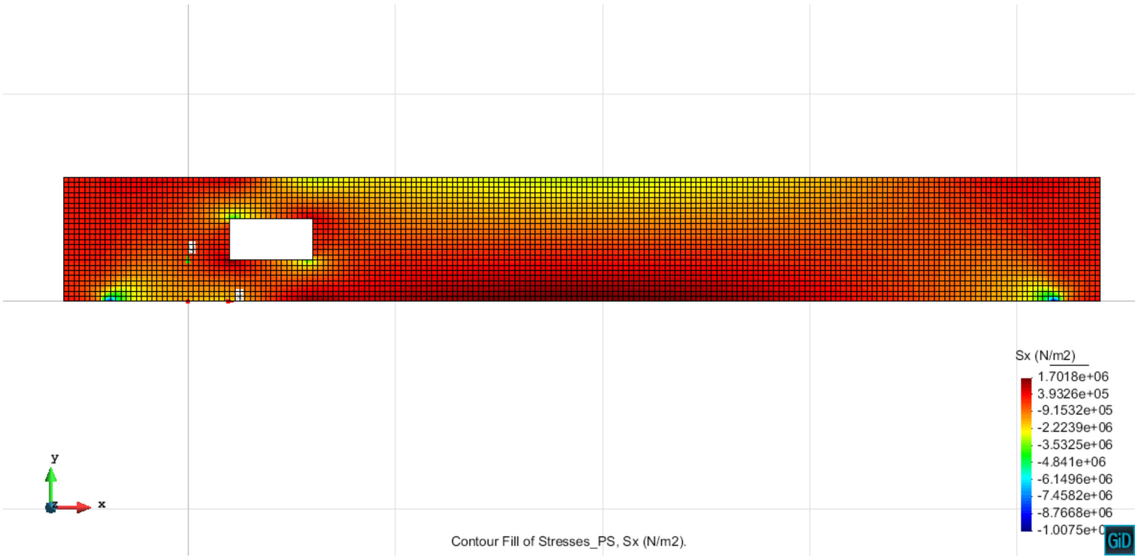

Fig.3.4: Stress (Sx) (N/m2) in the plate without steel reinforcement.

There is stress concentration at the corners of the ventilation pipe hole. However, the rest of the pipe is under higher tensile stress, in comparison to the reinforced metal sheet plate. Also, the reaction forces are much higher compared to the reinforced metal sheet plate. Therefore, the design alteration for the concrete plate has strengthened it.

Exercise 4: Prismatic water tank

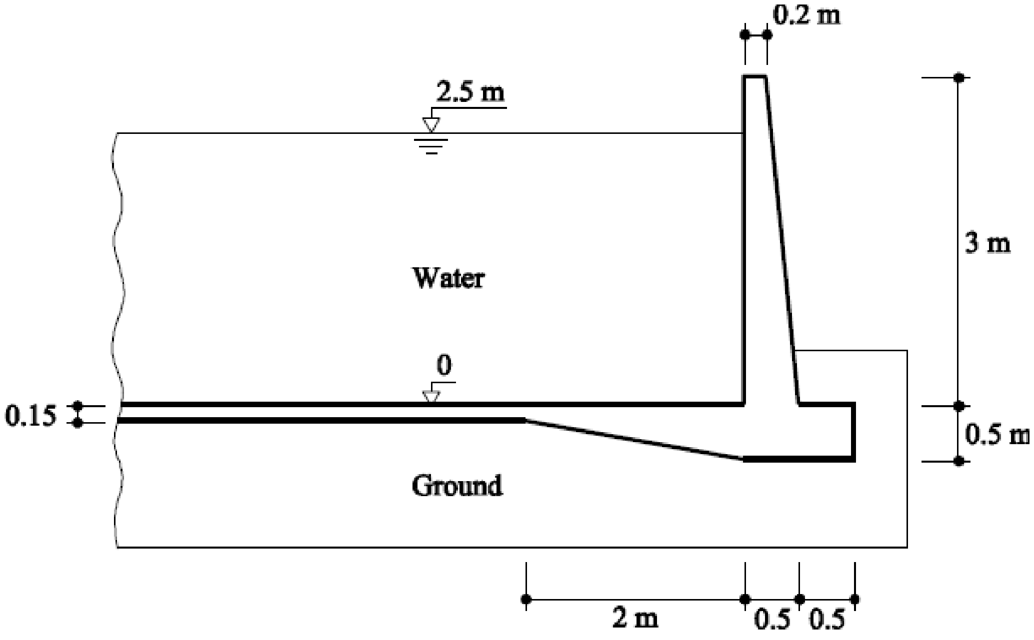

Fig 4.1: cross-section of the rectangular water tank

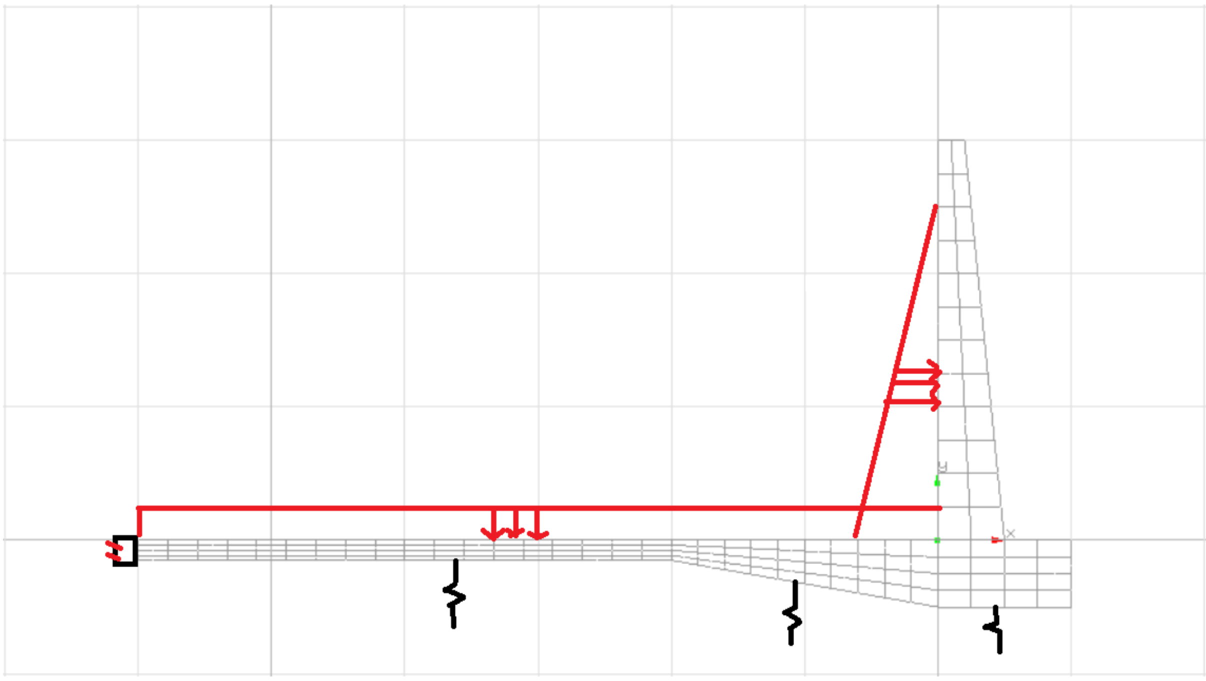

Fig 4.2: Meshing of the rectangular cross section of the tank.

For obtaining better mesh, four surfaces contour were created and meshing was applied. Elastic constrains were applied to the bottom of the tank that is in contact with the ground. On the left hand side of the tank symmetry condition was taken into account and displacement constraint in the x -direction is applied. An uniform pressure distribution is applied on the bottom part of the tank (as can be seen in the upper figure) taking into account the pressure force applied by the water (only) using $\rho*g*h$ where h = 2.5m . On the side of the tank, a linear load distribution is applied with min (0 kN/m) to be at the upper part and max (24.525 kN/m) on the lowest part.

Having defined all the parameters as explained above, meshing with quadrilateral element of 4 nodes is applied. The following results were obtained for stress analysis in x and y direction.

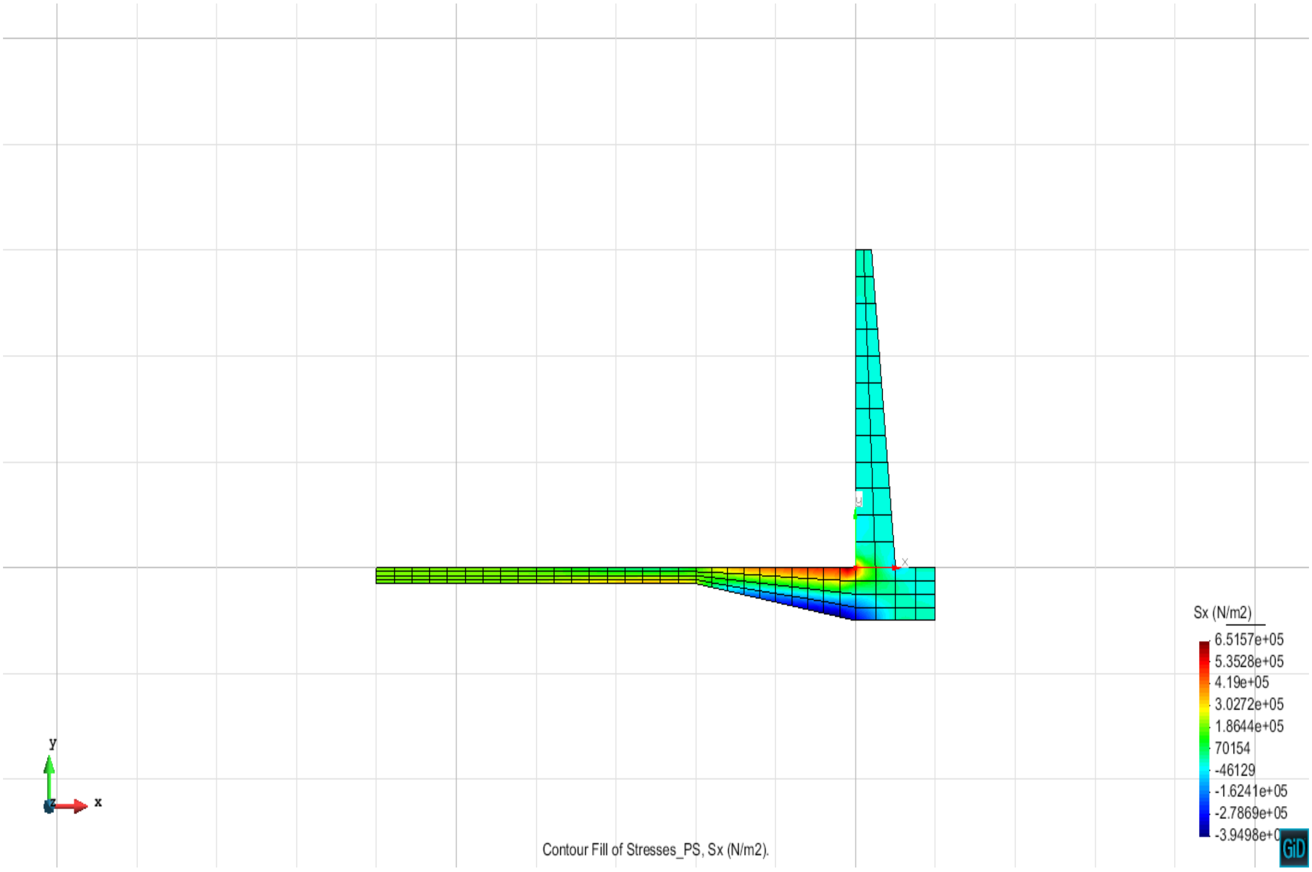

Fig 4.3: stress concentration in X-direction

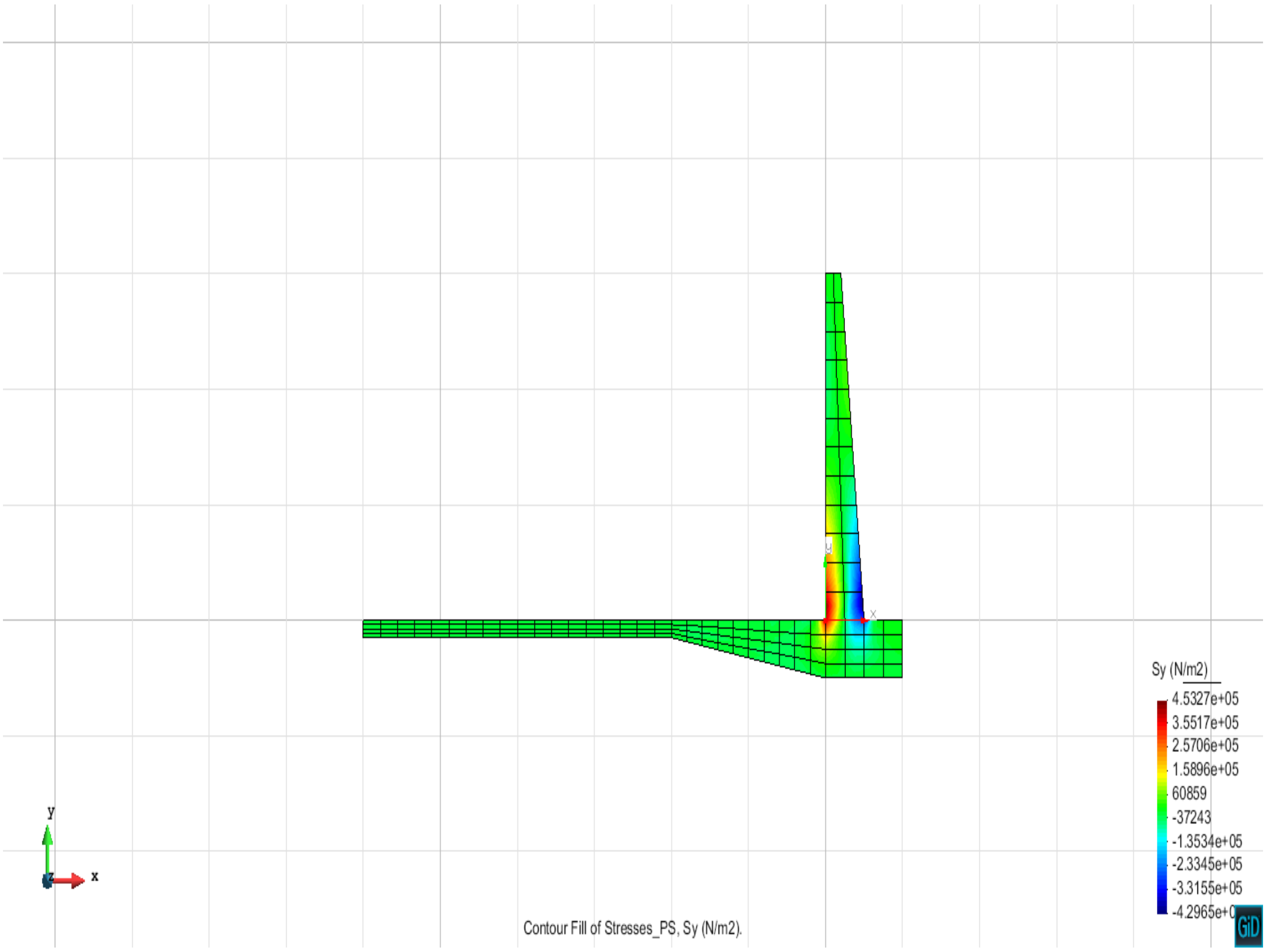

Fig 4.4: stress concentration in the y-direction.

As can be seen in the above figures, the stress concentration is higher in the right corner for both in x and y direction. It is expected to behave like this as the pressures are highest at that point. Reinforcement can be done in the right hand side of the tank to reduce stress in x direction.