Computational Structural Mechanics and Dynamics

HomeWork.No.1

GiD

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MS-Computational Mechanics

Exercise -1: Thin Plate under Self Load

A thin plate is analyzed under self weight with certain boundary conditions and material properties (given in the problem statement).

a) *Triangular-3 Elements*

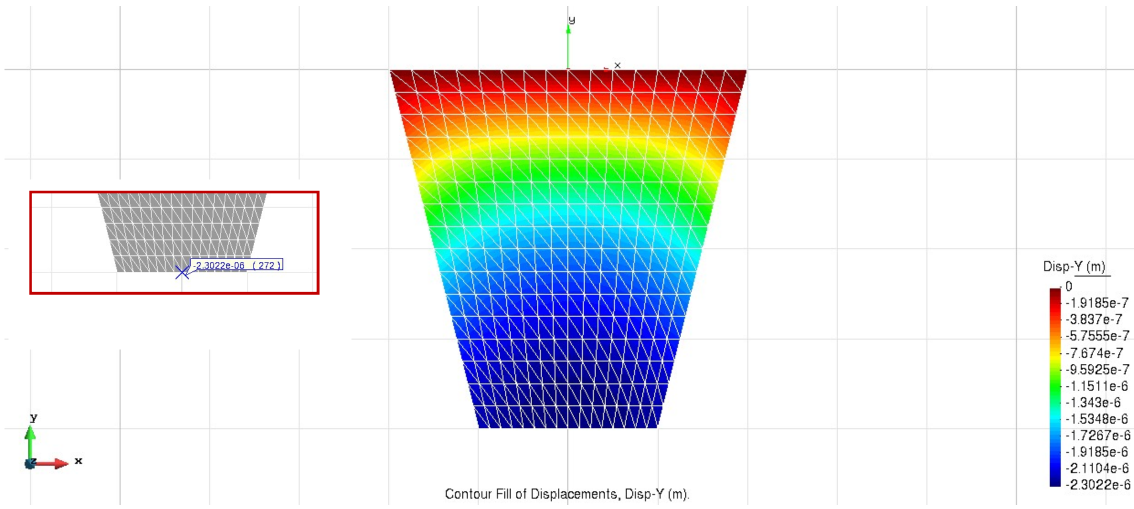

Figure 1.1 Diagram of displacement U_Y (m) using Triangular elements with 3 nodes

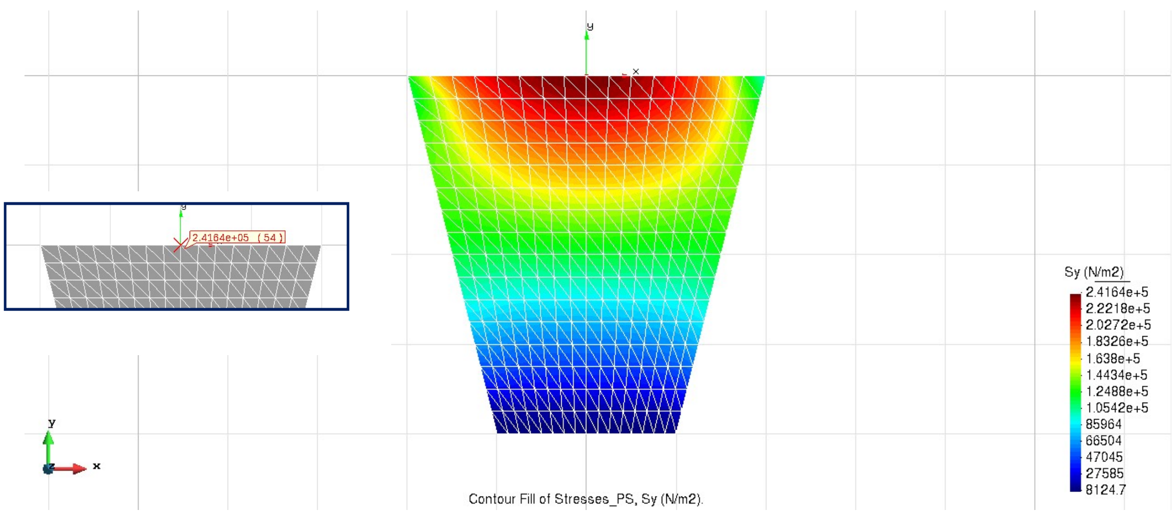

Figure 1.2 Diagram of stresses S_y (N/m^2) using Triangular elements with 3 nodes

Simulation results with 3 node triangular elements.
Displacements in Y direction = 2.3022e-6 m
Stresses in Y direction at point B = 2.4164e5 N/m^2

b) Triangular-6 Elements

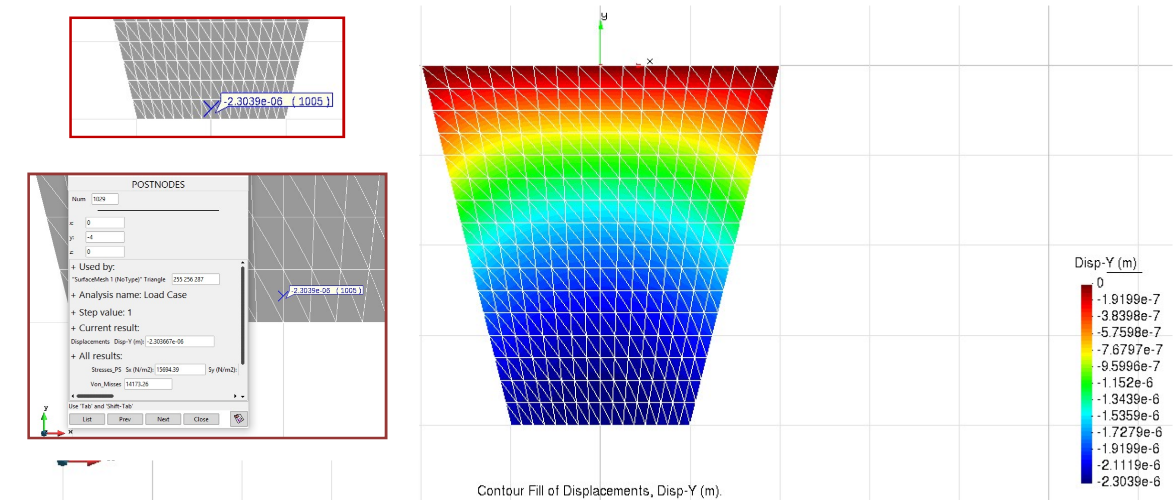

Figure 1.3 Diagram of displacement U_Y (m) using Triangular elements with 6 nodes

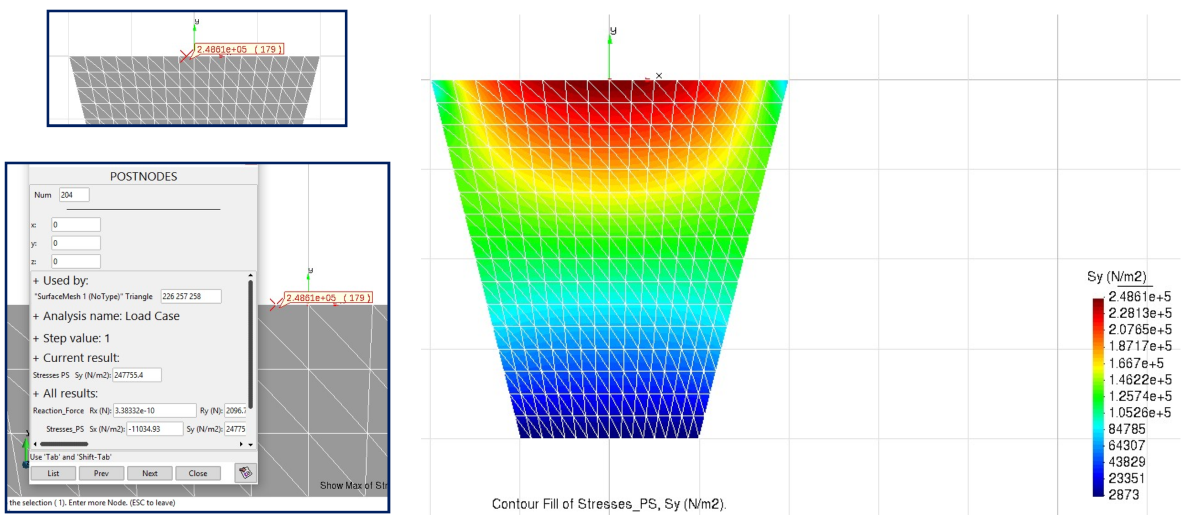

Figure 1.4 Diagram of stresses S_y (N/m^2) using Triangular elements with 6 nodes

Simulation results with 6 node triangular elements.

Displacements in Y direction = 2.3037e-6 m

Stresses in Y direction at point B = 2.4776e5 N/m^2

c) *Quadrilateral-4 Elements*

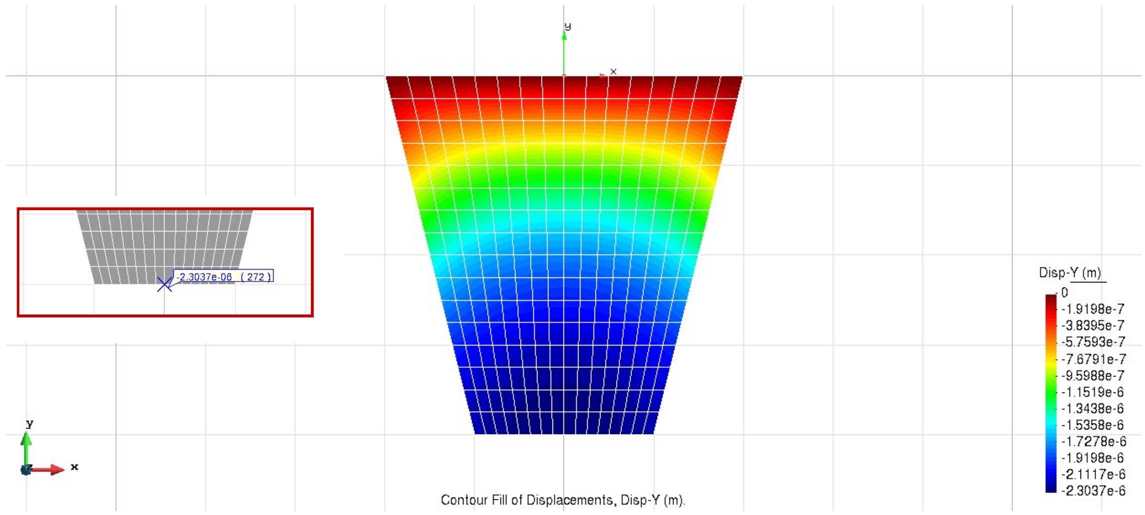

Figure 1.5 Diagram of displacement U_Y (m) using Quadrilateral elements with 4 nodes

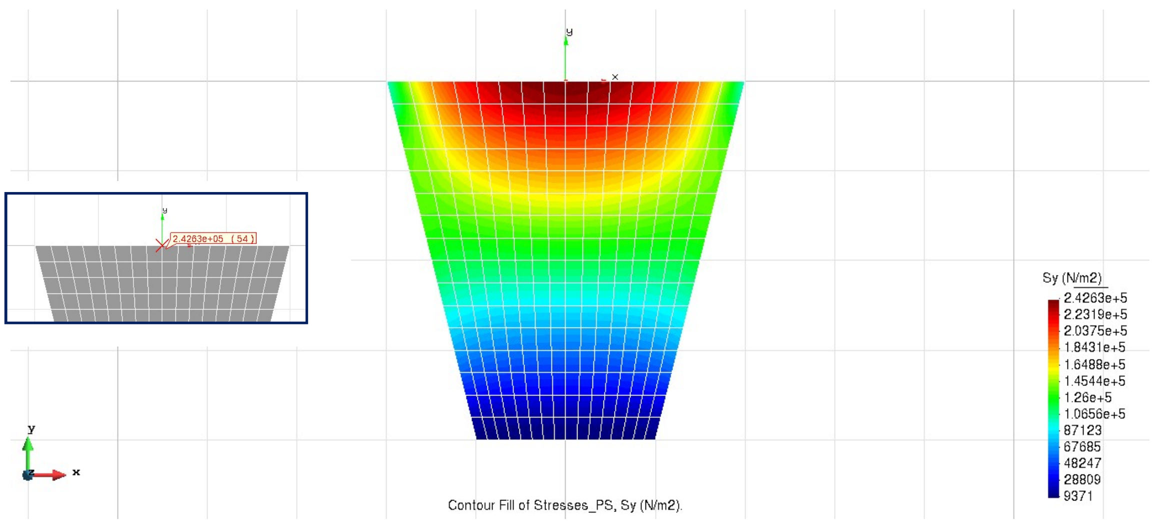

Figure 1.6 Diagram of stresses S_y (N/m^2) using Quadrilateral elements with 4 nodes

Simulation results with 4 node quadrilateral elements.
Displacements in Y direction = 2.3037e-6 m
Stresses in Y direction at point B = 2.4263e5 N/m^2

d) *Quadrilateral-8 Elements*

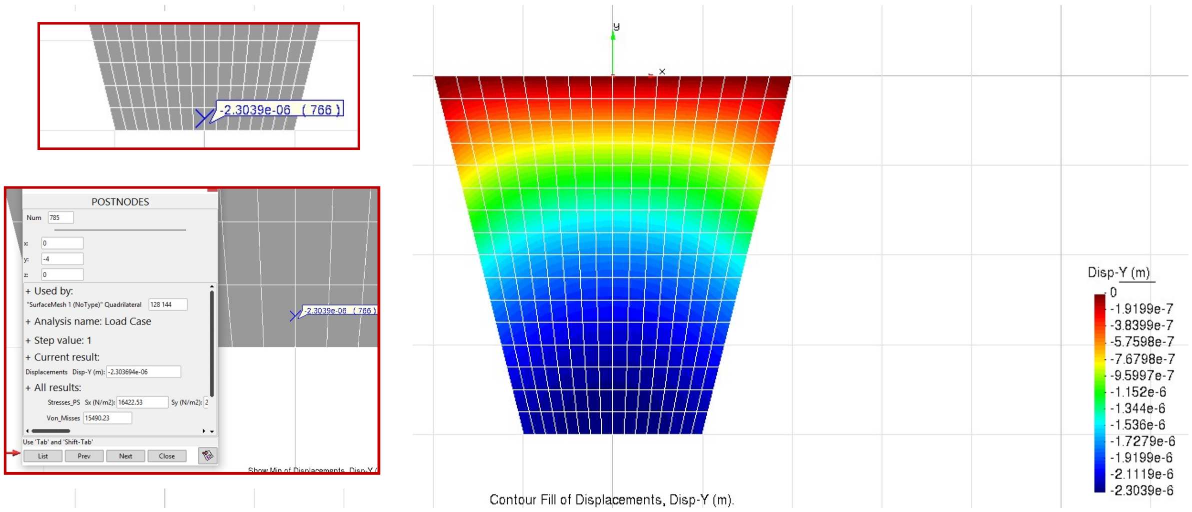

Figure 1.7 Diagram of displacement U_Y (m) using Quadrilateral elements with 8 nodes

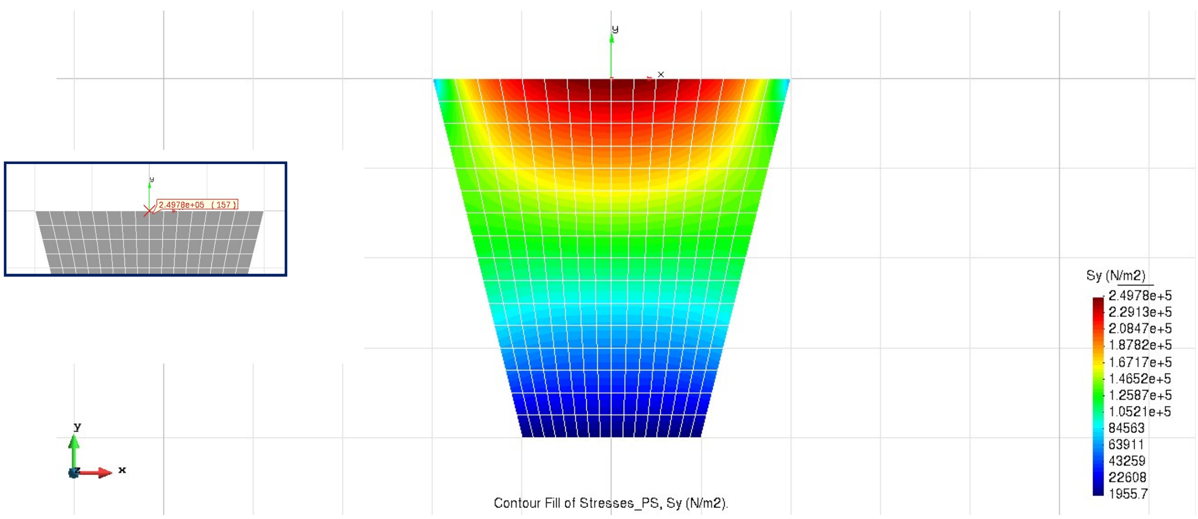

Figure 1.8 Diagram of stresses S_y (N/m^2) using Quadrilateral elements with 8 nodes

Simulation results with 8 node quadrilateral elements.
Displacements in Y direction = 2.3037e-6 m
Stresses in Y direction at point B = 2.4978e5 N/m^2

e) *Quadrilateral-9 Elements*

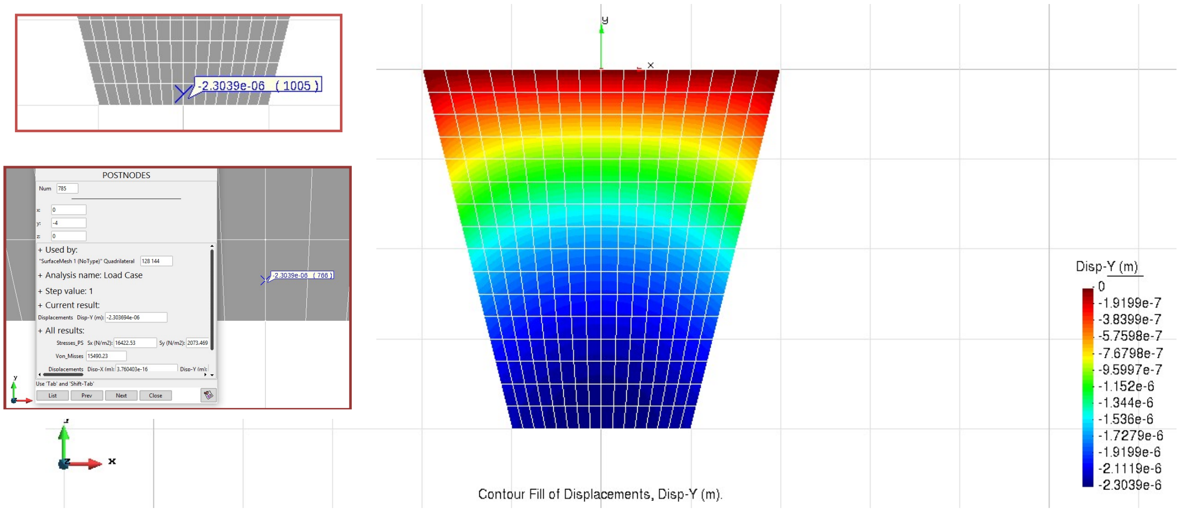

Figure 1.9 Diagram of displacement U_Y (m) using Quadrilateral elements with 9 nodes

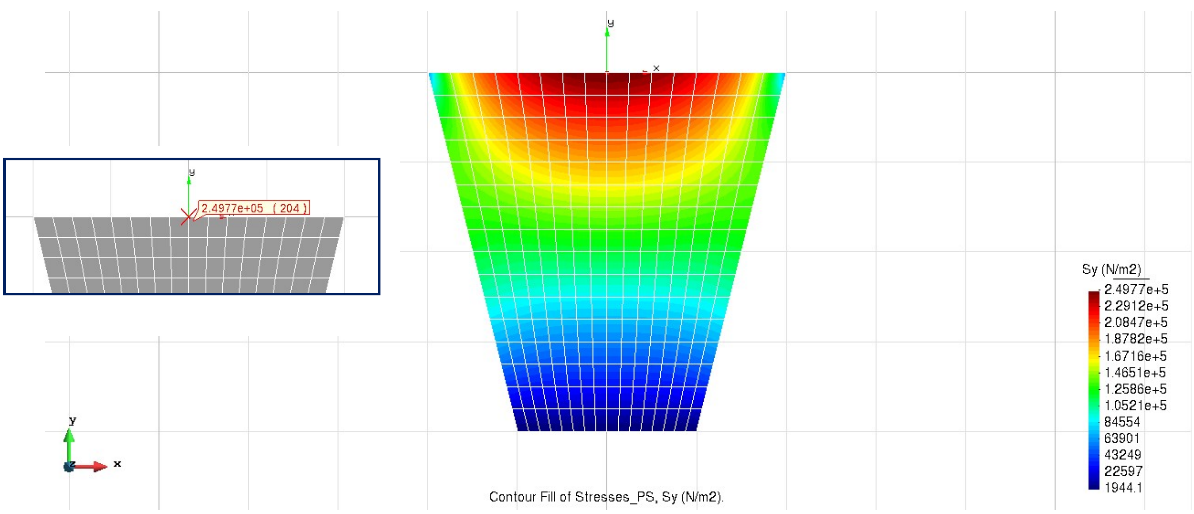

Figure 1.10 Diagram of stresses S_y (N/m^2) using Quadrilateral elements with 9 nodes

Simulation results with 8 node quadrilateral elements.
Displacements in Y direction = 2.3037e-6 m
Stresses in Y direction at point B = 2.4977e5 N/m^2

Comparison of the Results

5 different types of elements are used to see the variation in simulation. Results are presented in the table below. The error of the results is calculated against the given data.

Displacement in Y direction = 2.26e-6 m

Stresses in Y direction at point B = 2.470e5 N/m^2

Elements Types	*DOF*	*Displacement (m)*	*Stresses at Point B (N/m^2)*	*% Error in Displacement*	*% Error in Stresses*
Triangular-3	289	2.3022e-6	2.4164e5	1.83	2.17
Triangular-6	1089	2.3037e-6	2.4776e5	1.90	0.30
Qaudrilateral-4	289	2.3037e-6	2.4263e5	1.90	1.77
Qaudrilateral-8	833	2.3037e-6	2.4978e5	1.90	1.11
Qaudrilateral-9	1089	2.3037e-6	2.4977e5	1.90	1.11

Table 1- Comparison of the results with different elements.

Elements with higher DOF provide better results in both triangular and quadrilateral.

Convergence diagrams for each type of elements for displacement and stress are presented below.

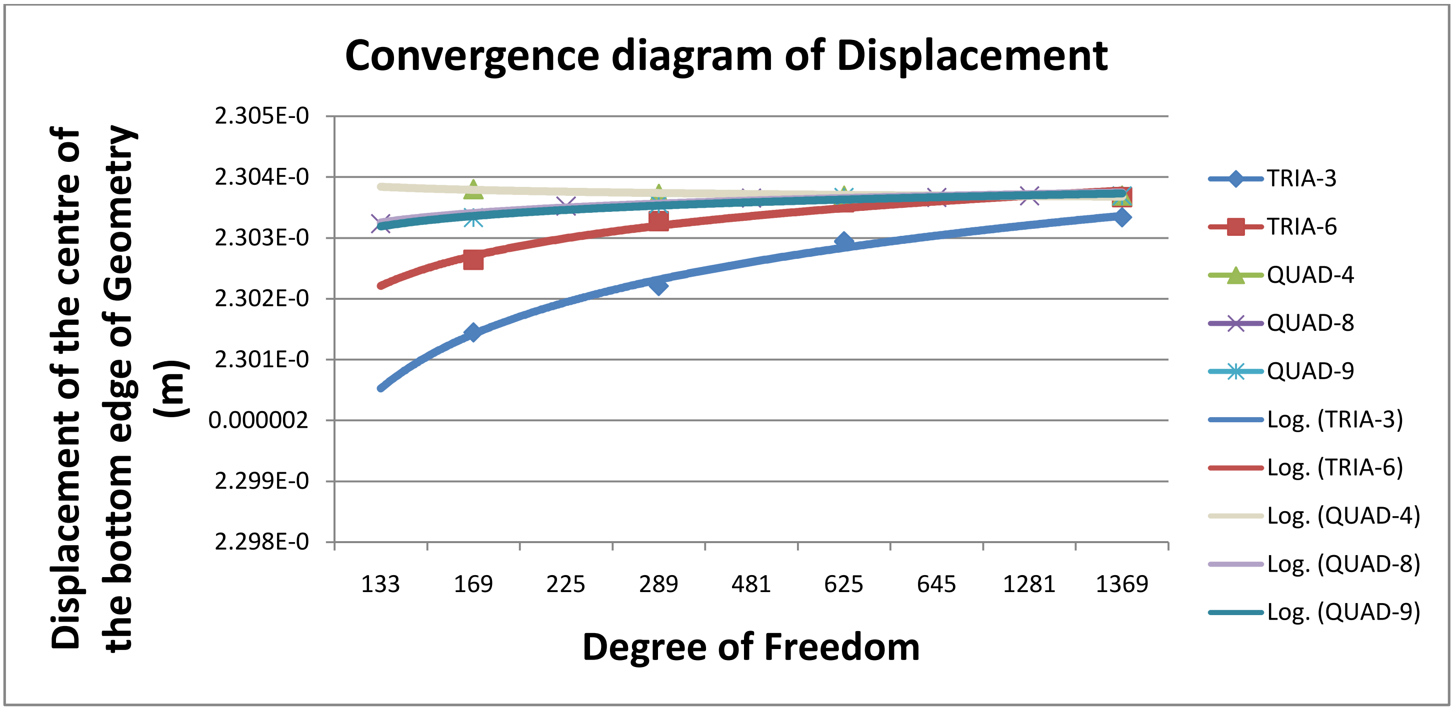

Figure 1.11 Convergence diagram of displacement in each type of elements.

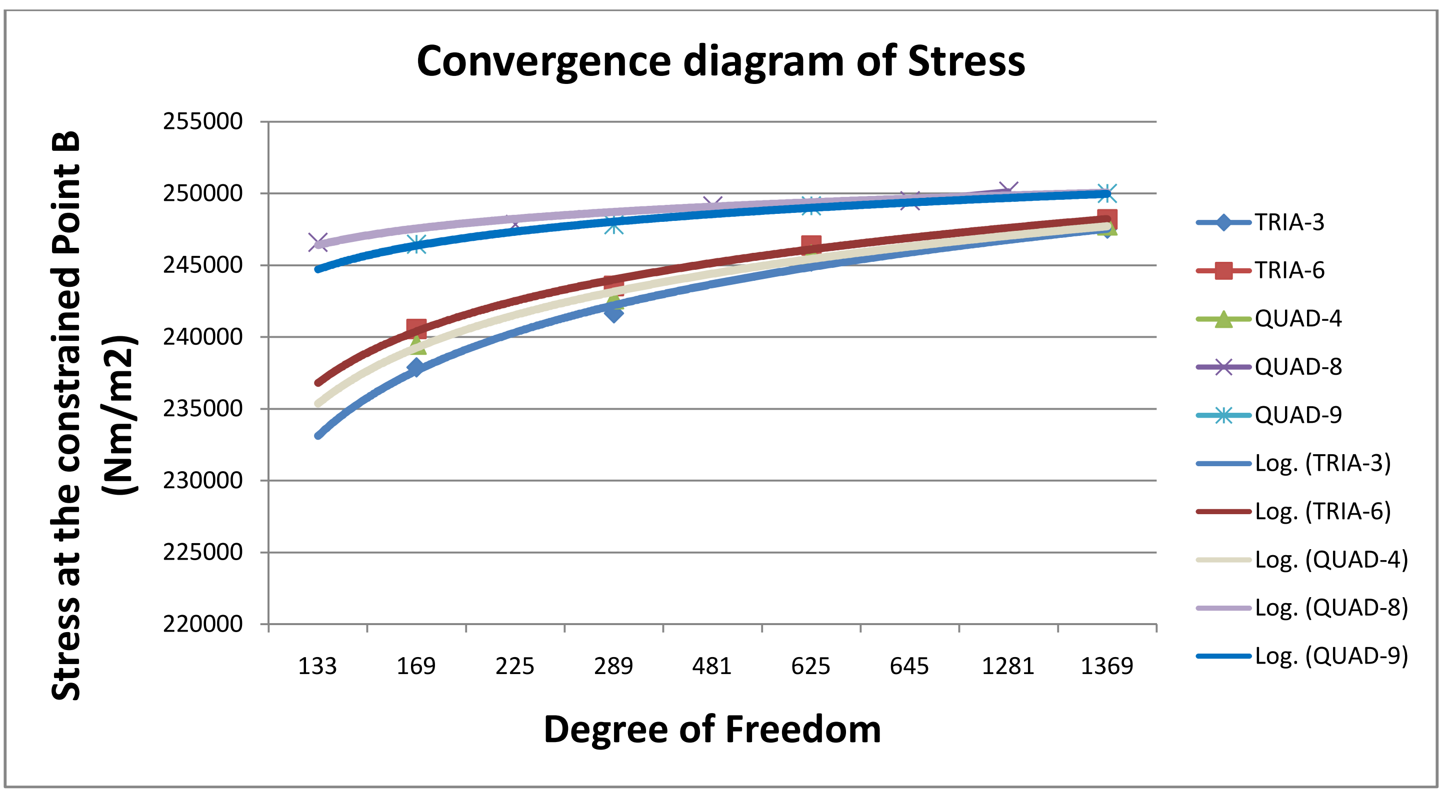

Figure 1.12 Convergence diagram of stress in each type of elements

Exercise -2: A Plate with 2 circular sections supported On 3 Columns

A thin plate with 2 circular cut outs, supported over 3 thin columns is analyzed for stress distribution in Y direction under sagging. Stress distributions are computed due to dropping of central column with variations of initial displacement.

a) <u>*δ= 0*</u>

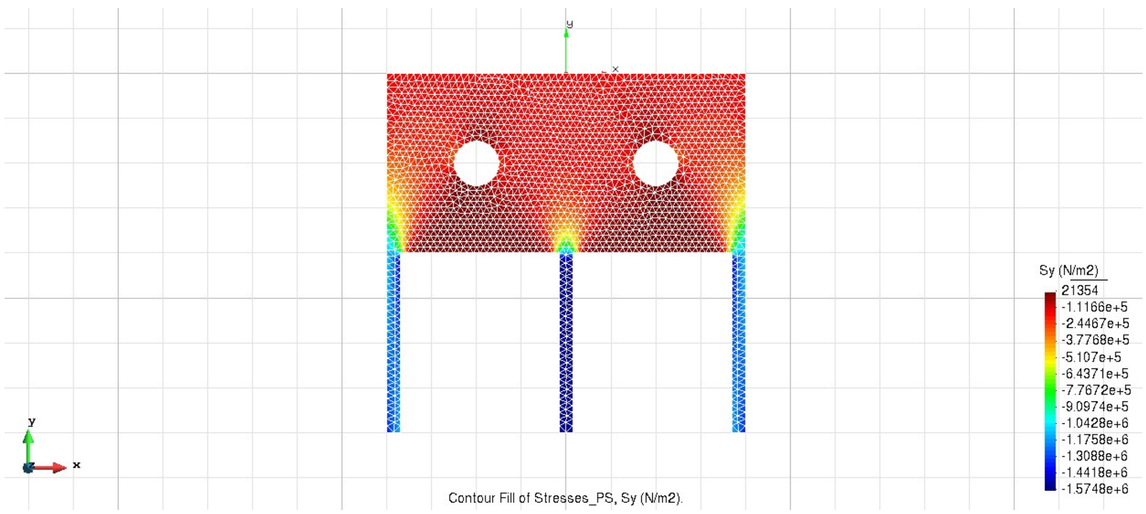

Figure 2.1 Diagram of stresses S_y (N/m^2) with zero sag in middle column

b) <u>*δ= 0.005 m*</u>

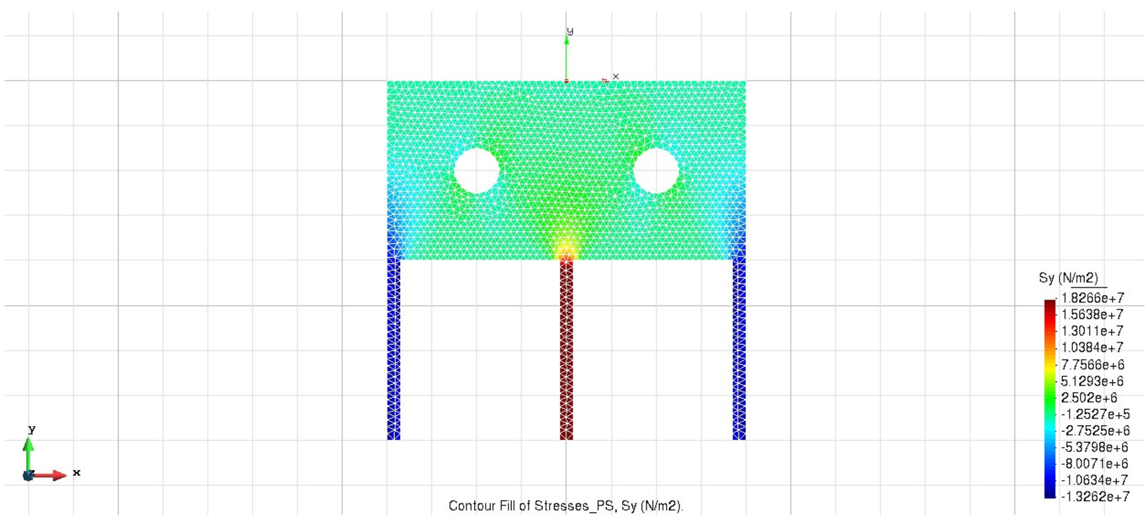

Figure 2.2 Diagram of stresses S_y (N/m^2) with 5 mm sag in middle column

c) <u>δ= 0.010 m</u>

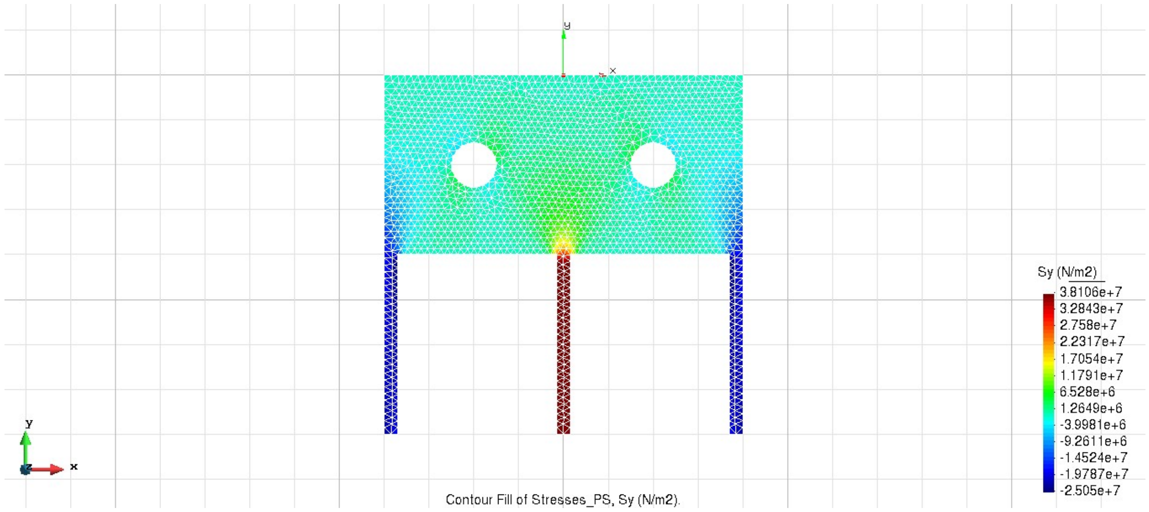

Figure 2.3 Diagram of stresses S_y (N/m^2) with 10 mm sag in middle column

d) <u>δ= 0.1 m</u>

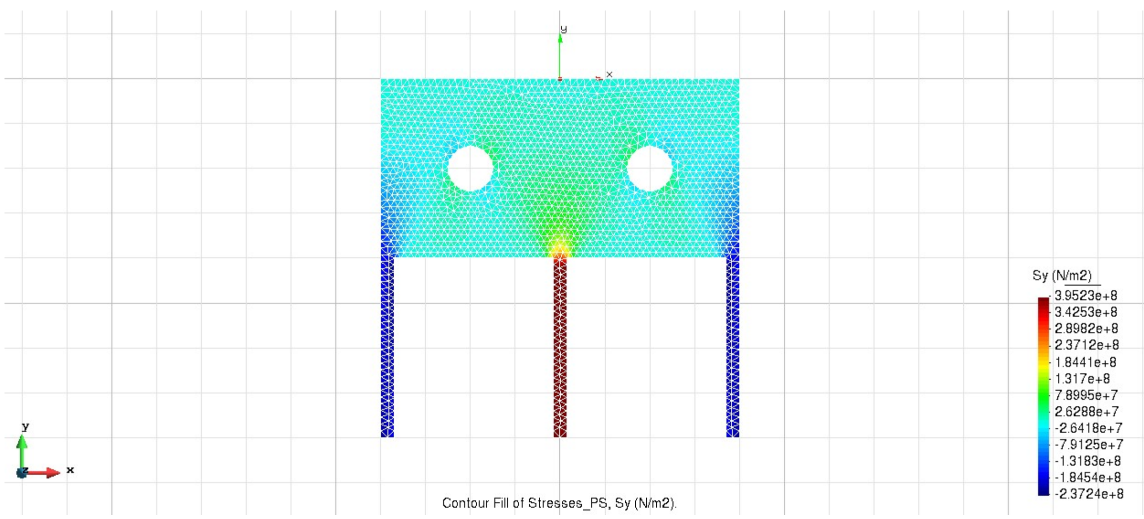

Figure 2.4 Diagram of stresses S_y (N/m^2) with 100 mm sag in middle column

Results

Initial Sag (mm)	*DOF*	*Stresses at Point B (N/m^2)*
$\delta = 0$	1866	2.4164e5
$\delta = 5$	1866	2.4861e5
$\delta = 10$	1866	2.4263e5
$\delta = 100$	1866	2.4978e5

Table 2- Comparison of the results with variation of initial displacement of middle column.

It is evident from the above 4 cases that sag produces higher stresses in middle columns as compared to the corner columns. Stress gradient in the area of intersection between middle columns and plate is relatively large which may lead to failure. Tensile stress in the middle columns increases as sag increase.

Exercise -3: A Plate with a ventilation Hole.

A concrete plate with steel reinforcement is analyzed for stress distribution around the ventilation hole. The simulation results show that the corner of the holes has higher values of tensile & shear stress, (when there is no steel enforcement). As concrete have low yield point that's why a steel enforcement is done around the area of stress concentration.

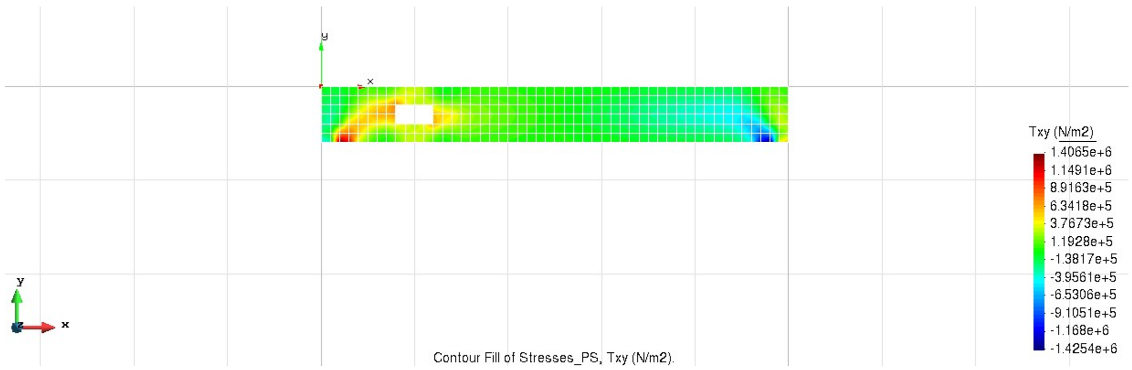

Figure 3.1 Diagram of stresses T_{xy} (N/m^2) in concrete plate without steel enforcement

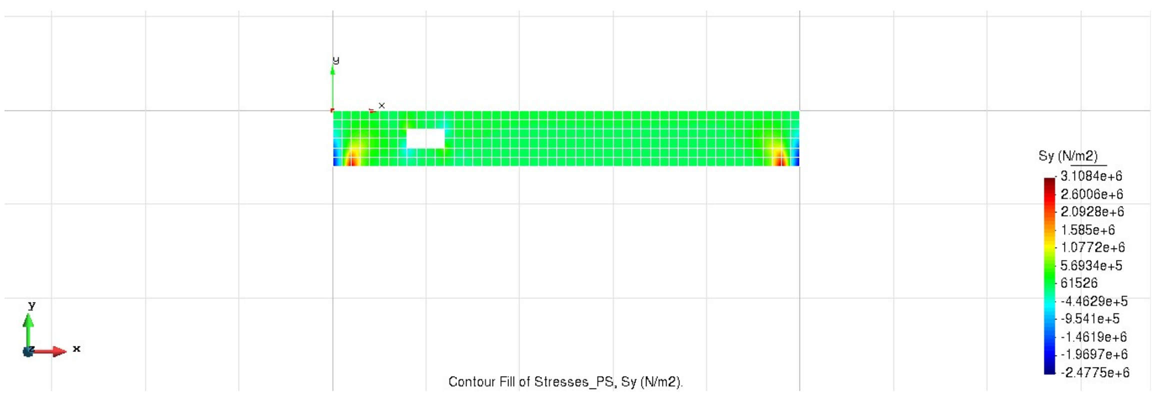

Figure 3.2 Diagram of stresses S_y (N/m^2) in concrete plate without steel enforcement

A steel plate of 0.008 m (total 0.016 m both sides) is imbedded at hole opening in order to overcome the possible failure of concrete.

Figure 3.3 Diagram of stresses S_y (N/m^2) in concrete plate with steel enforcement

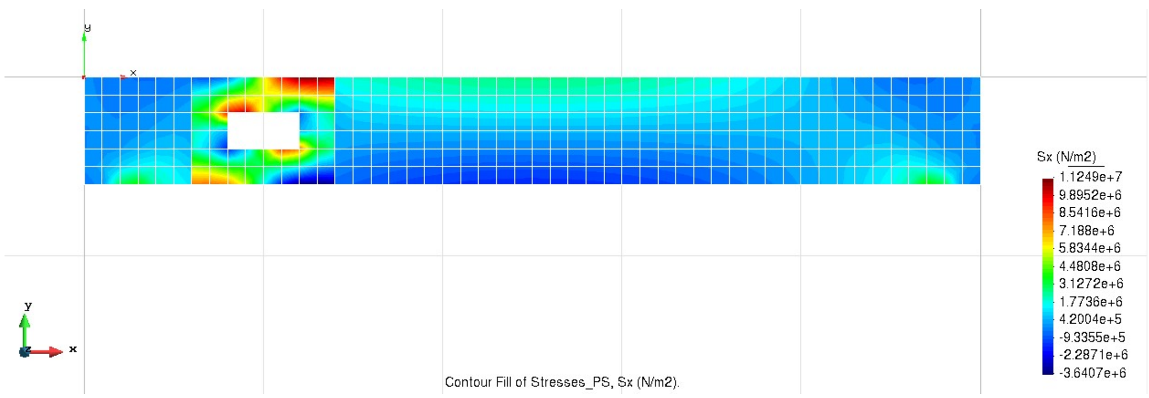

Figure 3.4 Diagram of stresses S_x (N/m^2) in concrete plate with steel enforcement

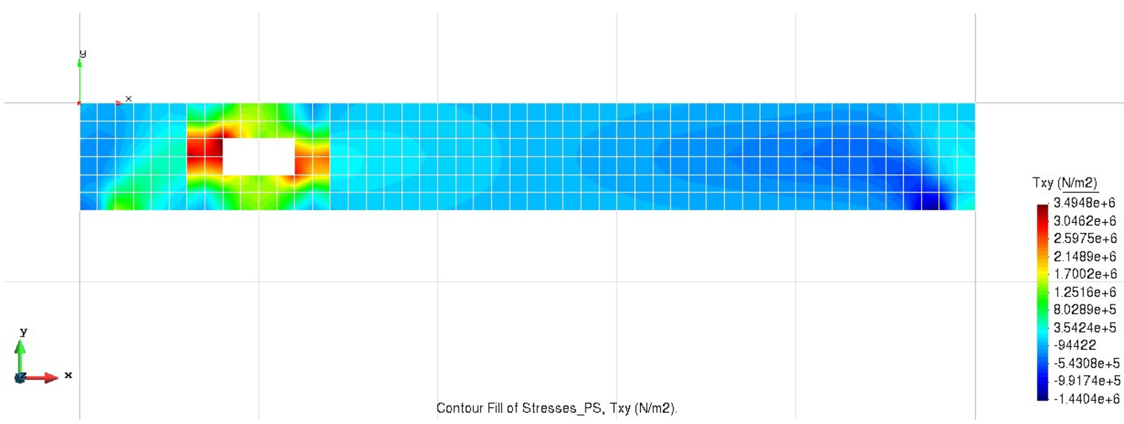

Figure 3.5 Diagram of stresses T_{xy} (N/m^2) in concrete plate with steel enforcement

After steel enforcement, the major portion of the stresses are shared by the steel plate and concrete is safe. As steel have greater strength than concrete, so our plate is safe from damage.

Steel is under compression loads and there is discontinuity between the joint of two materials that should not be there, either there is a discontinuity in FE model or steel response is amplified, it requires some further investigation.

Exercise -4: A Plate with a ventilation Hole.

A large water tank is under analysis to see the stress acting on the walls. The cross section of the tank with applied boundary conditions is shown below.

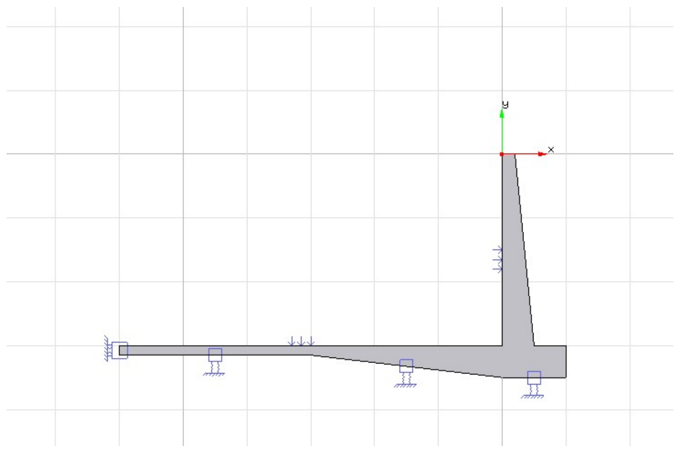

Figure 4.1 Diagram of axis symmetric cross-section of water tank.

In order to build FE model, elastic boundary condition with given stiffness is applied at the base of the tank along with axis-symmetry condition with (x = 0). Uniformly distributed static pressure (pressure due to water head) along with the linearly distributed pressure at the side wall with minimum at the top and maximum value at the bottom, are applied.

The simulation is done considering plane –state with default thickness of 0.1 m.

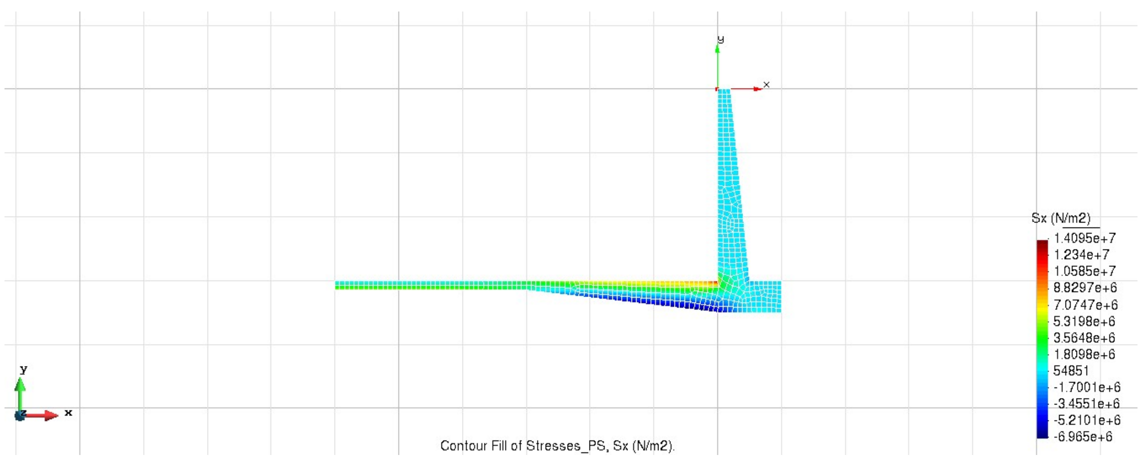

Figure 4.1 Diagram of stresses S_x (N/m^2)

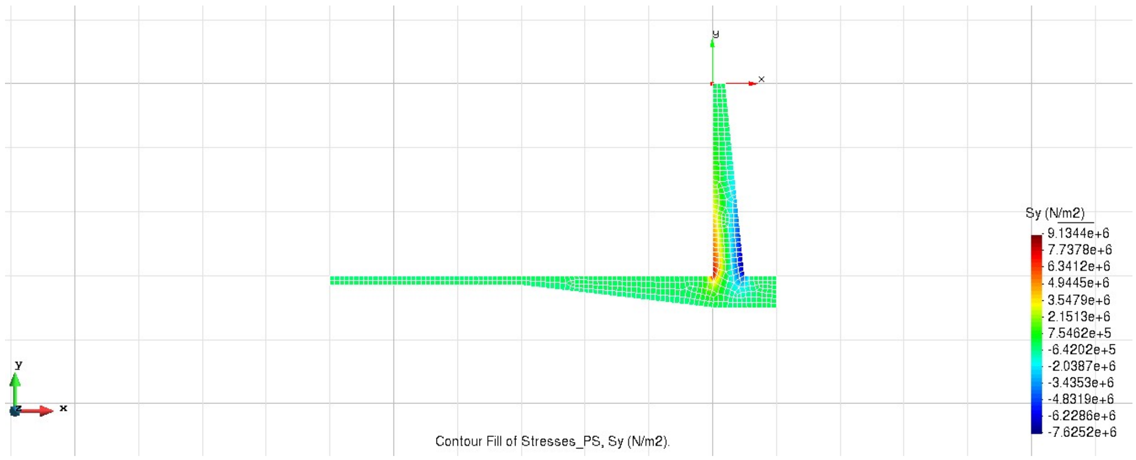

Figure 4.2 Diagram of stresses S_y (N/m^2)

It can be seen that right bottom corner of the tank is under high stress in both X & Y directions. It is quite oblivious to see that this area requires reinforcement.