# GiD Project 1

***Students: Marcello Rubino – Lei Pan – Aditya Mangaonkar***

# 1. Introduction

In the following problems, we have implemented GiD to analyze the stress field, displacement field and Von-Misses stress field of these structures. Consequently, we are able to find the most dangerous areas of the structures where should get more attentions.

# 2. Problem 1

## 2.1 Geometry

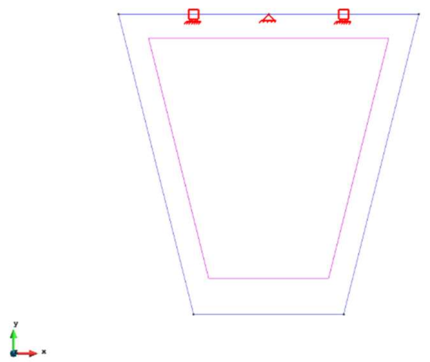

Figure 1. The model of problem 1

## 2.2 Data

There are three boundary constraints on the top of the model. The middle one has fixed both X and Y directions' displacements. The other two only constraint the Y direction's displacement. The force here in problem 1 is the plate's own weight.

## 2.3 Mesh

In problem 1, we have applied triangular elements with 3 and 6 nodes and quadrilaterals with 4, 8 and 9 nodes. We increased the level of the refinement of the mesh by multiplying by 2 the number of elements wanted at the edges of the surface. The grid follows this rules:
Level 1 – 4x4 (quadrilaterals = 16 – triangles = 32)
Level 2 – 8x8 (quadrilaterals = 64 – triangles = 128)
Level 3 – 16x16 (quadrilaterals = 256 – triangles = 512)
Level 4 – 32x32 (quadrilaterals = 1024 – triangles = 2048)
Level 5 – 64x64 (quadrilaterals = 4096 – triangles = 8192)

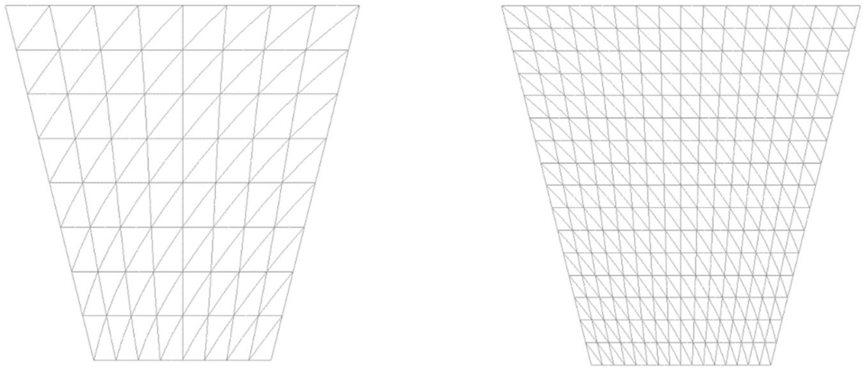

Figure 2. Triangular elements with 3 and 6 nodes mesh

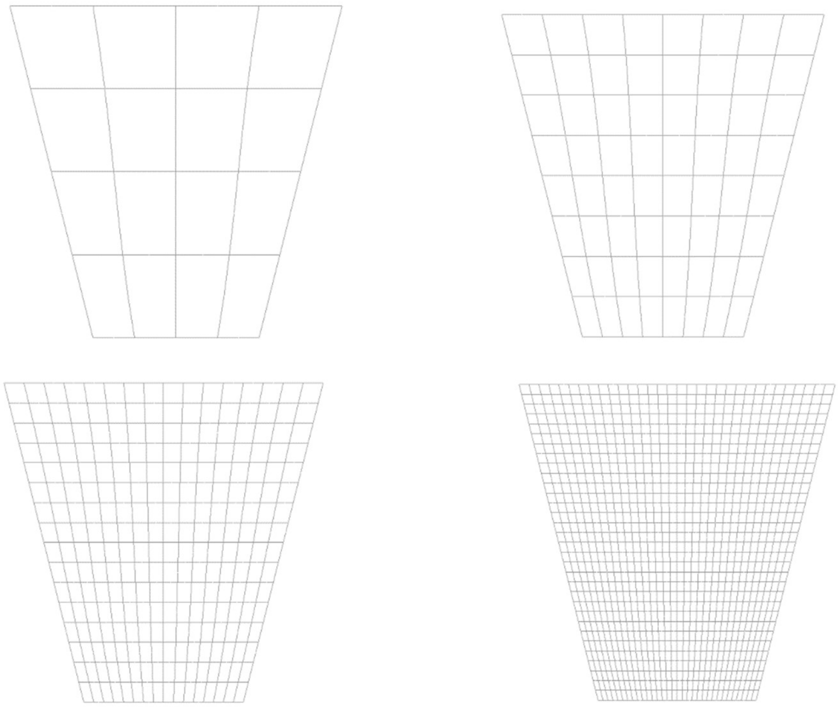

Figure 3. The quadrilaterals element with 4, 8 and 9 nodes mesh.

In figures 2 and 3 we show some samples of the refinement method used.

## 2.4 Processing and postprocessing

### 2.4.1 Quadrilaterals element

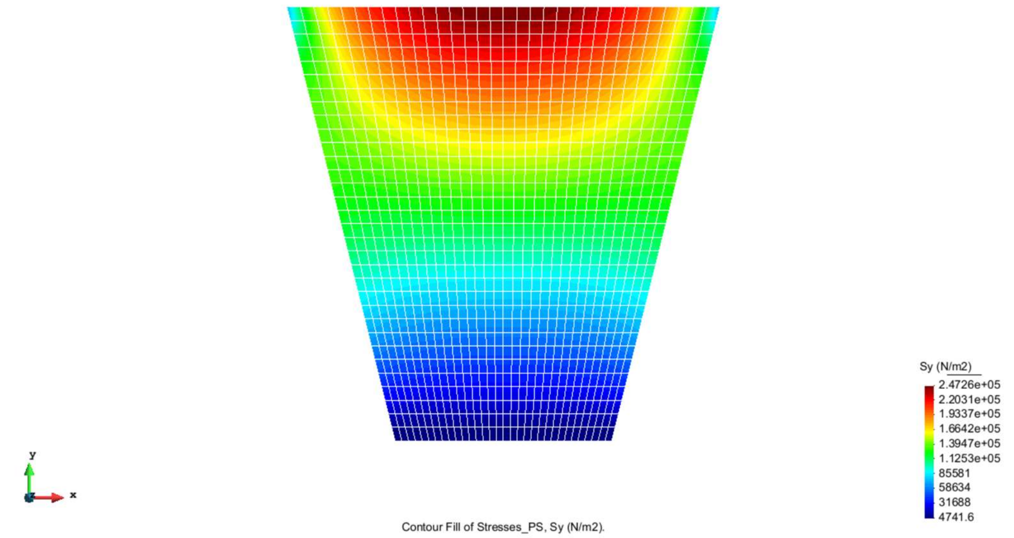


Figure 4. Stresses-y of problem 1 using quadrilaterals 4 nodes element

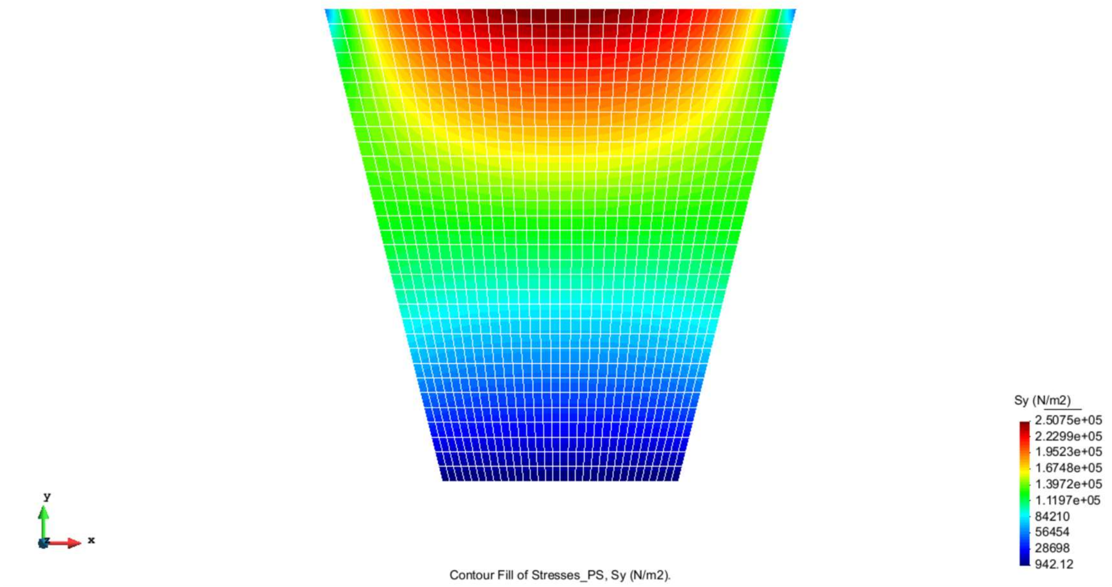


Figure 5. Stresses-y of problem 1 using quadrilaterals 8 nodes element

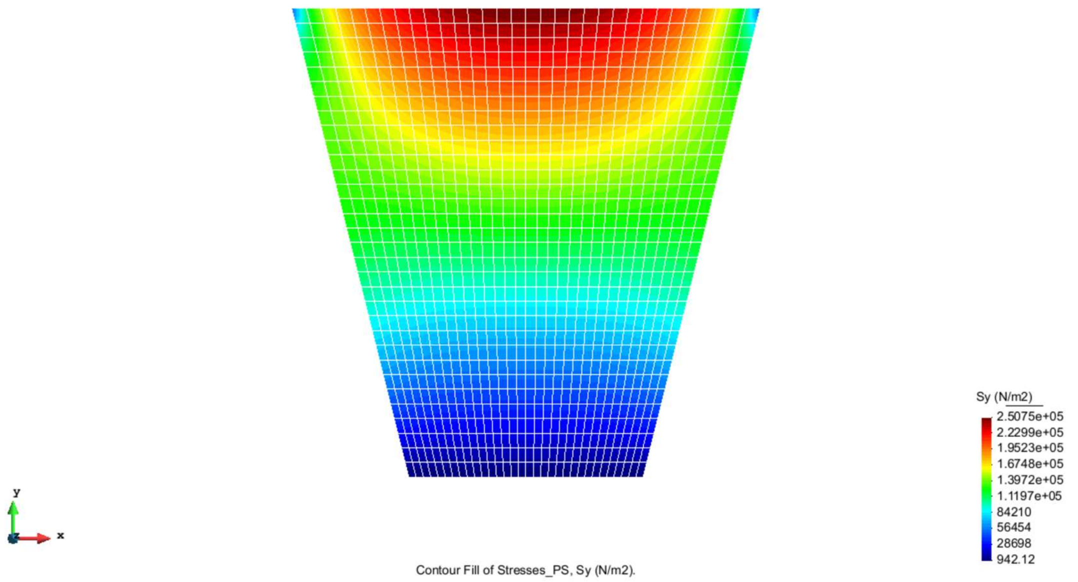


Figure 6. Stresses-y of problem 1 using quadrilaterals 9 nodes element

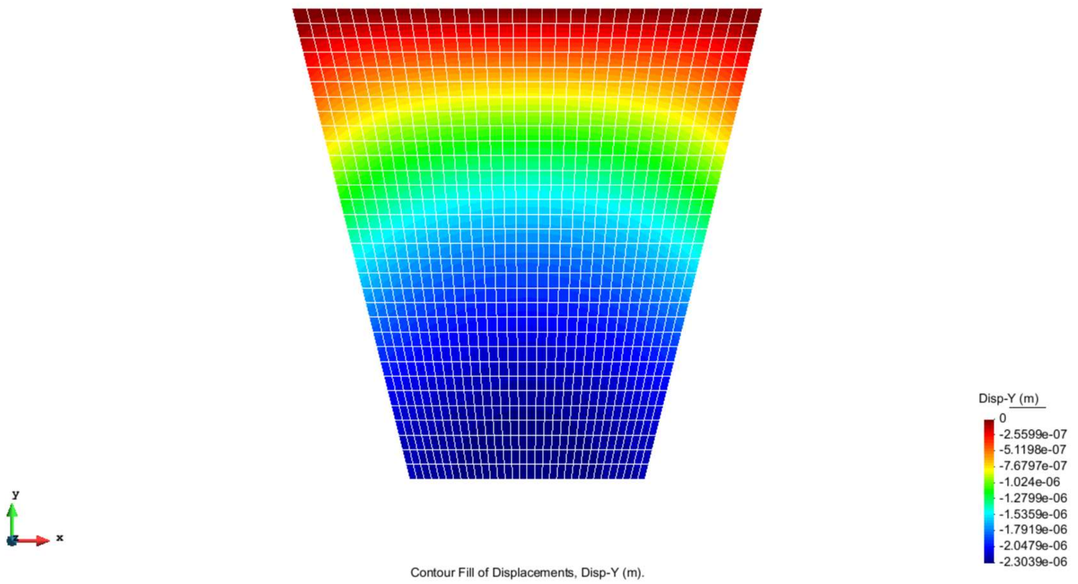


Figure 7. Displacements of problem 1 using quadrilaterals 4 nodes element

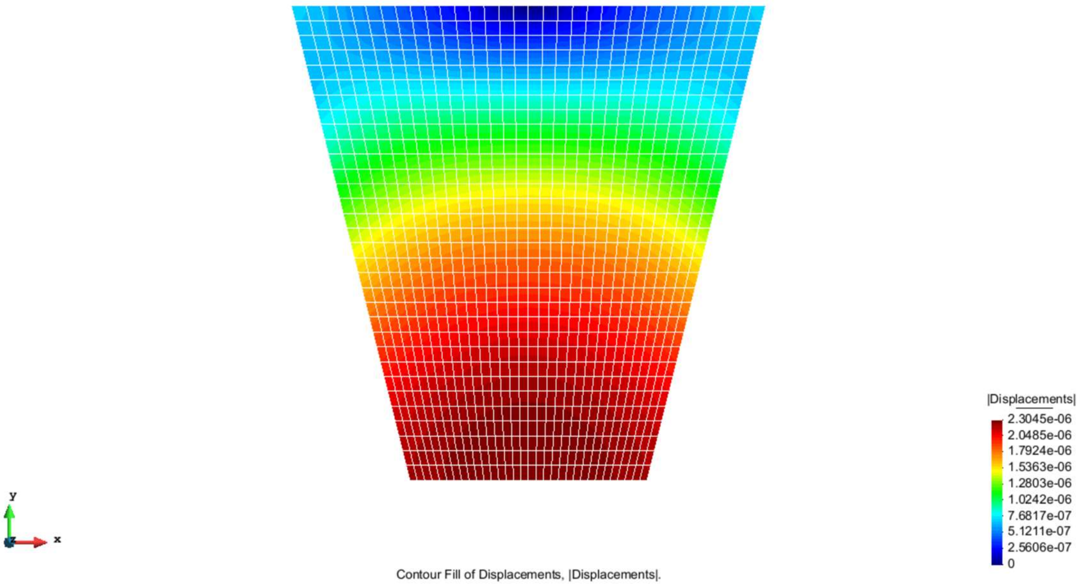


Figure 8. Displacements of problem 1 using quadrilaterals 8 nodes element

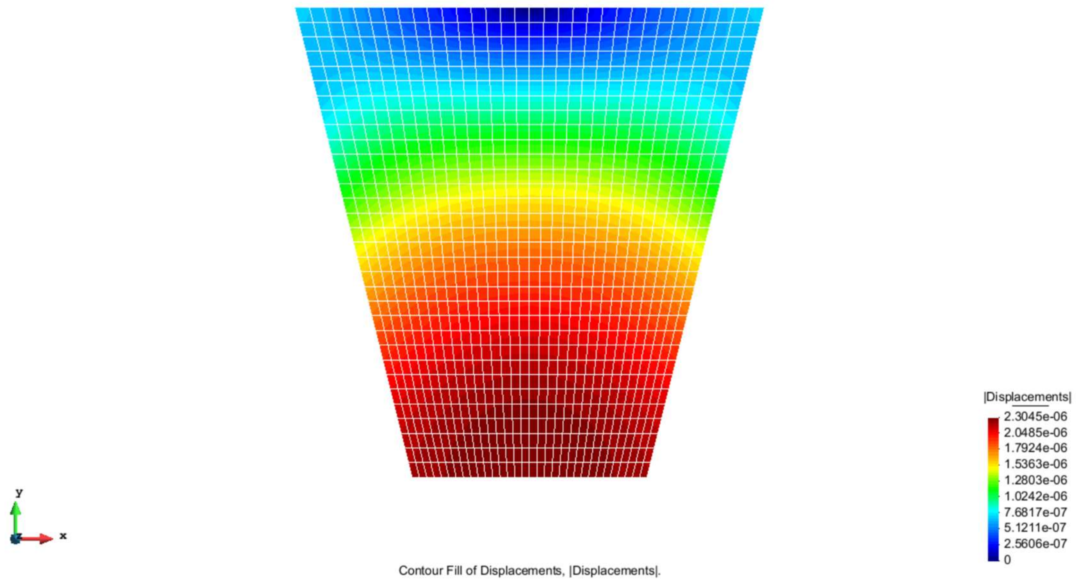


Figure 9. Displacements of problem 1 using quadrilaterals 9 nodes element

From above pictures, for quadrilaterals element we can find that using high order element can increase the accuracy. We can see that at this level of refinement There is no difference in terms of displacements and stresses between the 8 node elements and the 9 node one.

### 2.4.2 Triangular element

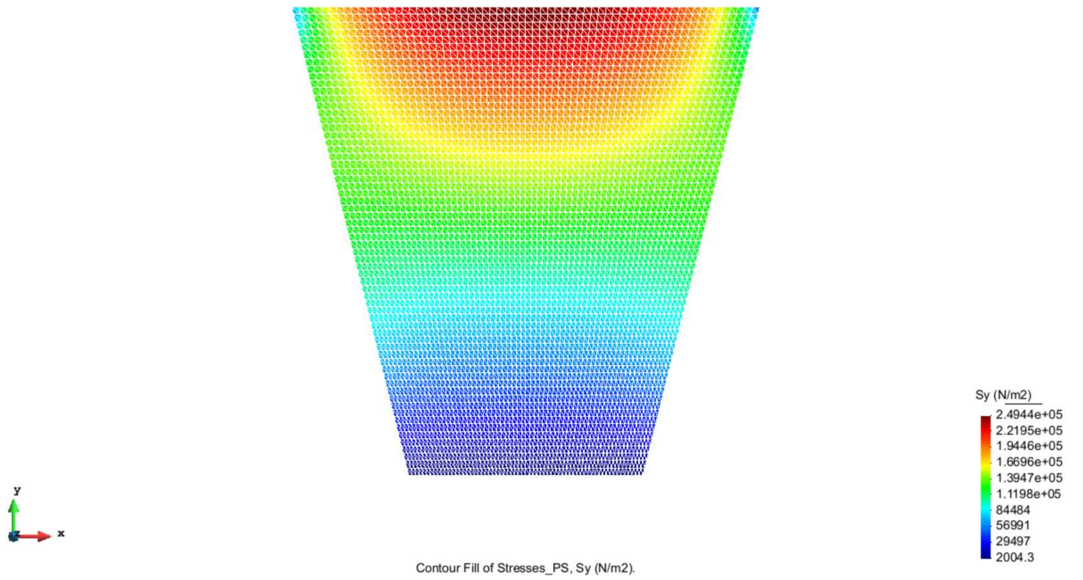


Figure 10. Stresses-y of problem 1 using triangular 3 nodes element

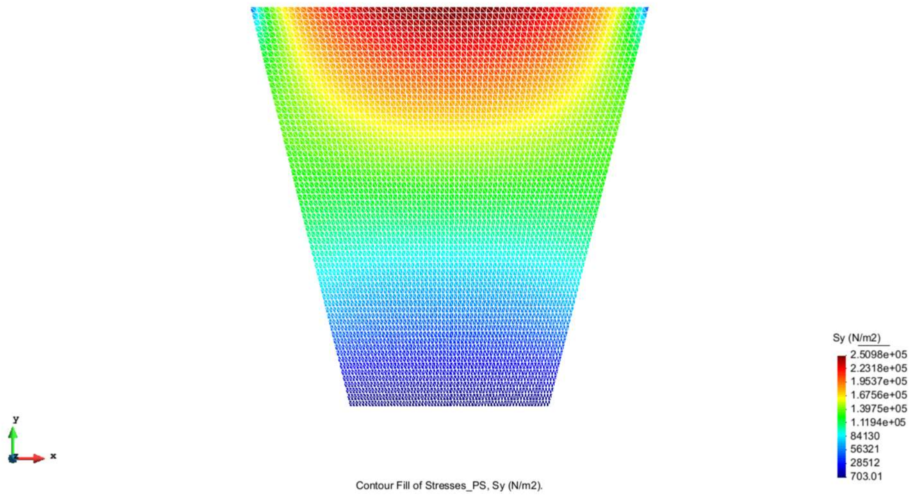


Figure 11. Stresses-y of problem 1 using triangular 6 nodes element

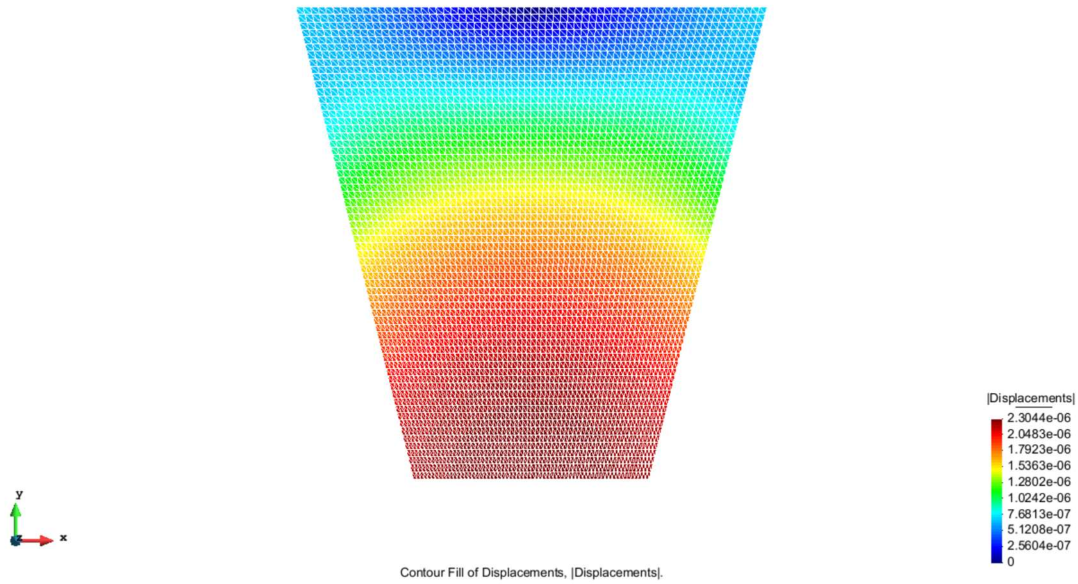


Figure 12. Displacement of problem 1 using triangular 3 nodes element

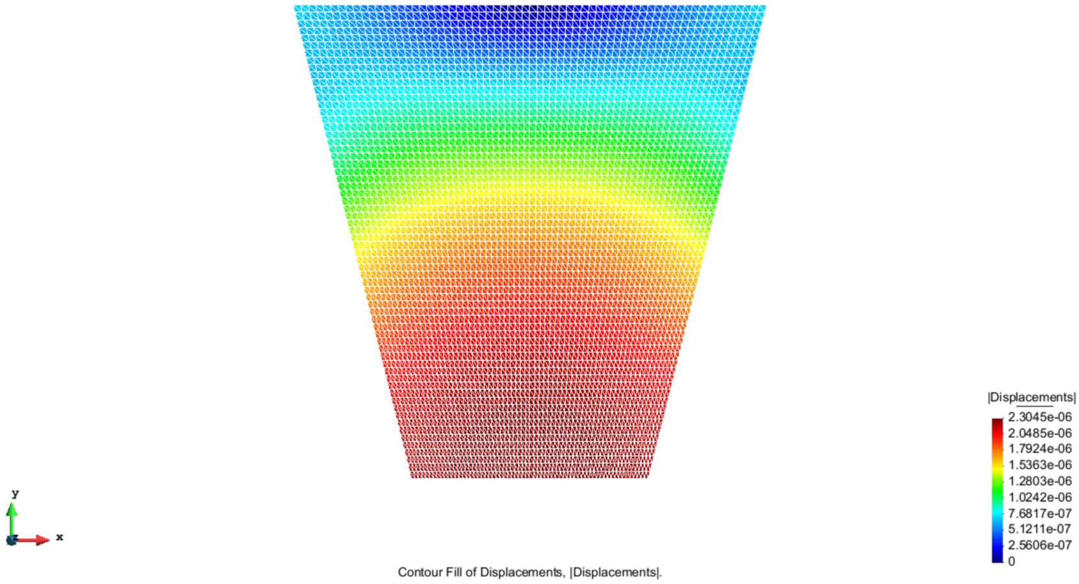


Figure 13. Displacement of problem 1 using triangular 6 nodes element

From above results, for triangular element, the difference between highest stress is small. But increasing the nodes still increase the accuracy. We can see the same situation in terms of displacements.

The results between the triangular and quadrilaterals elements are close.

Summing up we can say that if the level of the mesh refinement is high, there is really small difference between the different element types, while for low levels of accuracy the different types of elements have different behavior, prizing more the high quality elements (quadratic type – quadrilaterals).

## 2.5 The convergence

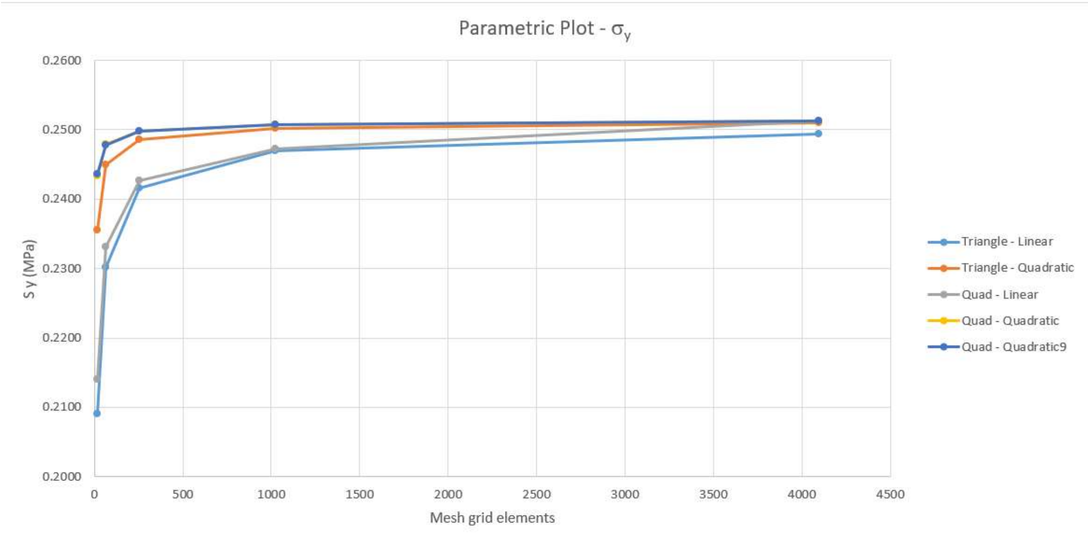


Figure 14. The convergence of stress

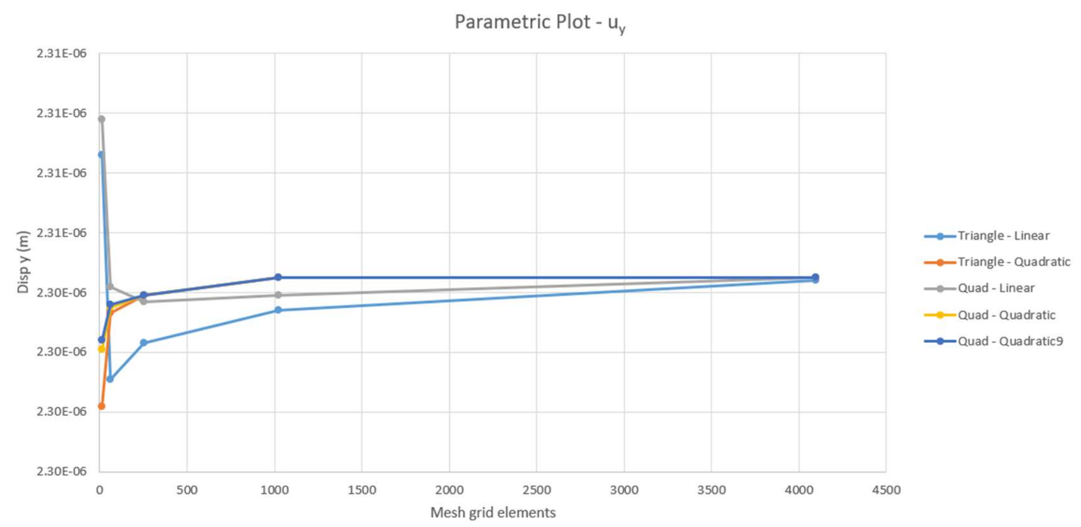


Figure 15. The convergence of displacement

We have used five types of elements, Triangle-Linear, Triangle-Quadratic, Quadrilaterals-Linear, Quadrilaterals-Quadratic, Quadrilaterals-Quadratic9, to analyze the convergence of this model. As above figures has shown, by increasing the element number which is called refining the mesh, all the element types present nice convergence. In the two graphs we show the convergence of displacement of the middle point of the side ED and the stresses along Y direction at the node B. For "mesh grid elements" we mean the number of structural quadrilaterals used in the mesh. In case of triangles, the mesh uses the same logic and divides into two triangles each quadrilateral of the grid.

# 3. Problem 2

## 3.1 Geometry

According to the description of the problem 2, we have built the following model.

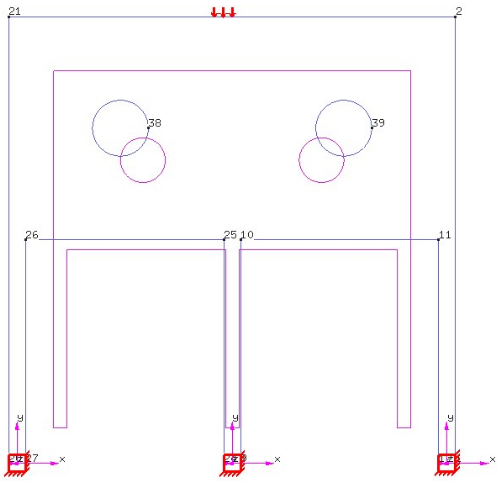


Figure 16. The model of problem 2

## 3.2 Data

Firstly, the boundary constraints are imposed in the bottom of the three columns and the y-directions of the central column is imposed the displacement $\delta = 0.2m$. The other directions of the columns are fixed. Then the force is applied on the top edge of the model which is uniform distributed load.

## 3.3 Mesh

We have used the triangular elements with 3 nodes to create the mesh.

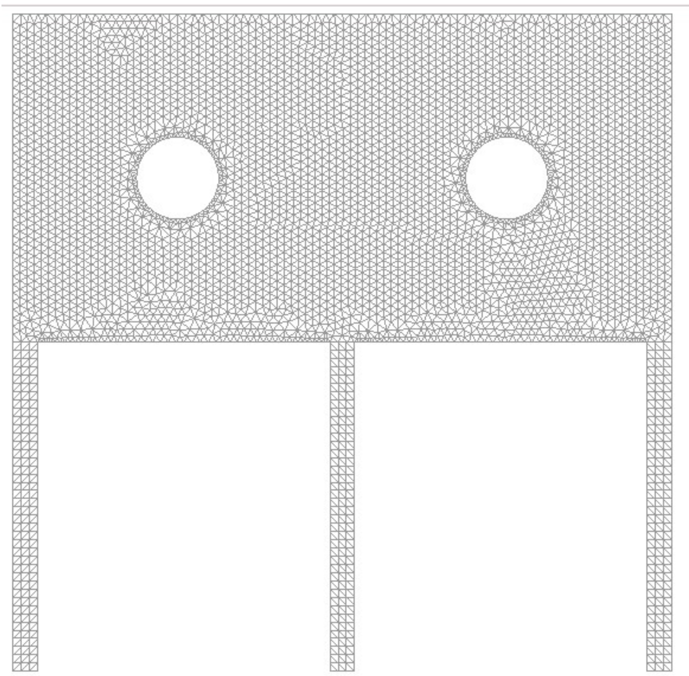

Figure 17. The mesh of problem 1

From the figure 2, we can see that the mesh density around the circles and the connection area between the columns is higher. Because the stress and strain in these areas are more complicated and the damages are more likely to happen in these areas.

## 3.4 Processing and postprocessing

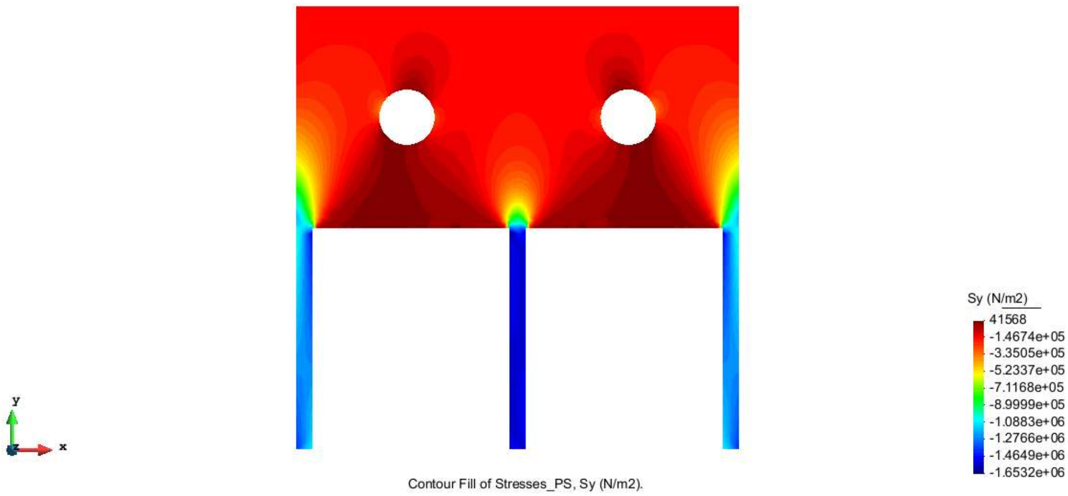


Figure 18. The stress

In problem 1, we know that the Y-direction stress $\sigma_y$ should be taken more care than $\sigma_x$. And in the areas between the columns and the circles and on the top area of the circles, the $\sigma_y$ is high. We can see that we have to take care of the angles area, where we refined the mesh in order to catch better high levels of the gradient of the stresses.

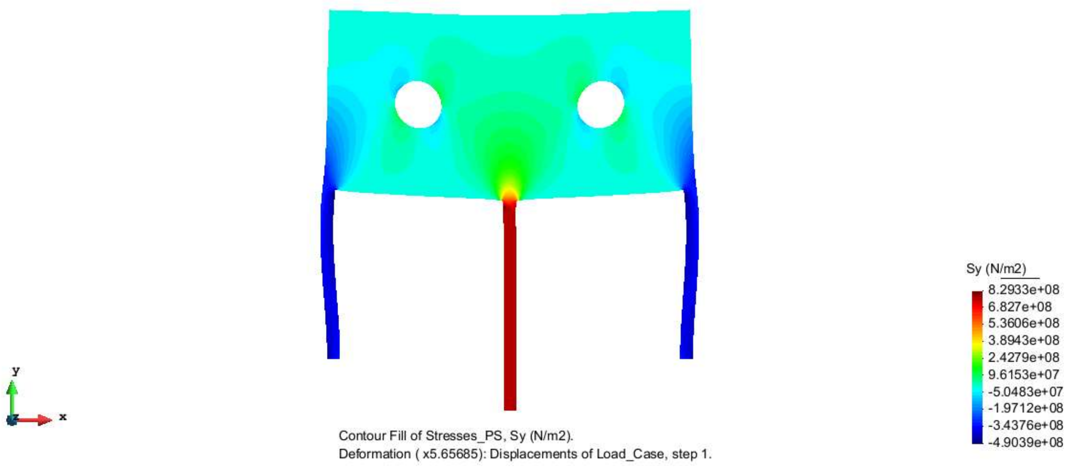


Figure 19. The deformation

From above picture, we can find that the highest stress value is in the central column and it’s caused by traction given by the drop of the column. The other two columns will have horizontal displacements which could cause the extra moments. Their y-direction displacements are caused by compressive force so they are negative and they are about 5/8 of the displacement on the central column.

# 4 Problem 3

## 4.1 Geometry

Figure 20. The model of problem 3

## 4.2 Data

For the boundary conditions, because the concrete plate is supported by simple supports, so we just constraint the y-direction displacement of two bottom sides of this plate. The Force is uniform distributed load applied on the top of the plate. And because the real situation is that the hole is reinforced by steel, so we combine two materials, concrete and steel, in this model.

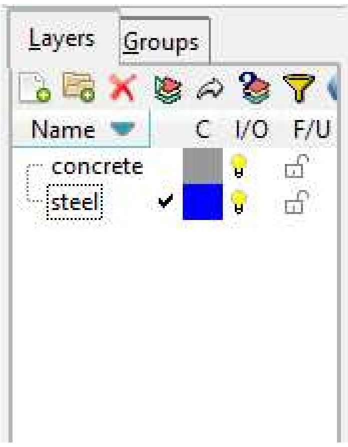


Figure 21. Combination of concrete and steel

## 4.3 Mesh

Figure 22. The mesh of problem 3

We have applied the quadrilateral elements with four nodes in this model. Then, we made the mesh of the concrete part and the steel part to match, in order to complete a collapse of the nodes around the same quadrilateral elements.

## 4.4 Processing and postprocessing

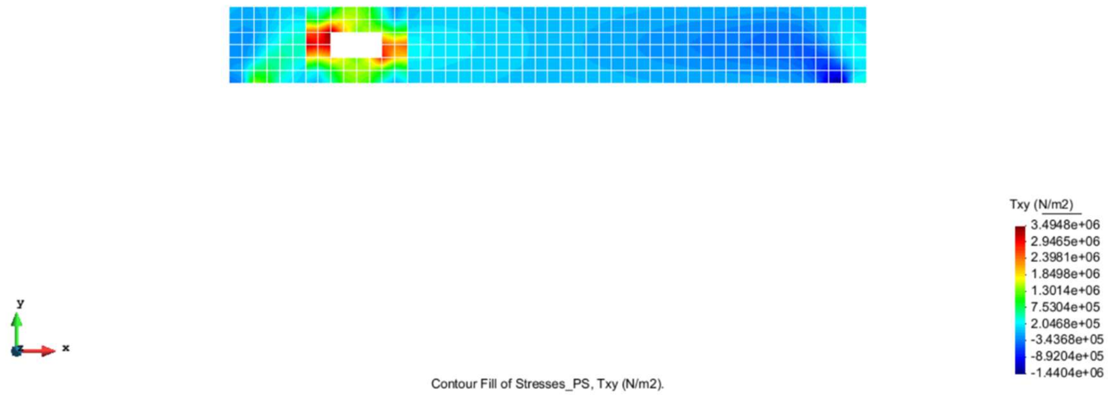


Figure 23. The stress distribution of problem 3

As we know, the shear stress can do great damage for simple support beam. In above figure, the shear stress in hole area is very high. Because the concrete doesn’t have enough ability to bear shear stress while steel does, so combining steel and concrete in hole area is good for protecting the beam.

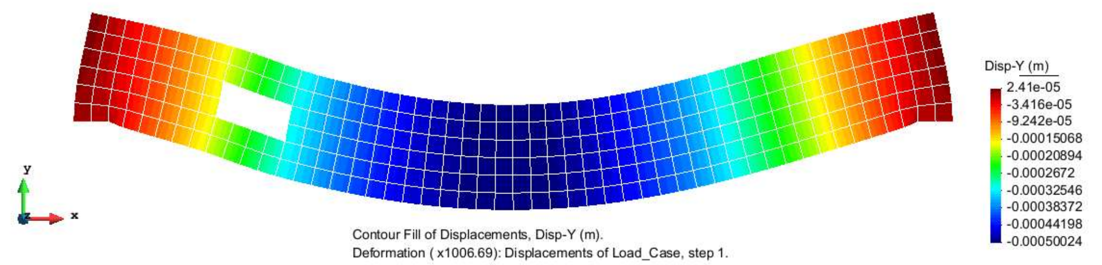


Figure 24. The displacements of problem 3

The biggest displacements are happening in the middle of the plate.

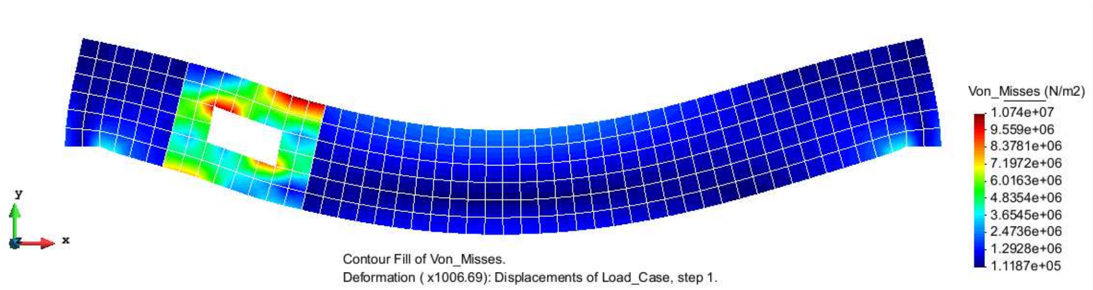


Figure 25. The Von-Misses of problem 3

From above picture, the Von-Misses distribution shows that the highest Von-Misses stress happens on the area of the hole where we have combined steel and concrete. Because we have combined the steel and concrete on the hole, so the steel can finely bear both the compressive and tensile stresses. This local increasing of stresses is linked to with the high level of shear mechanism around the hole.

# 5 Problem 4

## 5.1 Geometry

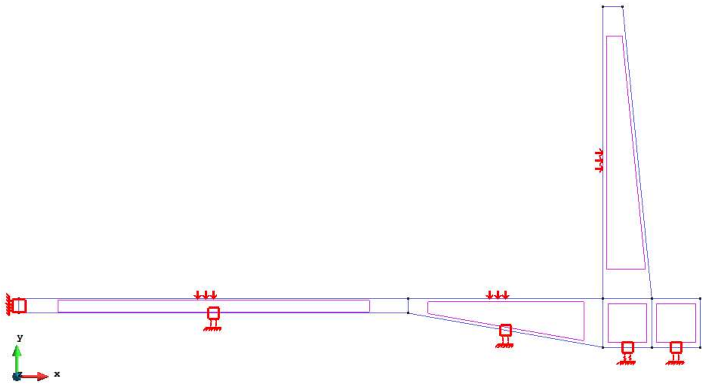


Figure 26. The geometry of problem 4

## 5.2 Data

As the geometry has shown, we have imposed five boundary constraints. On the left side of the structure, we impose the boundary constraints fixing the displacements of all directions. On the bottom of the structure, we impose the elastic boundary constraints $k(y) = 50N/m^3$ on y-direction. For the forces, on the vertical inside edge, we apply the linear changing force. On the top of the vertical inside edge, the force equal to zero while on the bottom of the edge, the force equal to $pgh$. On the horizontal edge, we apply the uniform distributed force which is equal to $pgh$. No tangential uniform load are given, since the water does apply only normal pressure.

## 5.3 Mesh

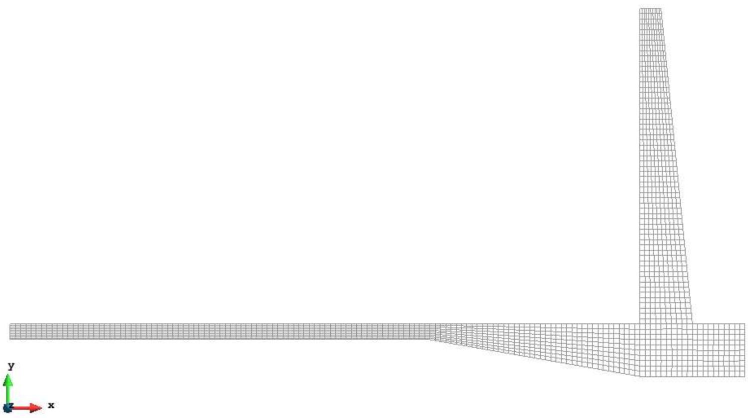


Figure 27. The mesh of problem 4

In problem 4, we have applied quadrilateral elements with four nodes to create the mesh. We made a structural type mesh by focusing on each surface created for the problem.

## 5.4 Processing and postprocessing

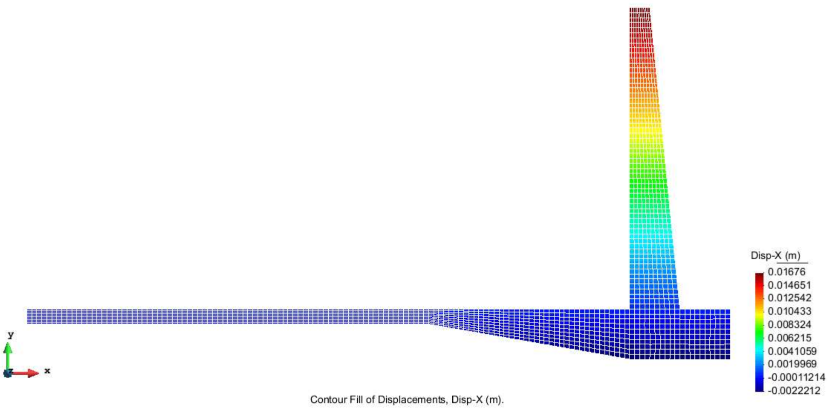

Figure 28. The displacement-X of problem 4

Form the result of X-direction displacement, we can see that the top the structure has the highest displacement because of the horizontal force. And another reason is that there is no constraints on the top of the structure, so the dam is free to move and it tends to be “pushed out” by the internal water pressure.

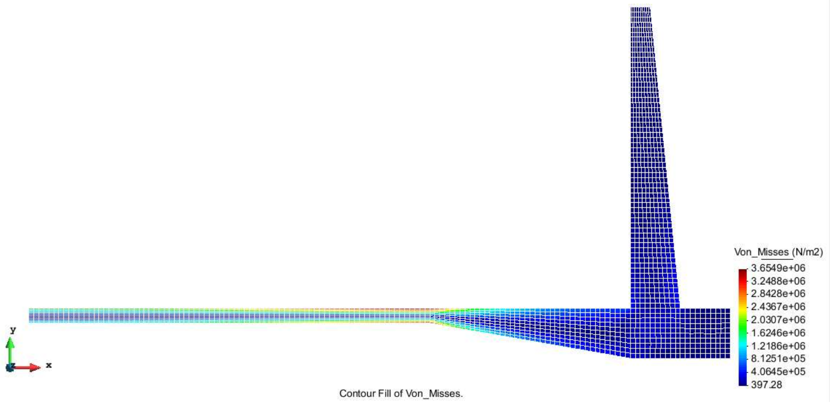

Figure 29. The Von-Misses stress of problem 4

The Von-Misses field shows that the middle area of the bottom edge has beard the highest Von-Misses stress and we should take care of this area like putting more steel bars in this area.

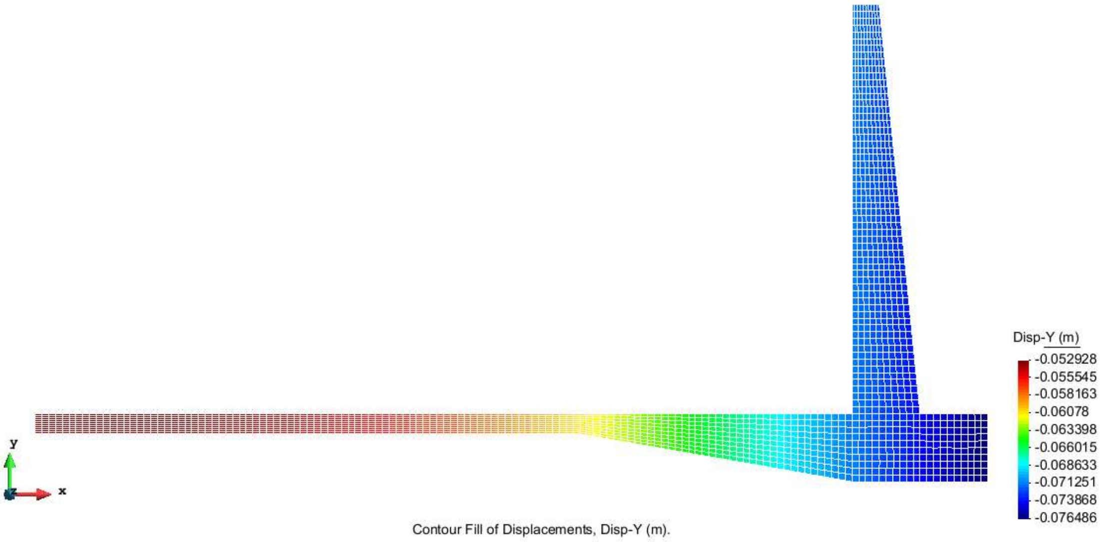


Figure 30. The displacement-Y of problem 4

The highest Y-direction displacement happens on the right side of the structure.