

# Computational Structural Mechanics and Dynamics - Practice 1

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## 1 Thin plate under dead weight

The next plate has to be analysed under different mesh refinements and different finite elements: Triangular (3 and 6 nodes) and Quadrilateral (4, 8 and 9 nodes)

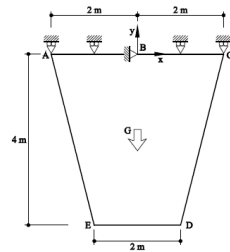


Figure 1: Problem Statement

The differences between the meshes of the geometry using 3 or 6 nodes can not be appreciated, but the number of nodes is significantly bigger in the second subcase.

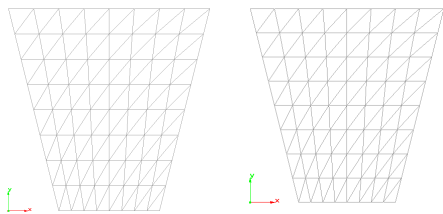


Figure 2: From left to right: Linear , quadratic triangular meshes

The stress and displacements appear to be very similar in both subcases, as can be seen in the next images.

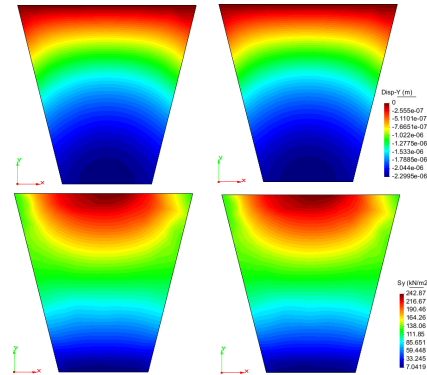


Figure 3: Displacements and Stresses in Y. Triangular linear and quadratic meshes

We can conclude that our results require elements of higher order or a more refined mesh to get the sought values of displacements and stresses. It can be seen in the following table:

Element	Nodes-Elements	Dy ED[m]	Sy B [ $\frac{MN}{m^2}$ ]
tri3	81,128	-2.2995e-6	0.24287
tri6	661,314	-2.30375e-6	0.24788
quad4	81,64	-2.3042e-6	0.23308
quad8	225,64	-2.3035e-6	0.24785
quad9	289,64	-2.3036e-6	0.24782

## 2 Plate with two sections

We have studied two different subcases of the problem stated.

1. Fixed, no displacement of the central column.
2. 0.25 m displacement

There are huge differences between the cases studied. When it comes to stresses in the x direction the difference is big, but the differences in the Y-direction are bigger, mostly due to the loads and prescribed displacements of the stated problem. The boundary conditions on the Y direction affect a lot the ones in the X direction, leading us to different results between subcases. Between the  $S_y$  cases we can see a main difference. In the first one (without prescribed displacement) the central column is working in compression, while in the -0,25 m prescribed displacement subcase this central column has to work against this boundary condition and starts working in traction.

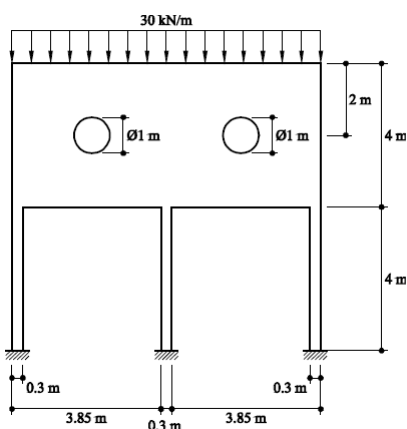


Figure 4: Problem Statement

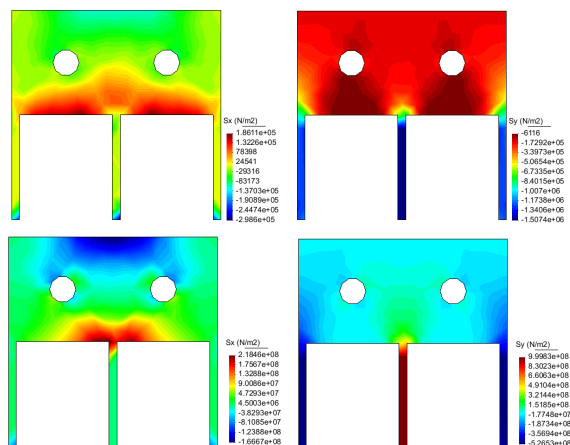


Figure 5:  $S_x$  (left column) ,  $S_y$  (right column) for each of the subcases:  $dY=0$  ,  $dY=-0.25$

The following table summarizes the subcases and the maximum stresses achieved in them. Both the behavior and magnitude of the values achieved are remarkably different, as can be seen next:

Subcase	$S_x [\frac{N}{m^2}]$	$S_y [\frac{N}{m^2}]$
Fixed	-2.98e+5 (comp)	-1.5e+6 (comp)
dY=-0.25	2.18e+8 (tract)	9.98e+8 (tract)

### 3 Plate with ventilation hole.

In this problem we have to model the behaviour of a concrete beam with a hole for ventilation that, due to increases in the design charge, it has been reinforced with two steel sheets as seen in Figure 6. We will analyze the stress state in the beam under the assumption of plane stress.

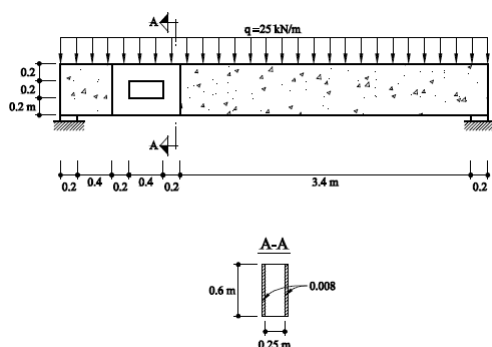


Figure 6: Scheme of the reinforced concrete beam.

To reduce the problem to a 2D model we have had to create two different surfaces, one on top of each other, for the central area where there are steel and concrete. To do so we have sent the steel sheets to a different layer, we have meshed both geometries separately and after that we have collapsed the nodes of the quadrilateral mesh.

To compare the effect of the placement of the reinforcement steel sheets we have also run a model without reinforcement. As we can see in Figures 7 and 8 the effect of the reinforcement sheets is a general reduction in the stresses. This fact is due to the higher stiffness of the reinforced beam that results in smaller displacements.

The maximum and minimum stresses, and maximum vertical displacements are shown in

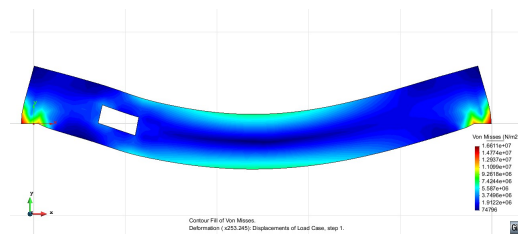


Figure 7: Von Mises stresses of the concrete beam without steel reinforcements.

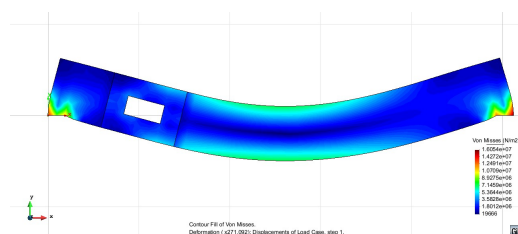


Figure 8: Von Mises stresses of the concrete beam with steel reinforcements.

the following table:

Subcase	Concrete	Concrete and steel
Max stress [ $\frac{N}{m^2}$ ]	1.6611e+7	1.6054e+7
Min stress [ $\frac{N}{m^2}$ ]	7.4796e+4	1.9666e+4
Max displacement [mm]	-1.9675	-1.8457

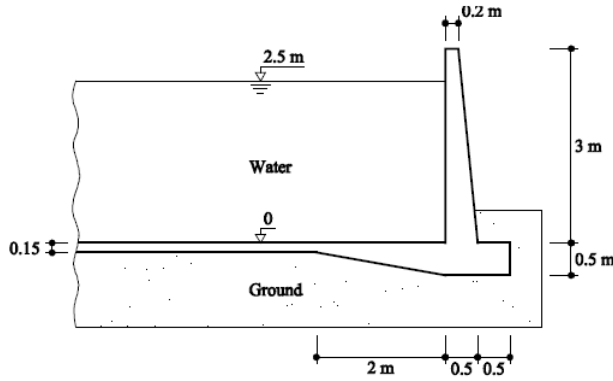
Therefore once seen the results we can conclude that the steel sheets improves the behaviour of the beam diminishing the strains and stresses and so it can hold higher design loads without major problems.

## 4 Prismatic water tank.

We have used the formula

$$P = \rho gh$$

to determine the loads on the walls of the tank; linear constant in the floor and linear from  $\rho gh$  at the base to 0 at the surface of the water. Elastic constraints have been used with the data given to simulate the tank interaction with the ground.



The results obtained are due to the effect of the water weight into the tank structure. We can appreciate in the following images how the stresses in both X and Y directions are. They are logic if we recall the 3rd image, where we can see the displacements.

We have also plotted the 1st principal stress (4th image), where it can be easily seen that the singular point at the interior corner is the one that has the higher risk of failure.

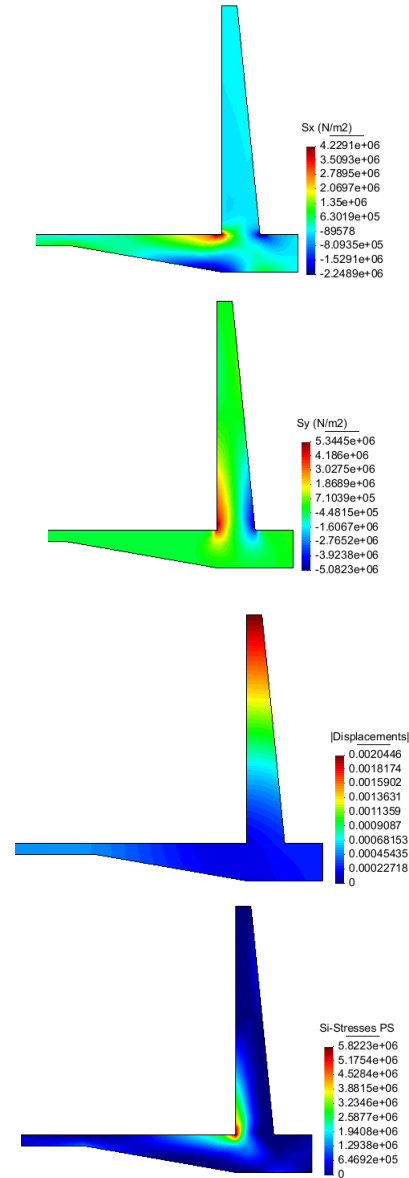


Figure 9:  $S_x$  ;  $S_y$  ; Displacements and  $S_{principal1}$