Practice 2

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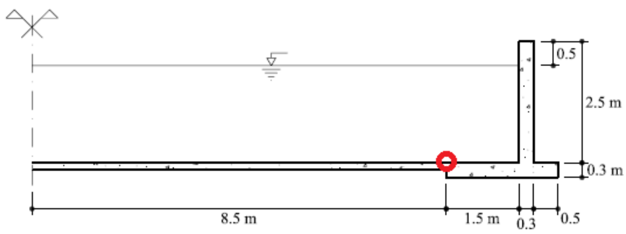
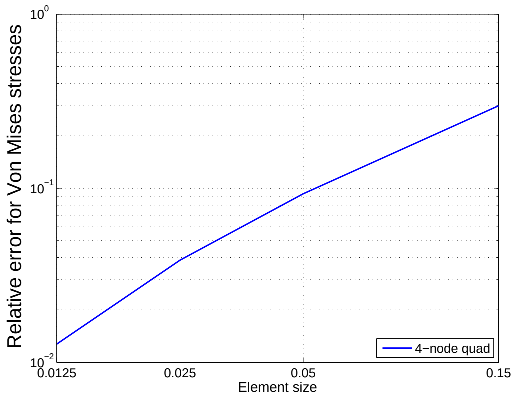
Exercise 1: Circular tank

This problem has been solved including the self weight of the structure, the pressure due to the water and the effect of the base slab at the bottom. A convergence analysis has been carried out to study the effect of the different element sizes for a structured mesh composed by 4-node quadrilateral elements using the value of the Von Mises stresses at the point depicted in figure 1a and computing the relative error obtained for every different mesh with respect to the stresses obtained using an element size equal to 0.00625 (75388 nodes). The convergence plot obtained is depicted in Fig. 1b. It can be concluded that the results obtained with an element size of 0.0125 are acceptable. The first and third principal stresses obtained for this mesh are depicted in figure 2, and the displacements are depicted in figure 3. The results obtained show that the displacements obtained are low and the concrete works under compression. However, there are small regions where tractions are important, and there are very small concentrations of stresses at some vertexes. It would be useful to round the vertexes and increase the section at the bottom of the wall to reduce the flexion and stresses due to traction.



(a) Point for the convergence analysis



(b) Convergence analysis

Figure 1

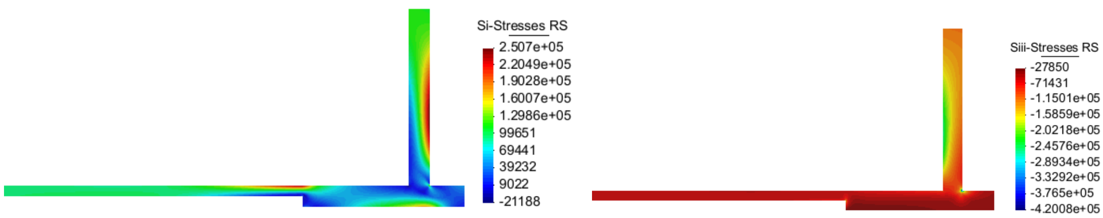


Figure 2: Principal stresses I and III

Figure 3: Module of the displacements

Exercise 2: Analysis of the flexion of a beam using hexahedra elements

The distribution of stresses in the axial direction can be obtained using the analytical solution for flexion problems:

$$\sigma_{xMAX} = \left| y \frac{M_z}{I_z} \right| = 3m \frac{2 \cdot 10000N \cdot 3m \cdot 12}{6^4 m^4} = 1666.67 \frac{N}{m^2}$$

The problem has been solved using structured meshes of 8-node and 20-node hexahedras with different element sizes. In figure 4, the evolution of the error in the stresses with respect to the analytical solution for different meshes using both elements is depicted. As is showed in the plot, the error obtained with the 20-node hexahedra element is lower than for the 8-node hexahedra when using the same number of nodes. This is due to the fact that the derivatives of the 20-node hexahedra element are not constant along the element. However, both elements show the same rate of convergence.

The results obtained when using an structured mesh composed of 20-node hexahedra with element size 0.75 are depicted in figures 5 and 6. The results show a linear evolution of axial stress which is usual in flexion problems. As is depicted in figure 6, there is an important concentration of stresses at the point of application of the loads. However, far from there the results are smooth and similar to the ones obtained from Resistance of Materials' theory. The vertical displacements along the neutral axis match the ones obtained using the beam theory (figure 5b).

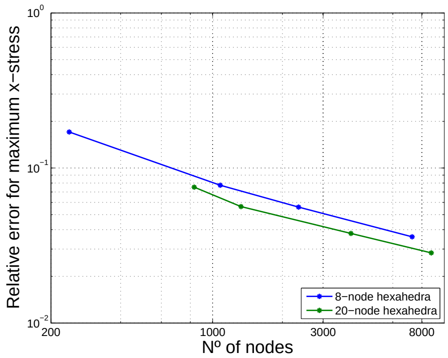
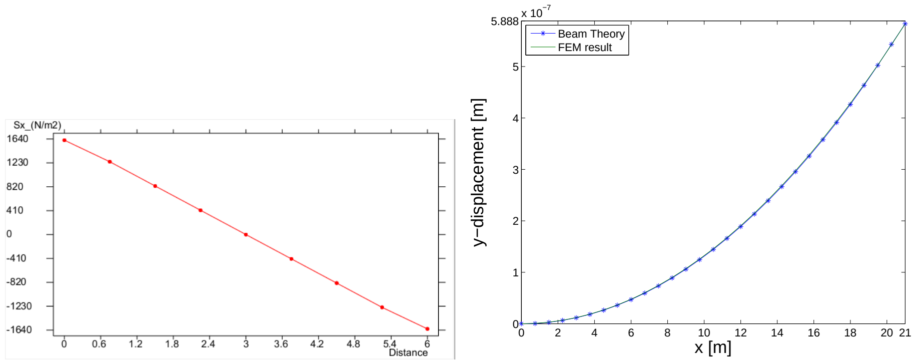


Figure 4: Analysis of convergence



(a) Vertical distribution of σ_x at x=10 **(b)** Vertical displacement along x

Figure 5

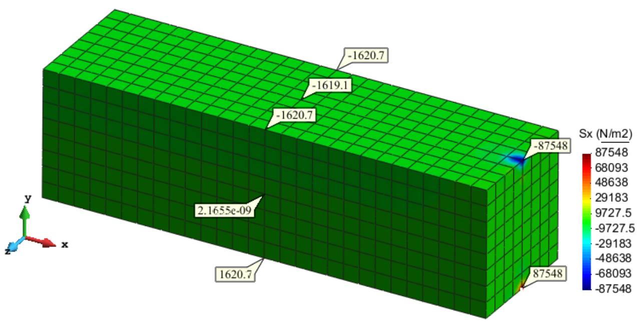
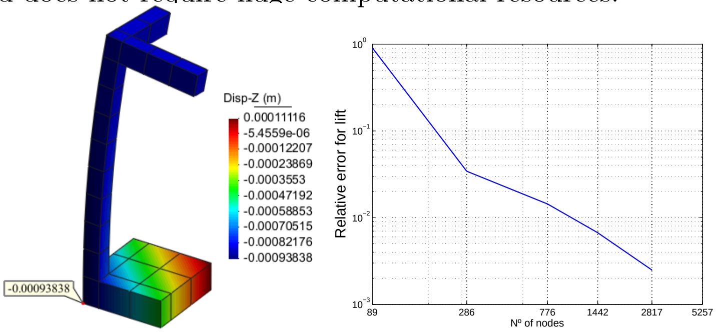


Figure 6: 3D distribution of σ_x

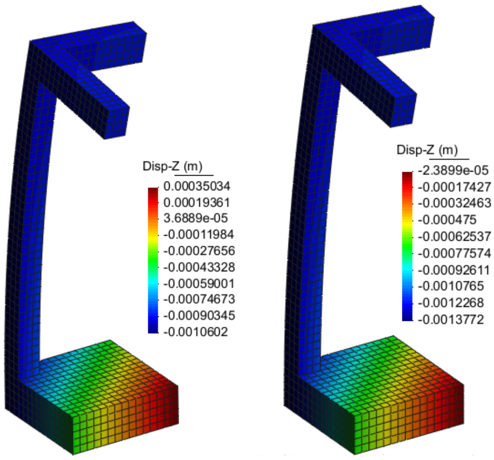
Exercise 3: Foundation of a corner column

This problem has been solved using 8-node hexahedrons. It has first solved without taking into account the self-weight of the soil over the base slab in order to decide which element size use in the study. The convergence analysis has been carried out solving the problem for different element sizes and computing the error obtained in the vertical displacement at the point depicted in figure 7 a) with respect to the result obtained when using 5270 nodes. An element size of 0.1 (2817 nodes) has been chosen as it gives an acceptable error and does not require huge computational resources.



(a) Point of the analysis **(b)** Convergence plot

Figure 7: Analysis of convergence



(a) **(b)**

Figure 8: z-displacement: Without weight of the soil (a) and for h=1 m (b)

The result obtained with the selected mesh show that the slab suffers lifting (figure 8 a). In order to prevent lifting, the self-weight of the soil over the base slab has been added to the model. The problem has been solved for different heights of the soil, and the vertical displacements obtained at the base have been studied (figure 9). The results obtained show that the lifting of the base is prevented for a height of the soil over the base equal to one (figure 8 b).

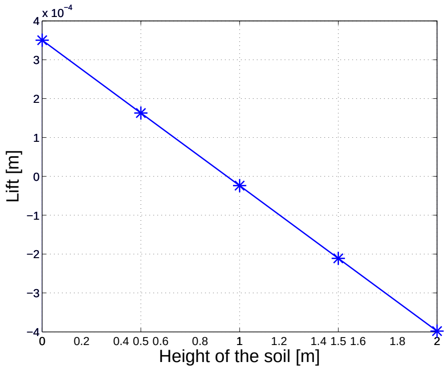


Figure 9: Lift vs Height of the soil