Computational Structural Mechanics and Dynamics
Practice 2

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1 Introduction:

In this report we are analysing structural behaviour of different types of 2D and 3D problems considering the problem type as revolution of solids,3D solids.The behaviour of displacement and stresses are analysed with different types of elements and different size of structured mesh and are compared.

Exercise 1: Circular tank:

We have analyzed structural behavior of the given problem using quadrilateral elements with 4 nodes with given concrete material , boundary conditions,load (water pressure,$p = \rho g h$),considered the base slab to be elastically supported by the ground and obtained the stress distribution of the cross-section of the tank.Compared the stress distribution for different structured mesh size.After refining structured mesh size the result obtained was more accurate and the stress distribution is shown below.Also the convergence plot of displacement v/s number of nodes is shown below.

(1) 4-noded quadrilateral elements with mesh element size (0.3)and structured size of(0.015)

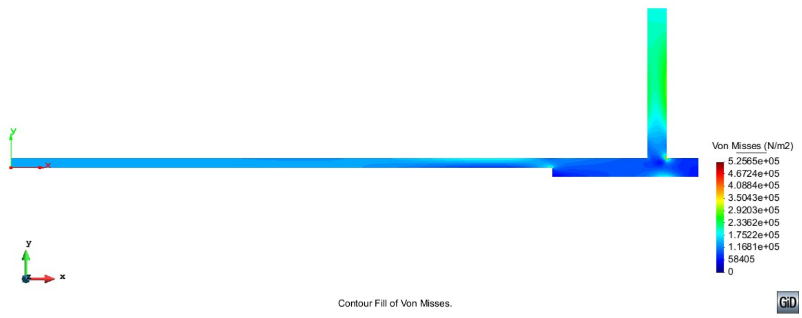

Figure 1: Von Mises Stress distribution

Figure 2: Stress distribution along y

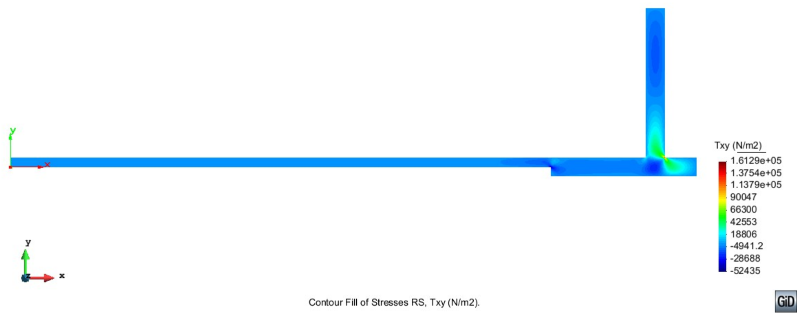

Figure 3: Shear Stress distribution

Figure 4: Displacements

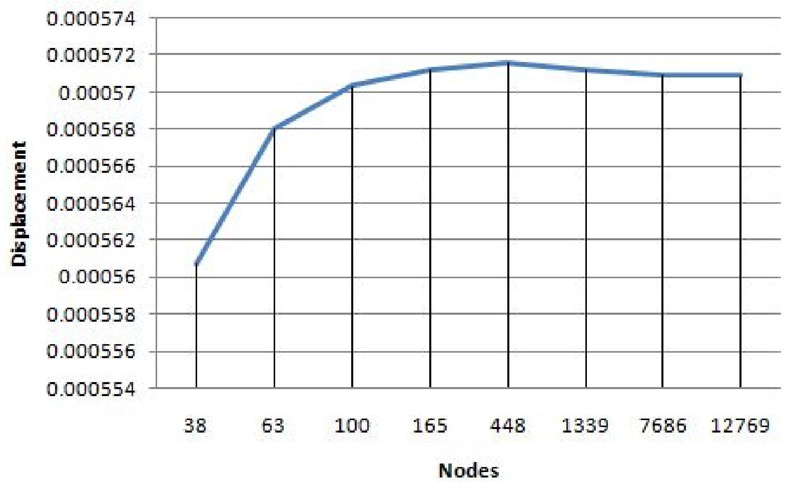

Figure 5: Convergence plot of displacement v/s no.nodes

Comments: From the above simulations we can see that with refined structured mesh, the Max.Von Mises stress is obtained as $5.2565e^{+5}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 1.798e^{+5}\frac{N}{m^2}$. $\sigma_x = 1.8084e^{+5}\frac{N}{m^2}$ and $T_{xy} = 1.6129e^{+5}\frac{N}{m^2}$.From the above convergence plot,we can see that with increasing number of nodes, displacement converges to satisfcatory results.Convergence plot of maximum stress is not computed due to the presence of stress concentration area.

From the simulation,it can be seen that Max.Von Mises stress is maximum at the inside corner and outside corner and the circular part of the tank as the maximum pressure of water is accumulated there.Hence there may be cracks or fracture on concrete at this points for higher pressure of water which results in failure of tank.A picture of displacement(deformation) under the given load is also shown in figure 4 .

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

We have analyzed the cantilever beam which is submitted to action of moment at the far end with given steel material using hexahedral elements of 8 and 20 nodes and obtained the deflection(displacement along y),stress distribution.The values are then compared with theoretical value obtained by using beam theory formula.

(1) 8-noded hexahedral elements

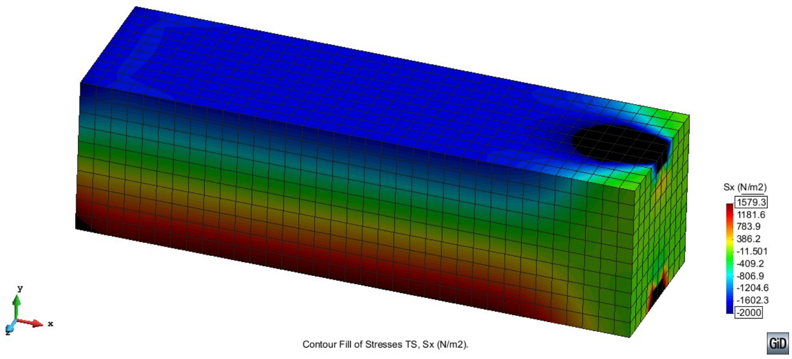

Figure 6: Stress distribution along x

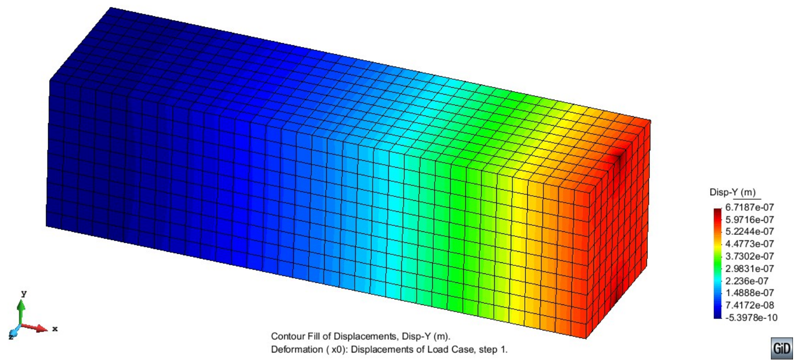

Figure 7: displacement along y

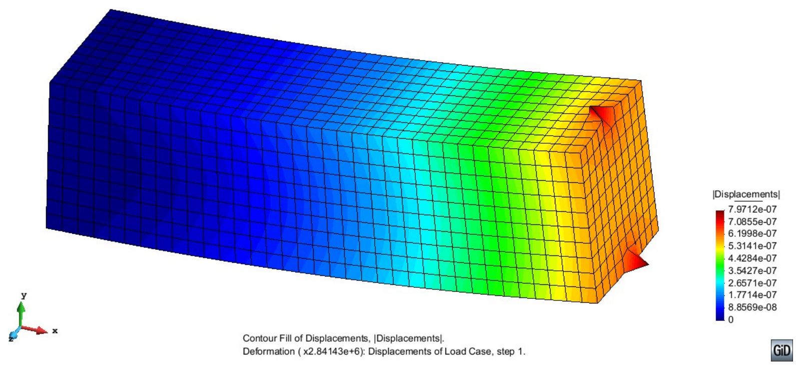

Figure 8: Effect of moment on cantilever beam

(2) 20-noded hexahedral elements

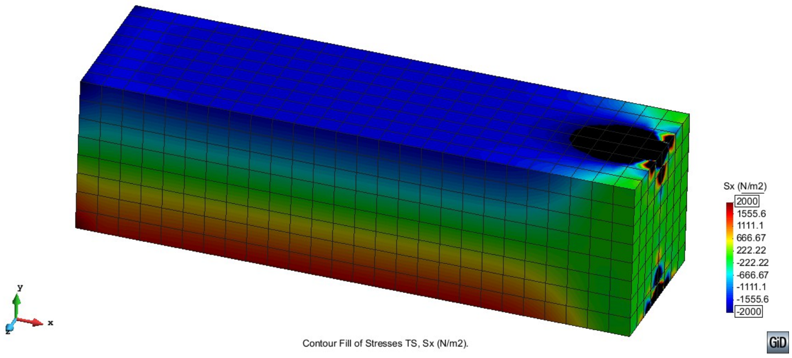

Figure 9: Stress distribution along x

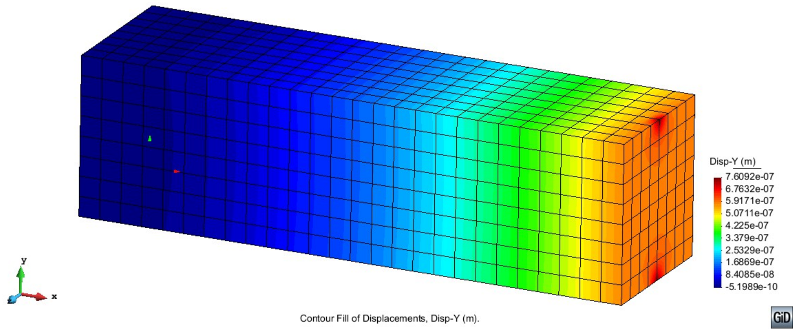

Figure 10: displacement along y

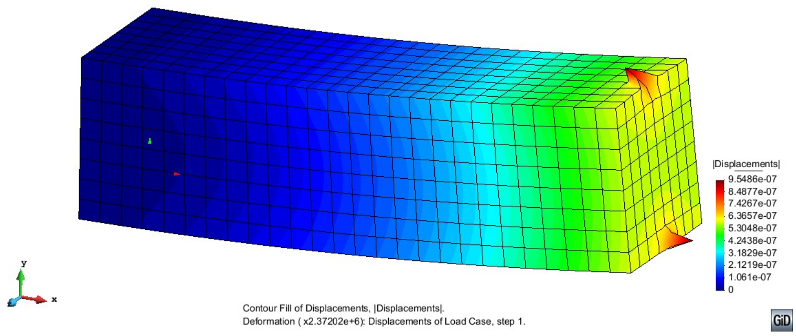

Figure 11: Effect of moment on cantilever beam

Theoretical values of delfection and stress using Beam Theory:

We know that from beam theory theoretical value of deflection 'δ or y' can be calculated using formula,

$$\delta = \frac{ML^2}{2EI}$$

$$I = \frac{bh^3}{12} = \frac{6 \times 6^3}{12} = 108m^4$$

$$\delta = \frac{(10000 \times 6) \times 21^2}{2 \times 2.1e11 \times 108} = 5.833e - 07m$$

$$\sigma_x = \frac{My}{I}$$

$$\sigma_x = \frac{(10000 \times 6) \times 3}{108} = 1666.67\frac{N}{m^2}$$

Element	$\mathbf{y}_{max}$in (m)	$\mathbf{y}_{act}/\delta$(m)	$\sigma_x(obtained)$ in $\frac{N}{m^2}$	$\sigma_x(theoretical)$in $\frac{N}{m^2}$
8-noded hexahedron	6.7187e-07	5.833e-07	1594.2	1.666.67
20-noded hexahedron	7.6092e-07	5.833e-07	1619.7	1.666.67

Table 1: Comparison Table

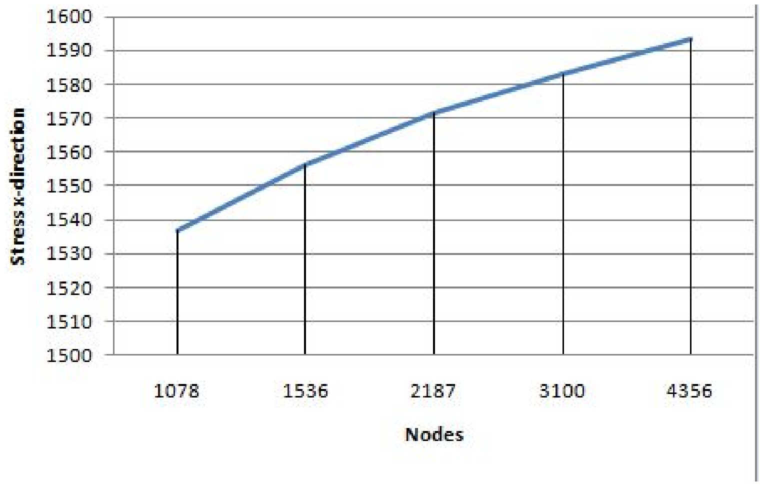

Figure 12: Convergence plot of stress along X-direction v/s nodes

Comments: From the above convergence plot,we can see that as the number of nodes are increased the σ_x values approaches the exact value of stress predicted by beam theory.The mesh can be refined further to approach the exact value,but the computational cost becomes too high.

Exercise 3: Foundation of a corner column:

We have analyzed the given corner column with its base/foundation using given data such as concrete material,considering assumption that that the slab is supported elastically by the ground.Used hexahedral elements with 8 nodes and analyzed stress distribution in the column and slab for two cases:

1.Not considering self-weight of column
2. Considering self-weight of column.

Following figures below shows the stress distribution and displacements for both the cases,which is then compared and has to be checked whether there is lifting of base slab and also need to decide whether we need to consider the self-weight or not.

(1) Not considering self-weight of column

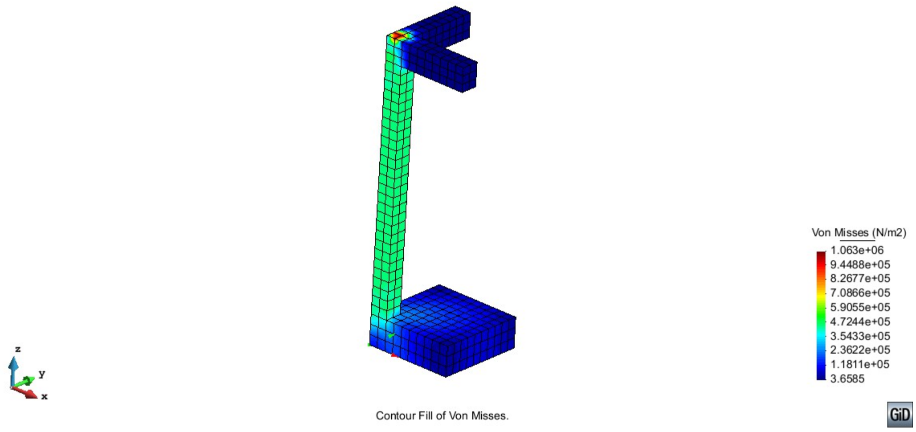

Figure 13: Von Mises Stress distribution

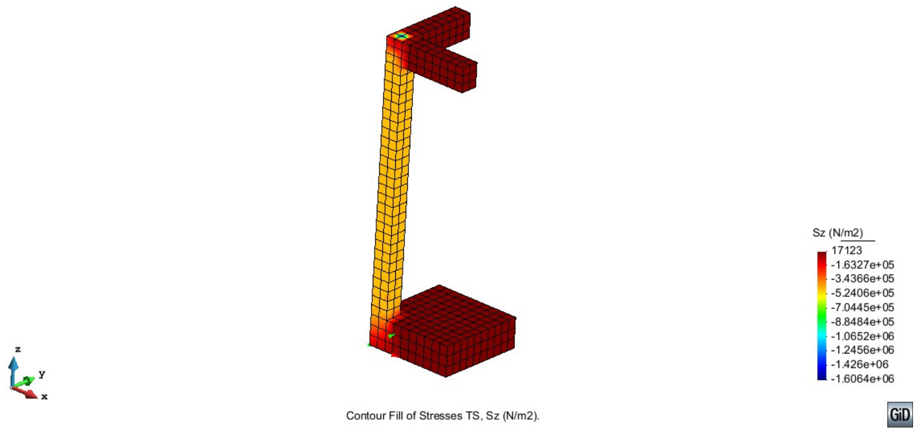

Figure 14: Stress distribution along z

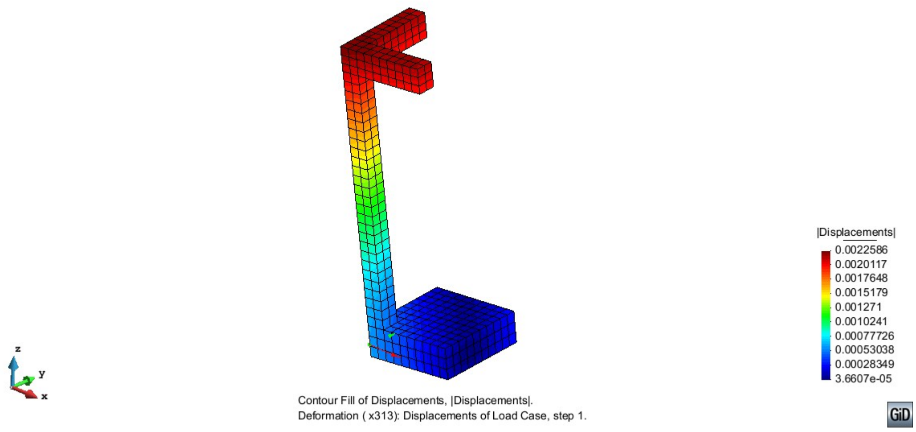

Figure 15: Effect of load on slab

(2) Considering self-weight of column

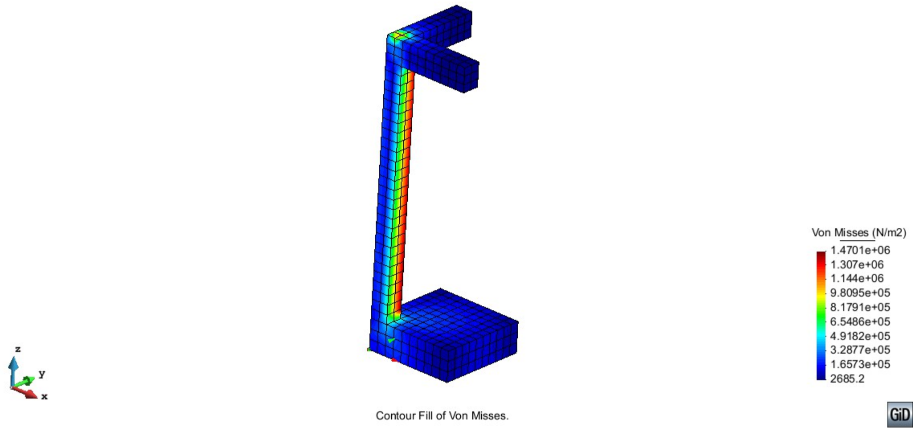

Figure 16: Von Mises Stress distribution

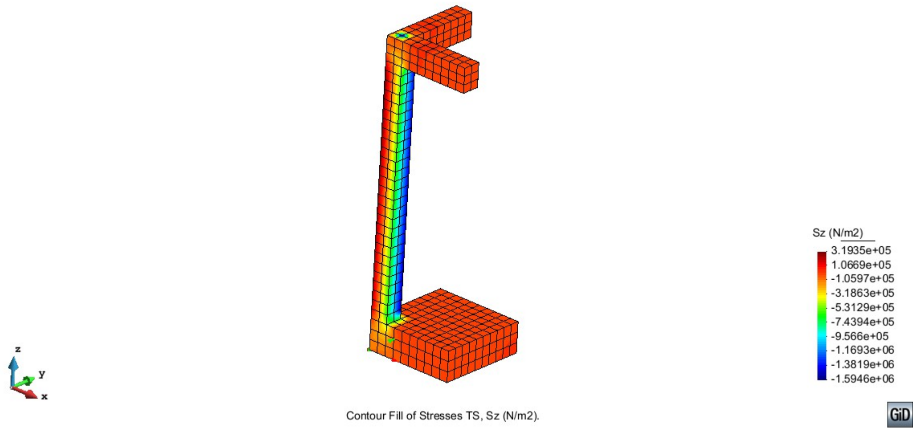

Figure 17: Stress distribution along z

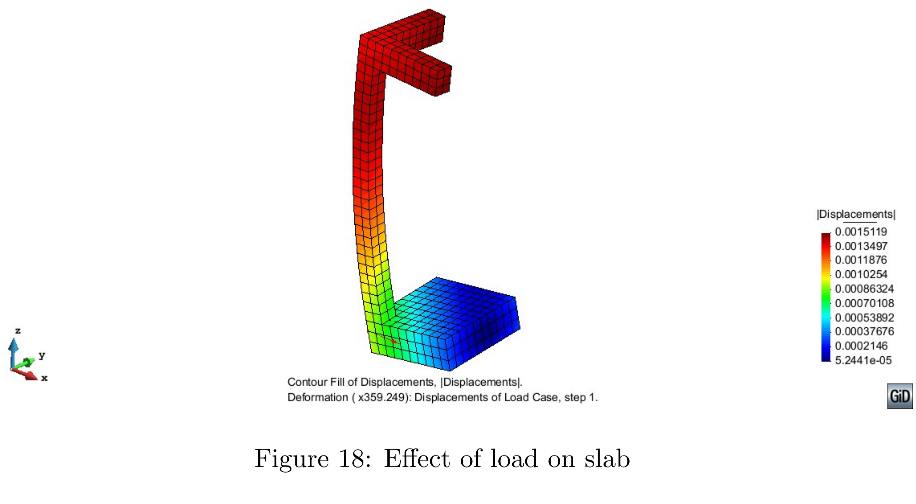

Figure 18: Effect of load on slab

Note: Following geometries of exercise 3 are created in 'YZ' plane and extruded along X axis.

The table below shows the stress distribution (Maximum values) of the column and slab after simulation for both the cases as mentioned above.

cases	Max.Von Mises in $\frac{N}{m^2}$	$Max.\sigma_z$in $\frac{N}{m^2}$	$Max.\tau_{xz}$in $\frac{N}{m^2}$
case 1:No Self weight	1.063e+06	17123	2.5465e+05
case 2:Self weight	1.470e+06	3.1953e+05	2.6676e+05

Table 2: Stress distribution table

Comments: From the simulation it can be seen that Max.Von Mises stress is maximum at the upper portion of corner column where the load is applied in case(1) as shown in fig.11 and is maximum at the upper portion of corner column where the load is applied and also at the entire vertical column in case(2)as shown in fig.14 since we are considering self-weight of column, which indicates that the failure is more at those portions.

As we can see from fig.13 and fig.16,which shows the effect of load on slab for both the cases,there is lifting of the slab.And we can also observe that if we consider the self-weight of column,there will be buckling effect on column.Hence it is better to consider the self-weight of column so that we can successfully predict from the simulation where the column fails due to buckling effect and suitable suggestions can be made to modify the current design to counteract the buckling effect.