

24-650 Applied Finite Element Analysis

Homework No 9

Vessel Stand Buckling

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The objective of this assignment was to model the 3 buckling modes of the vessel on a stand as shown in Figure 1.



Figure 1: Vessel on a stand model

1. Setup

The first step was to extract the surfaces of the solid in SpaceClaim and then import them to Ansys Mechanical in a Static Structural module. The appropriate offset for the surfaces was **TOP**, the material **Structural Steel** and the thickness for the shell elements was **10 mm**. To model the vessel as full of fluid, a distributed mass of **1 metric ton** was assigned to the surfaces of the vessel body. This is shown in Figure A.1. The contact between the vessel and the stand is a **bonded contact** as shown in Figure A.2.

Finally, for the boundary conditions, a **fixed support constraint** was applied to the bottom of the vessel as it was bonded to a concrete floor. This is shown in Figure A.1.

2. Results and Analysis

After running the Static Structural simulation and importing the results (shown in Figure A.5 and Figure A.6) for the Eigen Value Buckling simulation, a converged solution was obtained for a mesh size of **7 mm**. The convergence is shown in Figure 2.

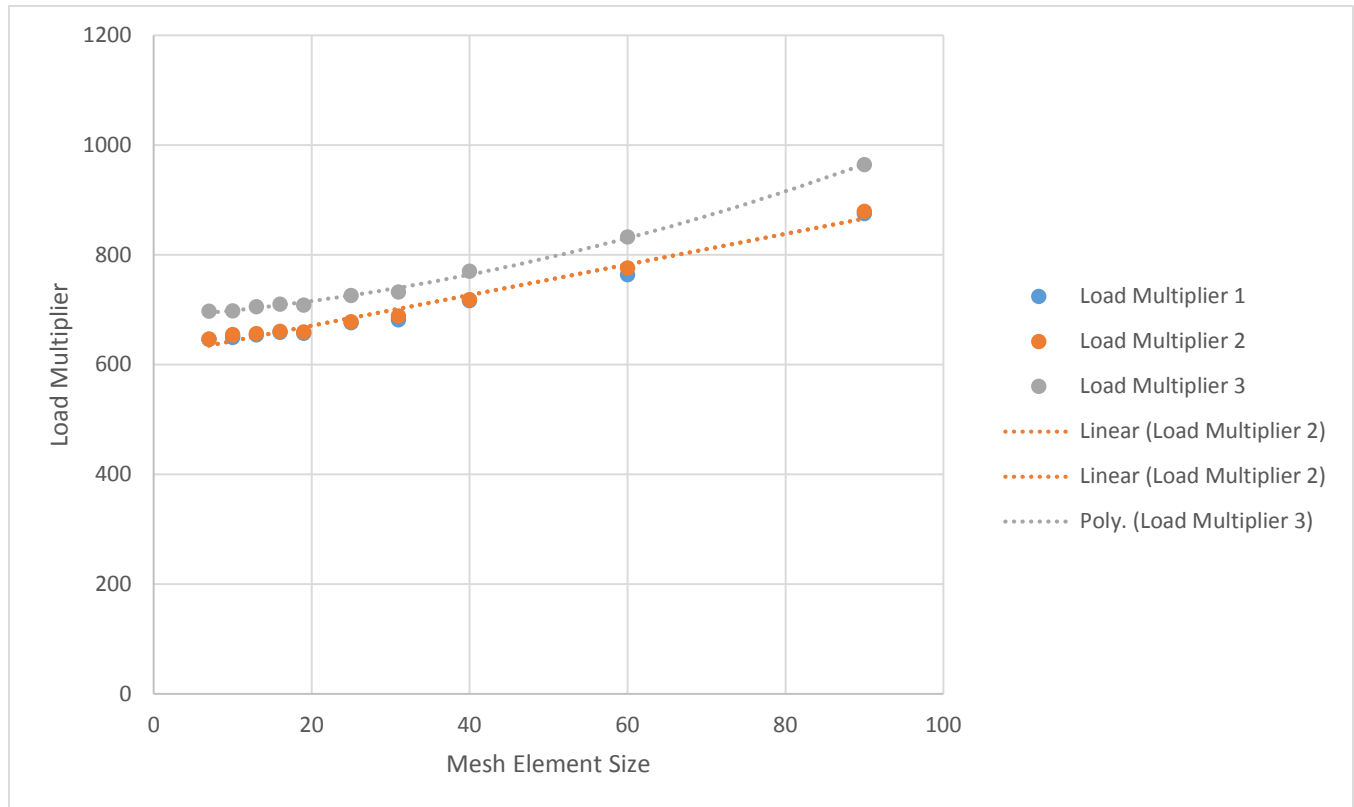


Figure 2: Convergence of the solution

As shown in Figure 2, for a Mesh Element Size of 7 mm, the solution changes in less than 1%. This mesh is shown in Figure A.3 (211,183 nodes and 210,651 elements). A warping factor plot is also shown in Figure A.4 confirming that the mesh is adequate because of the low values. The values obtained for the Load Multipliers are shown in Table 1.

Load Multiplier 1	Load Multiplier 2	Load Multiplier 3
646.24	646.63	697.06

Table 1: Load Multiplier

The three buckling modes are shown below.

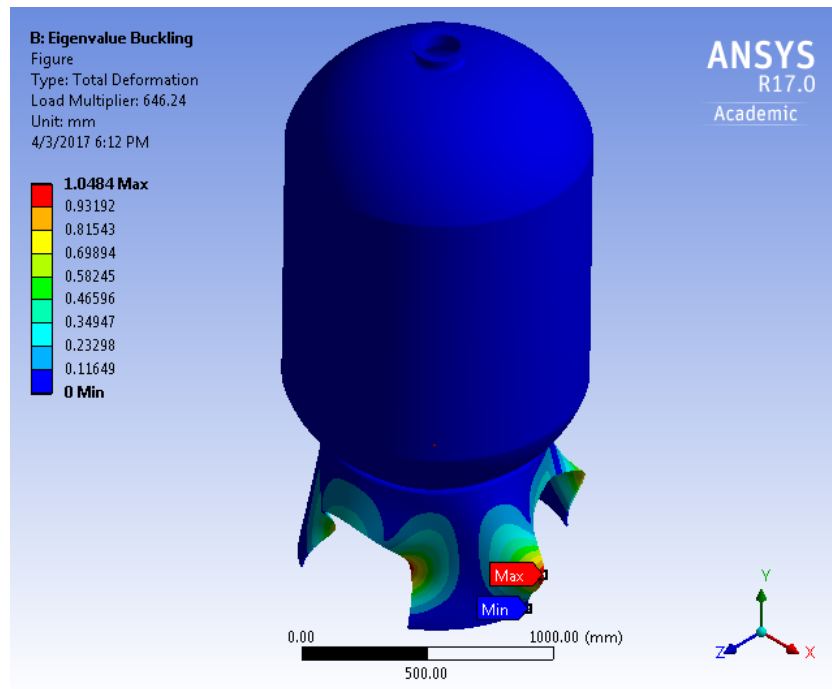


Figure 3: Buckling Mode 1

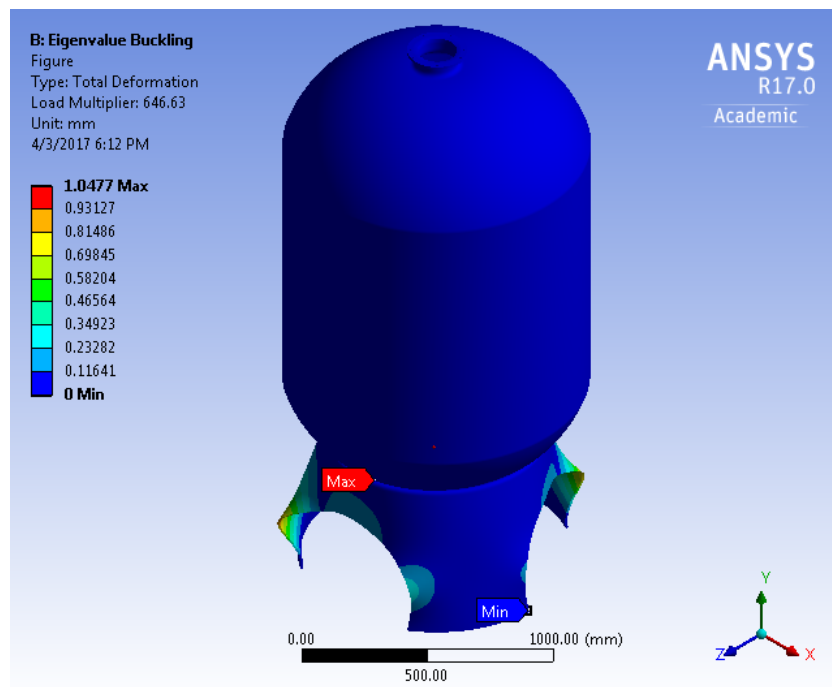


Figure 4: Buckling Mode 2

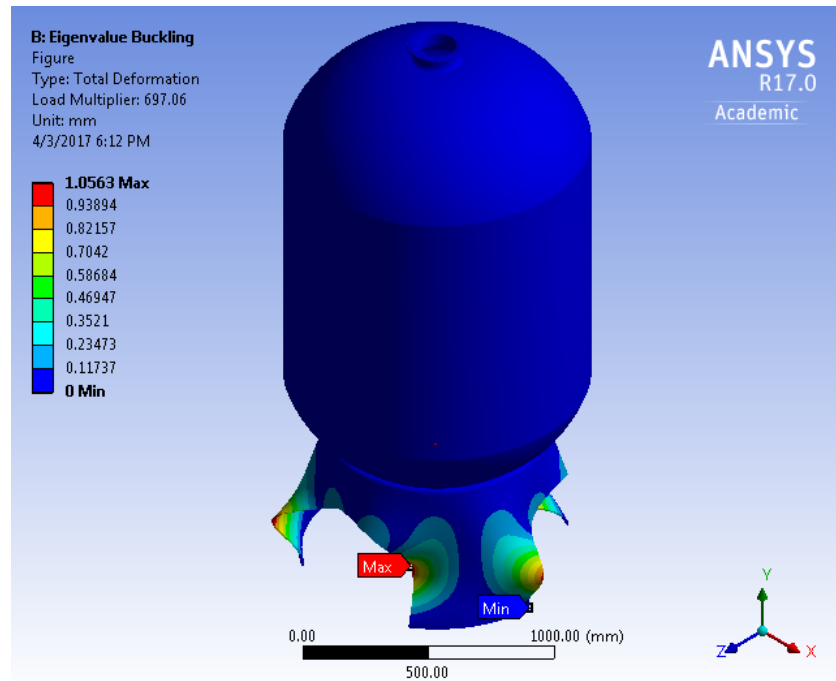


Figure 5: Buckling Mode 3

As shown in Table 1, Figure 3, Figure 4 and Figure 5, the buckling modes represent the shape the structure assumes when it buckles. The values in Table 1 represent a number which the applied load must be multiplied to obtain the buckling-load magnitude. In this case, we only care about the first positive load multiplier. If the load multiplier is **646.24**, it means that the distributed mass can be increased up to **646,240 metric tons** without producing buckling, but maybe producing the steel to yield.

3. Appendix

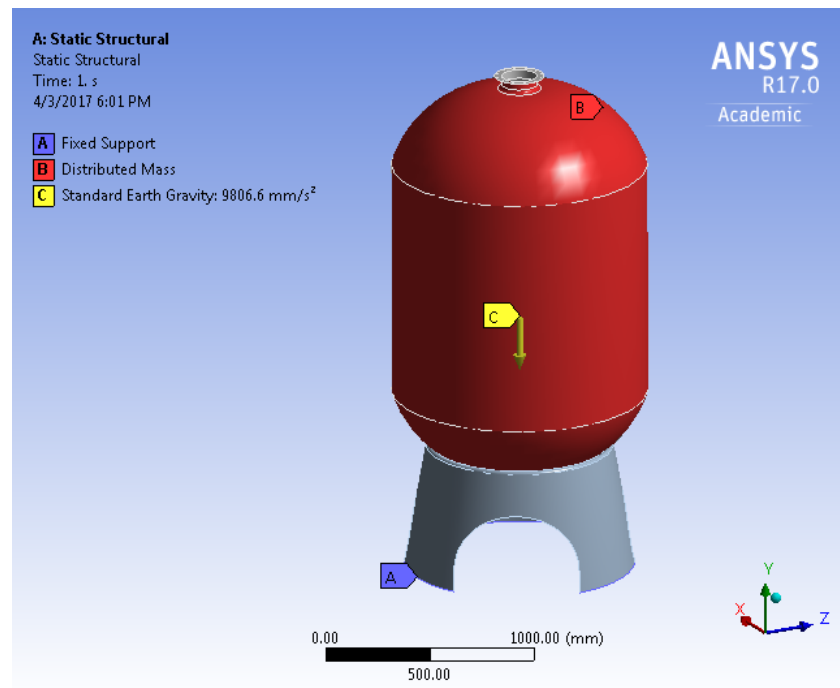


Figure A.1: Boundary Conditions

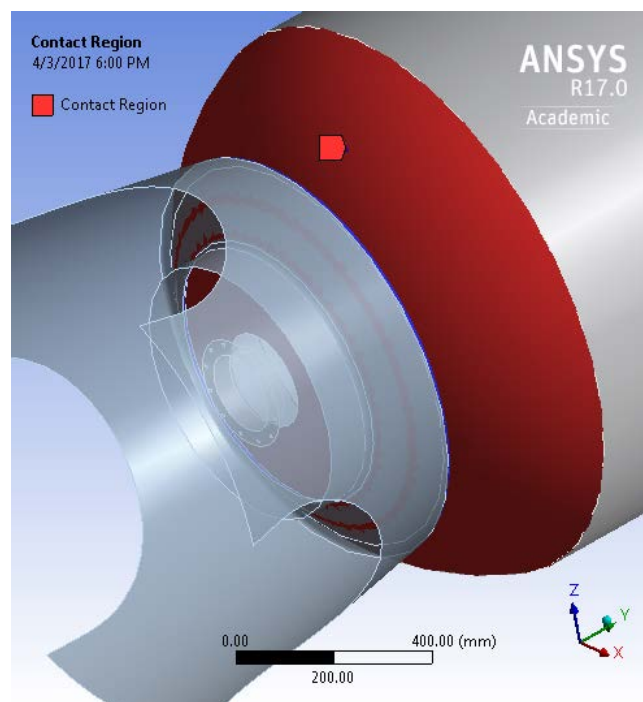


Figure A.2: Contact Region

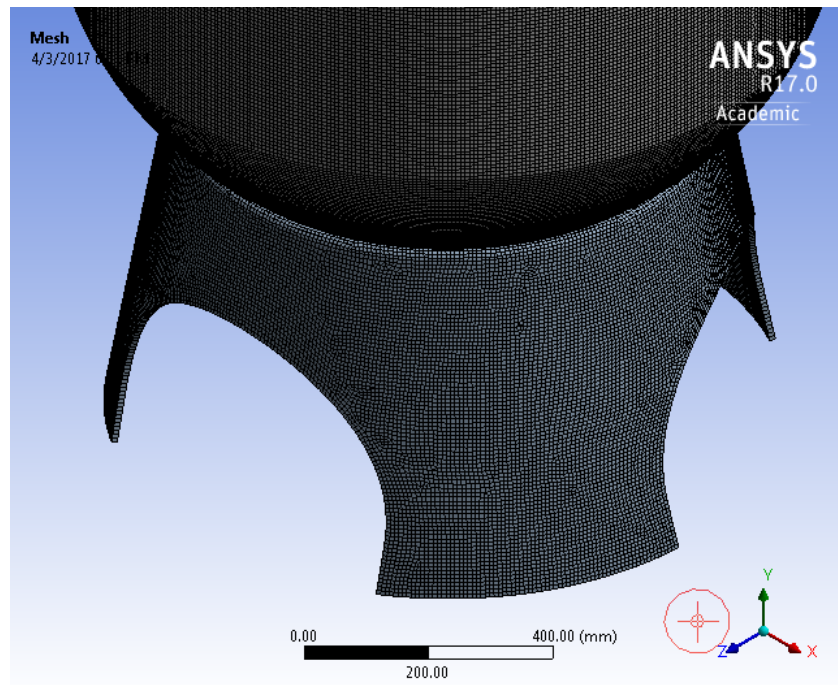


Figure A.3: Mesh (7 mm)

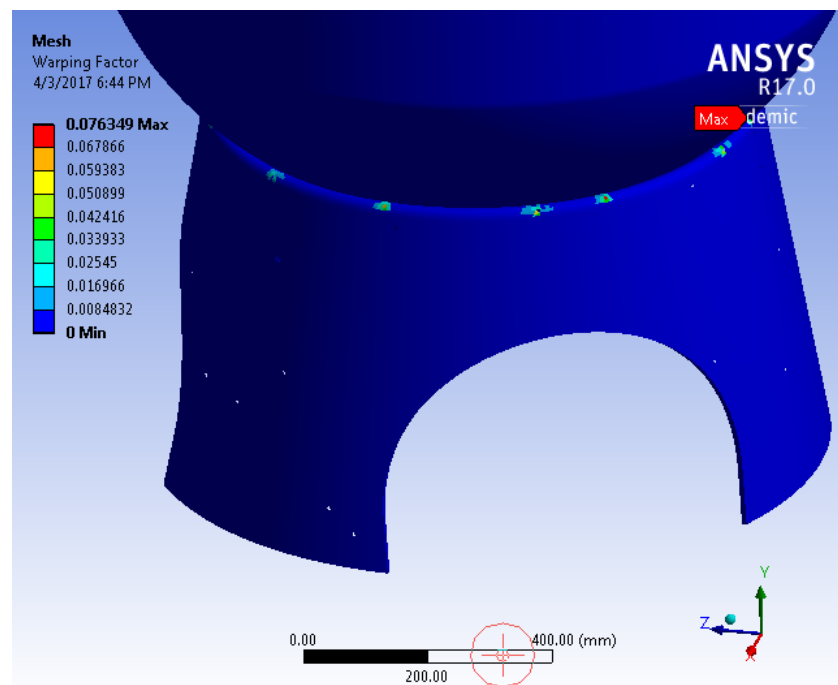


Figure A.4: Warping Factor

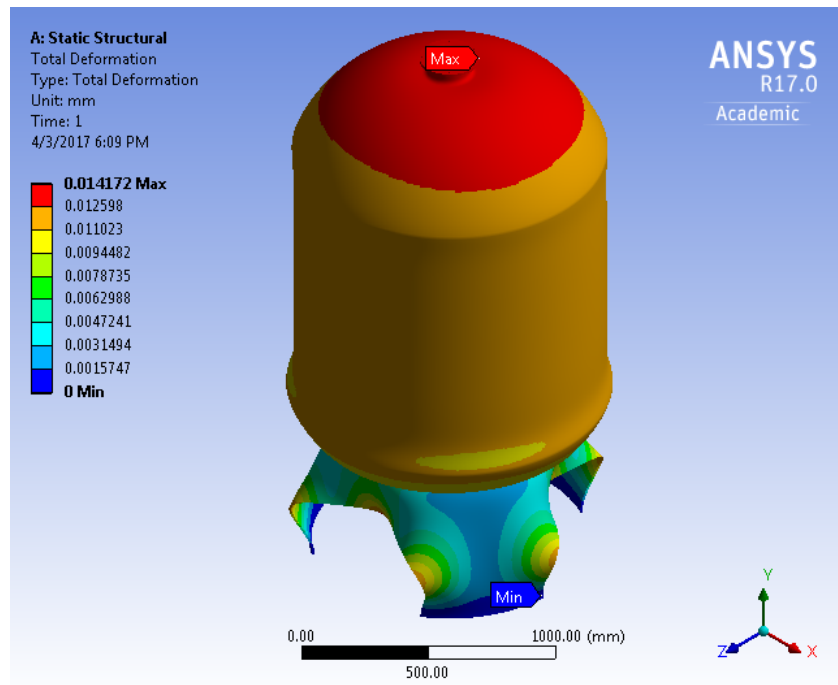


Figure A.5: Total Deformation

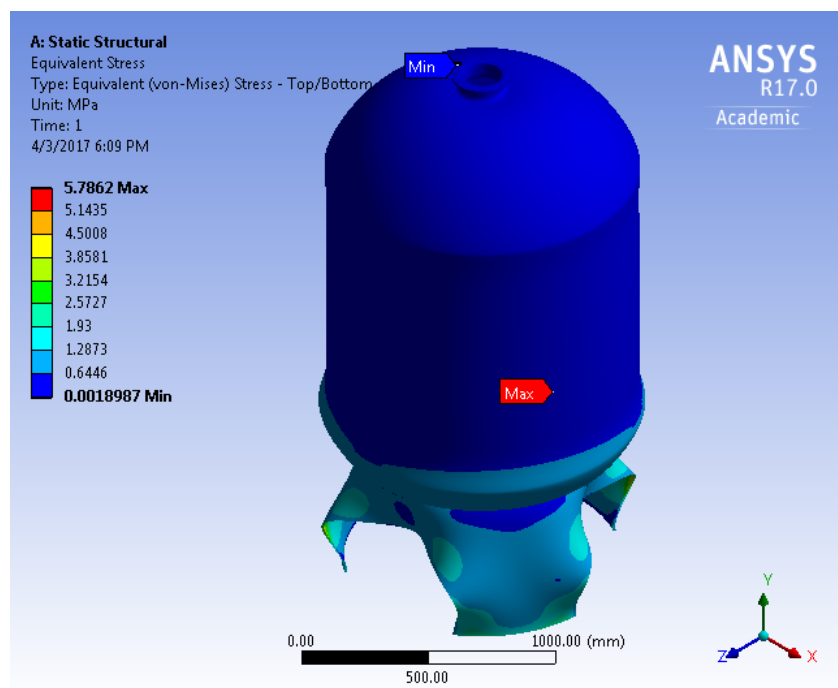


Figure A.6: Equivalent Stress

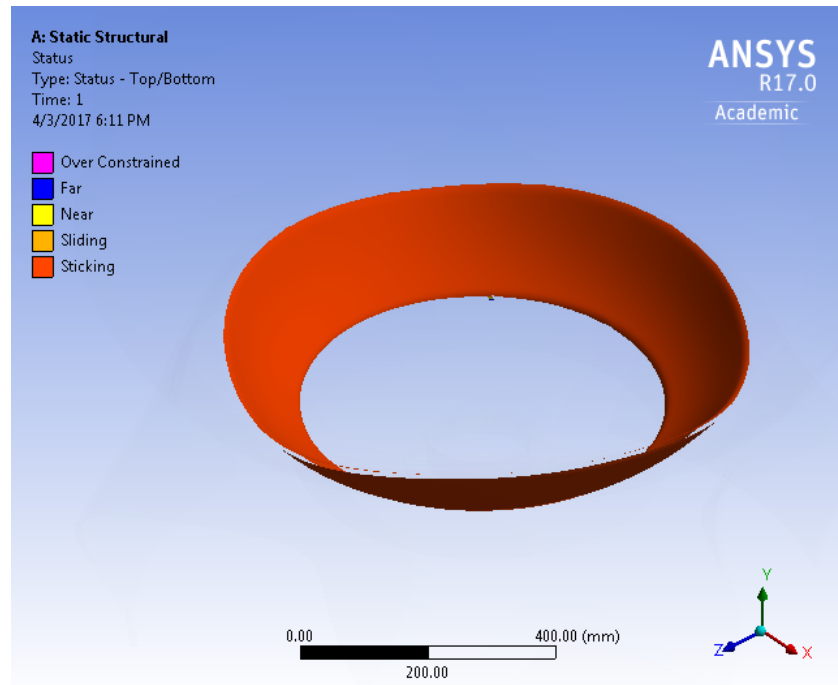


Figure A.7: Contact Status

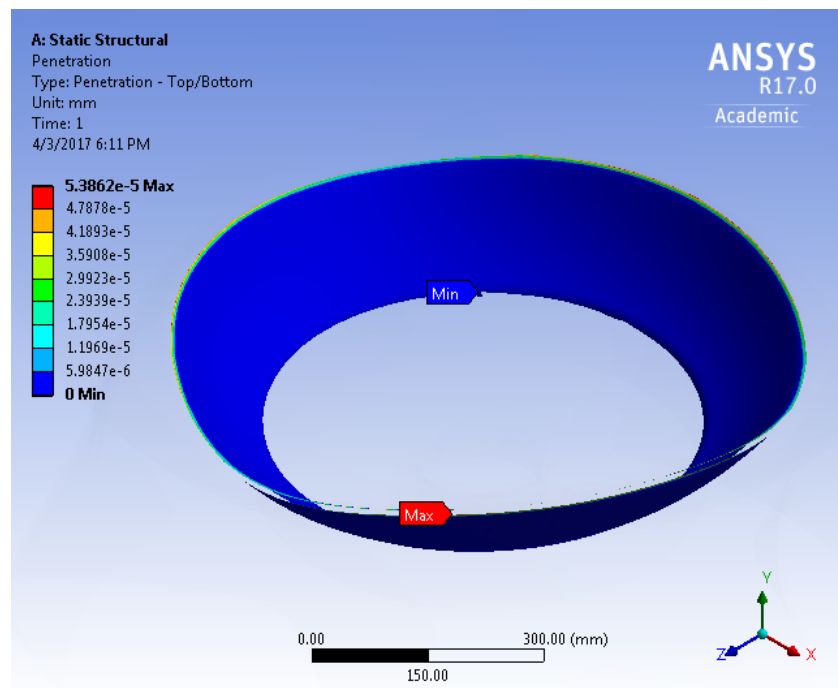


Figure A.8: Contact Penetration