Arborloo Concrete Base Shape Justification

The following document walks through the selection process for the selection of shapes that includes a triangle, circle; square for 2D and cone, dome for 3D. The final shapes determined to be used are the circular 2D slab and the 3D dome shape. Different tools such as ANSYS and MATLAB were used to analyze the structure and weight of these different shapes. Along with these tools, practical application was considered when narrowing down the selection to two different geometries. ANSYS models were constrained in the z-direction around the outer edge of the structure. Loads were applied to separate volumes, which were glued to the entire structure. Elastic Modulus and poison's ratio were kept constant between the models at 1.7E06 and 0.15.

Triangle

The triangle shape idea was originally introduced with the thought that less material could be used, thus reducing weight. Although a mold design would be rather simple, we decided not to pursue this shape. With further investigation it was found that actually more material would be needed. The distance from the hole in the triangle to any edge would require a minimum distance of 5'', to avoid fracture. Five inches is the safest distance our team had agreed upon. In order to satisfy this, without sacrificing space for the user to have access to the hole would require more material. Additional concerns were the ergonomics of carry a triangle with the center of gravity not symmetric over two axes.

Square

The structural ability of the square was very similar to that of the circle. The reason for not choosing the square was simple due to that fact that the circle consisted of 21.5% less volume. If we were to make slabs out of the same concrete that were 30'' per side/diameter and 2'' thick the circle is 22lbs less.

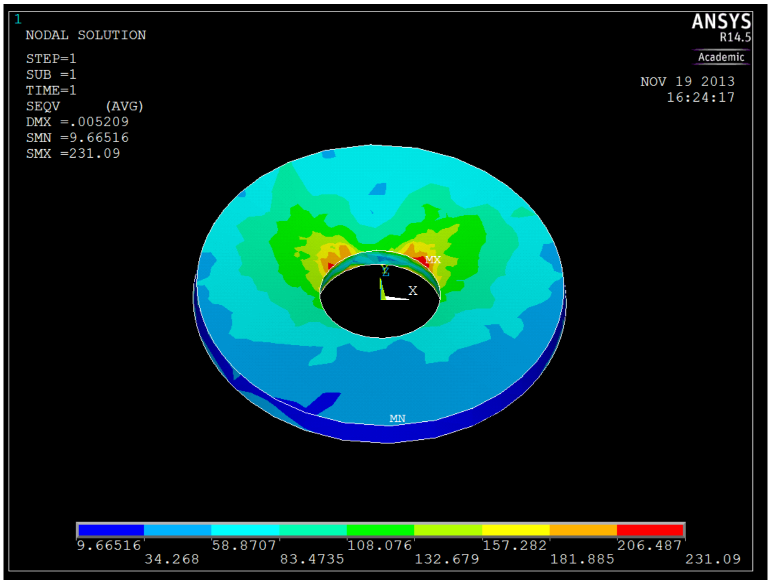
Circle

The circle was chosen because of the simplicity of the 2-D design and the ease of manufacturing. The circle has proven better than the square and triangle. The square because it is less material and the triangle for the same reason but also the circle is more symmetrical, which makes it easier to carry. The following analyze was done with two different loading scenarios. The first scenario assumes that the user will be squatting down so the two loads applied simulate feet. The next load simulates a bucket seat and the force being applied around the hole uniformly.

Foot-Print Applied Pressure: P=35.82 psi or two 500 lb distributed loads

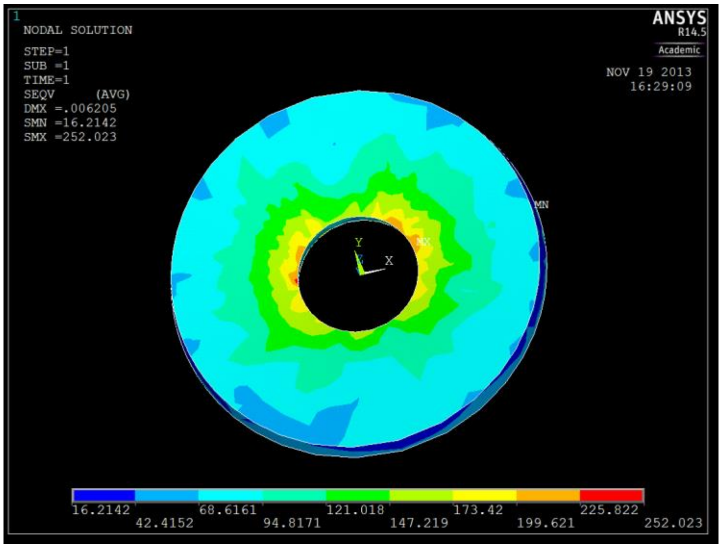
The results came back as we expected and the maximum stress occurs in the bottom surface around the hole. Therefore our flexural strength needs to be equivalent to the 231 psi for a 15" radius base, 5" radius cut out, and 2" thick. The bucket load was better distributed around the hole so the stress is around 200 psi. This is of course due to the increase in area of the load.

Picture 1



Ring Applied Pressure: 28.92 psi or 1000lb disturbed load

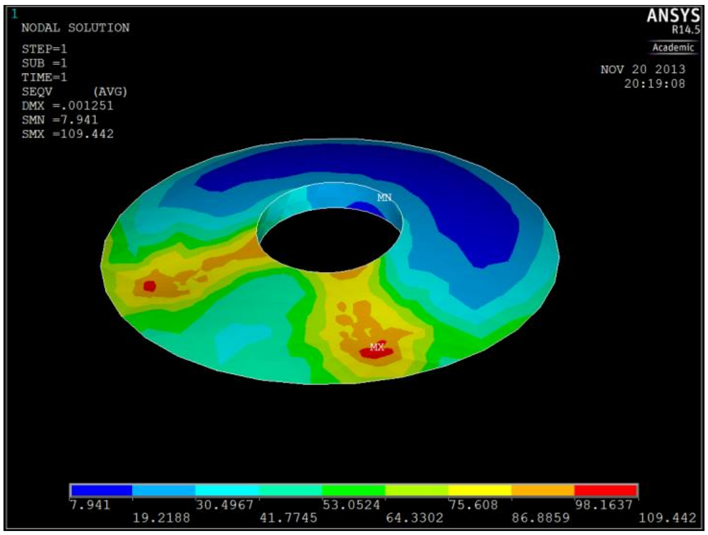
Picture 2



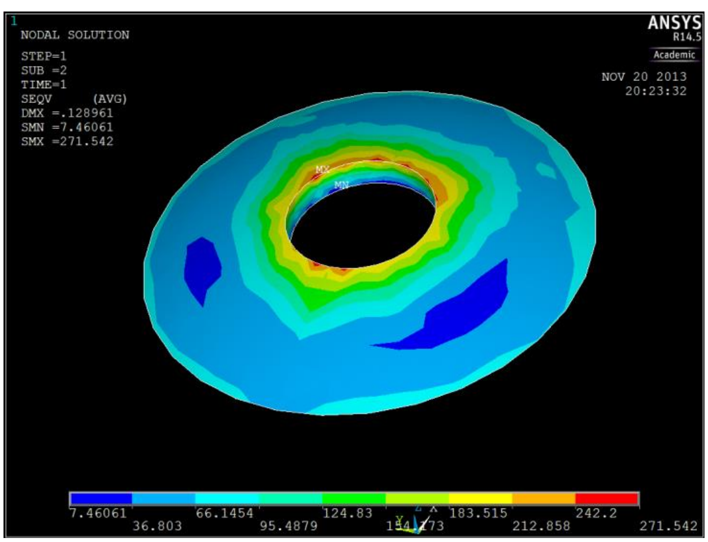
Dome

The dome was considered in the first place for a number of reasons. A dome shape ideally reduces tension and induces compression during loading. Since concrete is more likely to fail in tension than in compression, it could help reduce thickness significantly. The first loading case (picture 3) saw a lot less stress than the circle when the load was applied as feet load. During seat load (picture 4) the stress is significantly less with the tension component in blue. The stress is less than 50 psi, which will allow a decrease in thickness. The last picture shows the bucket loading with a 1'' thick slab. As you can see the stress is indicated in a light green color putting the stress at around 230psi in tension.

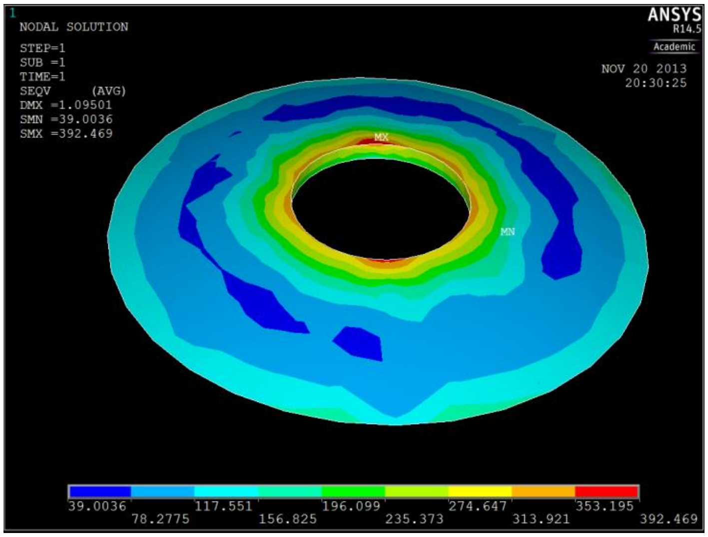
Picture 3



Picture 4



Picture 5

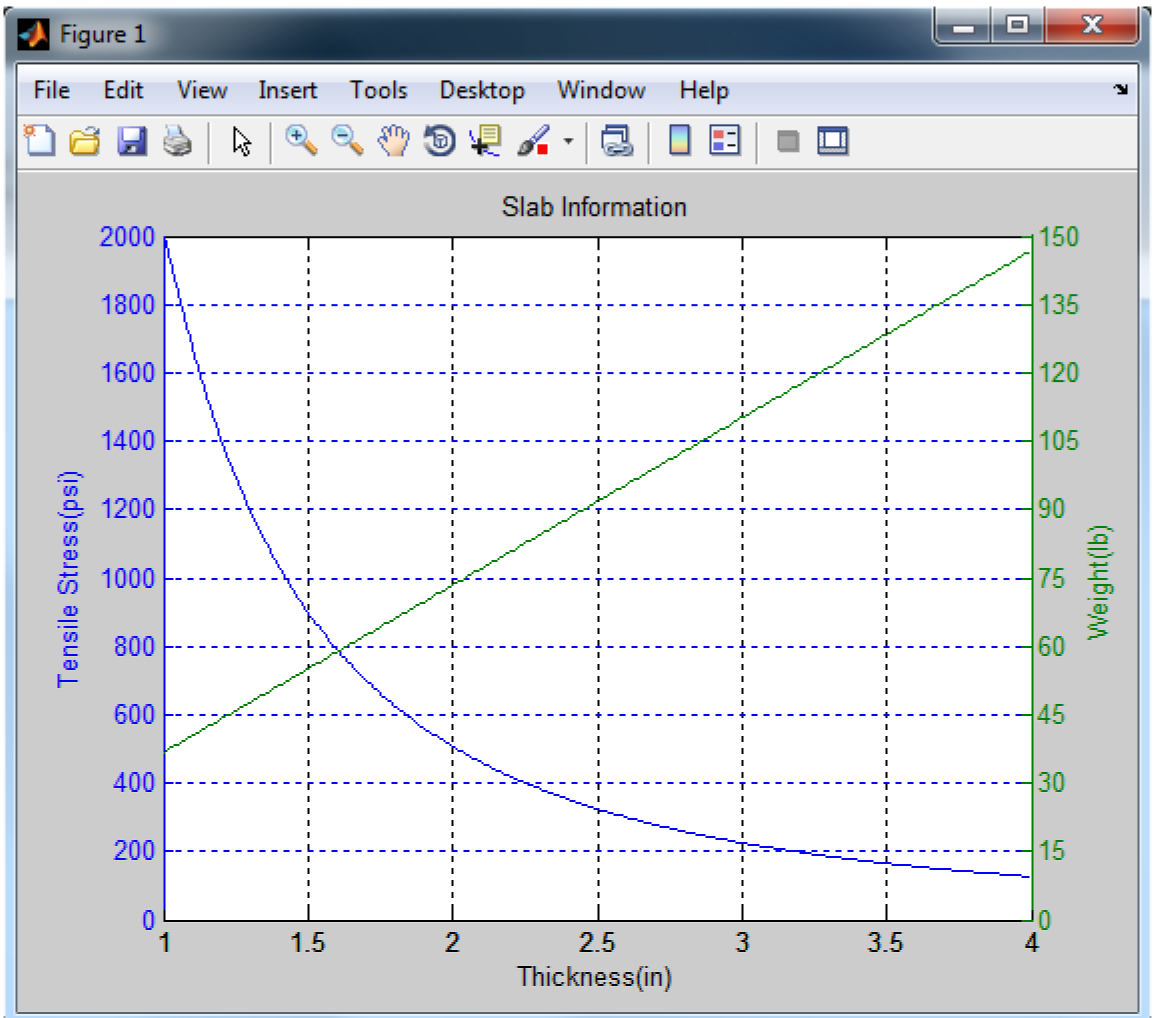


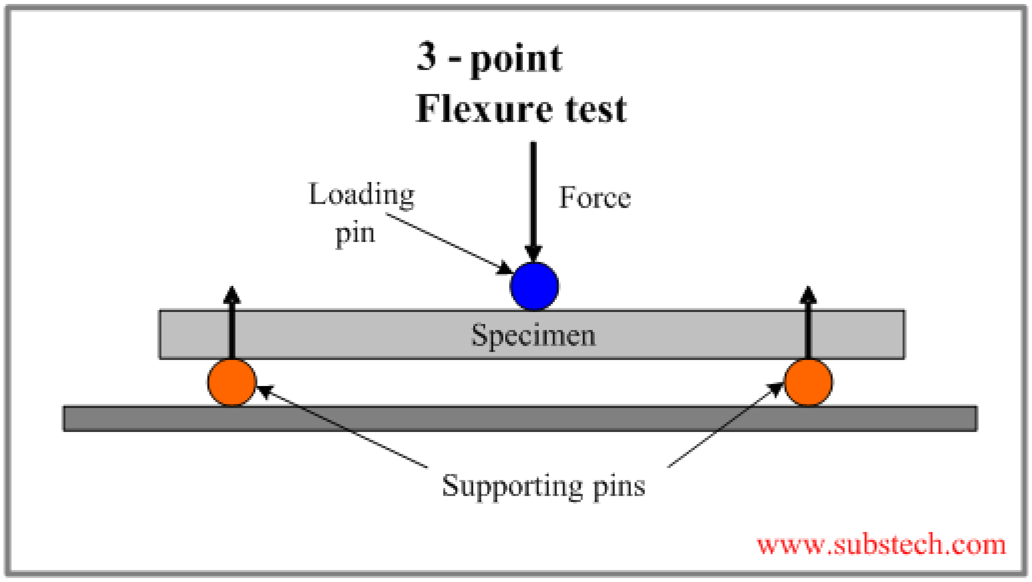
Cone

The cone shape was not chosen due to the fact it would be hard to incorporate a cone shape that is easy to sit/squat on while not using more materials than necessary. The dome provides more advantage when it comes to reducing stress in tension.

Thickness vs Weight/ Stress

The below table looks a 4in wide by 30in long beam with varying cross section. The stress is the bending stress of the beam. This shows that stress vs. thickness is nonlinear and gives us an estimate on effect that thickness plays in terms of stress. On the right axis is the calculated weight of the entire slab while the thickness varies. This analysis is helpful for estimating the behaviors of the flat circular slab. This chart is used after we determine the strength of a mix. First you find the equivalent tensile stress by matching the strength on the left axis. Then follow the line over to see where the value intersects the blue line. After trace that point on the blue line straight down to find your equivalent thickness. The green line shows the weight at that thickness.

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