Smooth Circular Footing on an Associated Mohr-Coulomb Medium

Problem description

The bearing capacity of a circular footing on associated Mohr-Coulomb medium is determined by MAP3D-VP and compared with a semi-analytic solution.

The circular footing, with a radius ‘a’ of 3m, is located on a material with the following properties:

Young’s modulus	E = 250.0 MPa
Poisson’s ratio	v = 0.2
Cohesion	c = 0.1 MPa
Friction angle	φ = 20°
Dilatancy angle	ψ = 20°

A semi-analytical solution, based on the slip–line method, was developed by Cox et al., (1961) to solve the axisymmetrical footing problem. It provides a value of the bearing pressure ‘q’ over the footing at failure for a friction angle of 20° of q = 20.1 c (where c is the cohesion of the material).

The corresponding slip-line net for a circular footing with a radius of ‘a’ is shown in Figure 1 (as referenced in Chen (1975)).

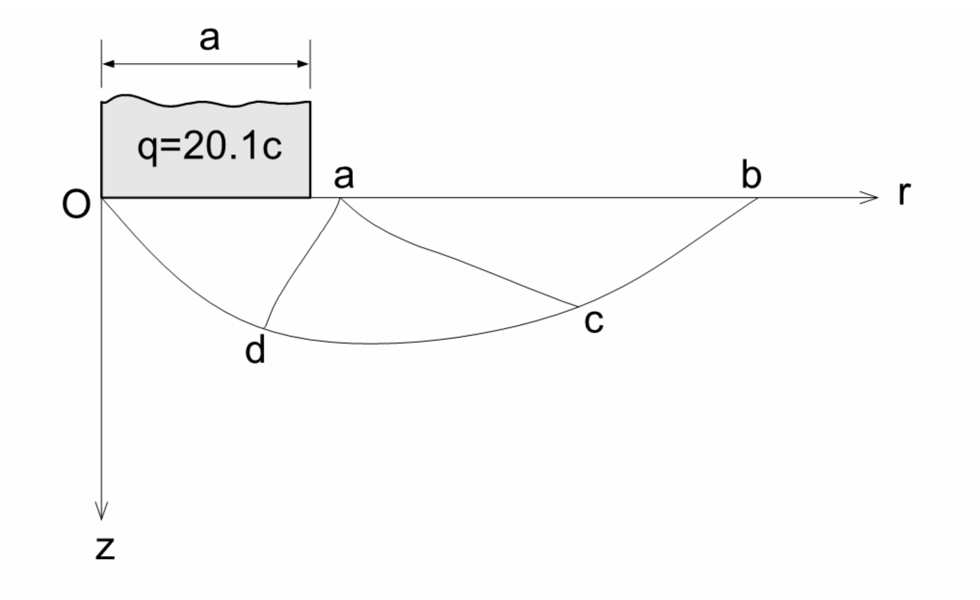

Figure 1. Cox slip-line net for a smooth circular footing where q is the bearing capacity (20.1 times the cohesion). Z is the axis of symmetry.

Model

The MAP3D-VP model geometry, with some fictitious force (FF) element blocks hidden, and the vertical solution grid, is shown in Figure 2.

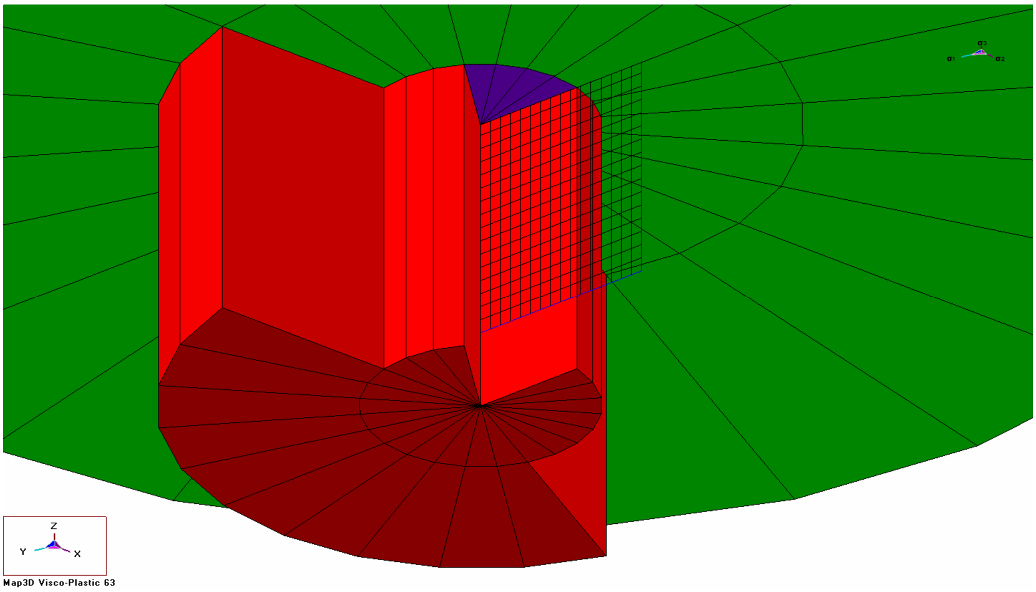

Figure 2. The MAP3D-VP model geometry used for this problem.

Vertical loading is applied in a series of steps to the 6m diameter circular footing shown as purple. The Mohr-Coulomb elasto-plastic material zone is constructed from FF blocks shown in red and extends 8m's beneath the ground surface green. Figure 3 shows the internal nodes generated within the plastic zone.

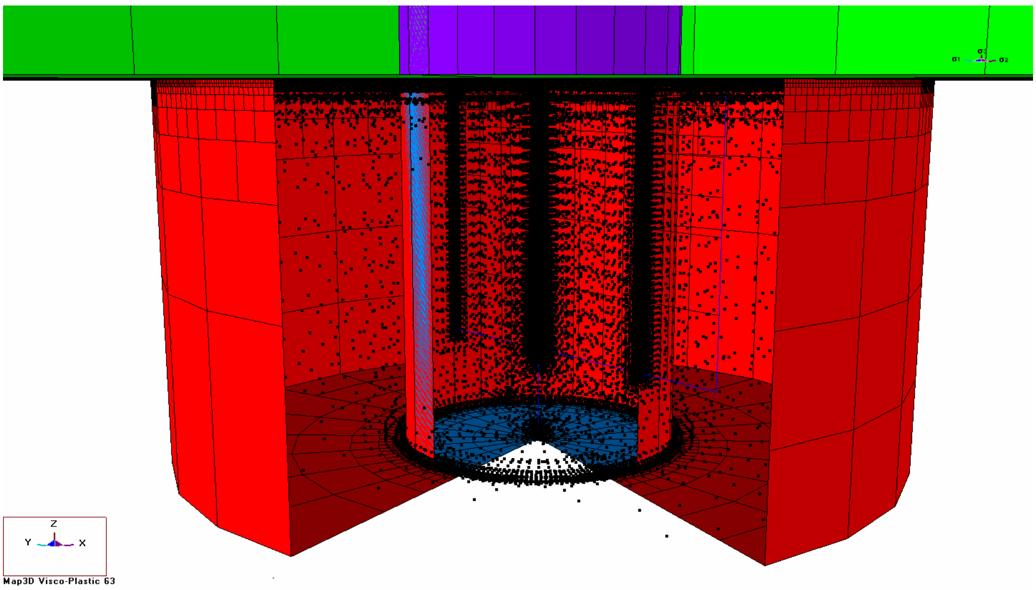

Figure 3. The MAP3D-VP model geometry showing interior nodes.

The figure has some faces hidden to show the internal nodes concentrated near the solution grids. A vertical solution grid used in the model beneath the footing is also shown on the figures. A line grid is also used for the load versus displacement plots and runs along the vertical Z axis.

Results and Discussion

The total displacements beneath the centre of the flexible footing have been plotted against the applied vertical loading in Figure 4. This plot shows the history of the bearing capacity of the footing through to collapse.   The plot includes the analytical value of the bearing load capacity of 2.01 MPa.

Contours of plastic maximum shear strain beneath the circular footing on the vertical solution grid are shown on Figure 5 (Mining Step 10 - bearing capacity).

Contours of plastic maximum shear strain beneath the circular footing on the vertical solution grid are shown on Figure 6. The LHS is prior to achieving the bearing pressure (Mining Step 9) and the RHS is at the bearing capacity (MS10).

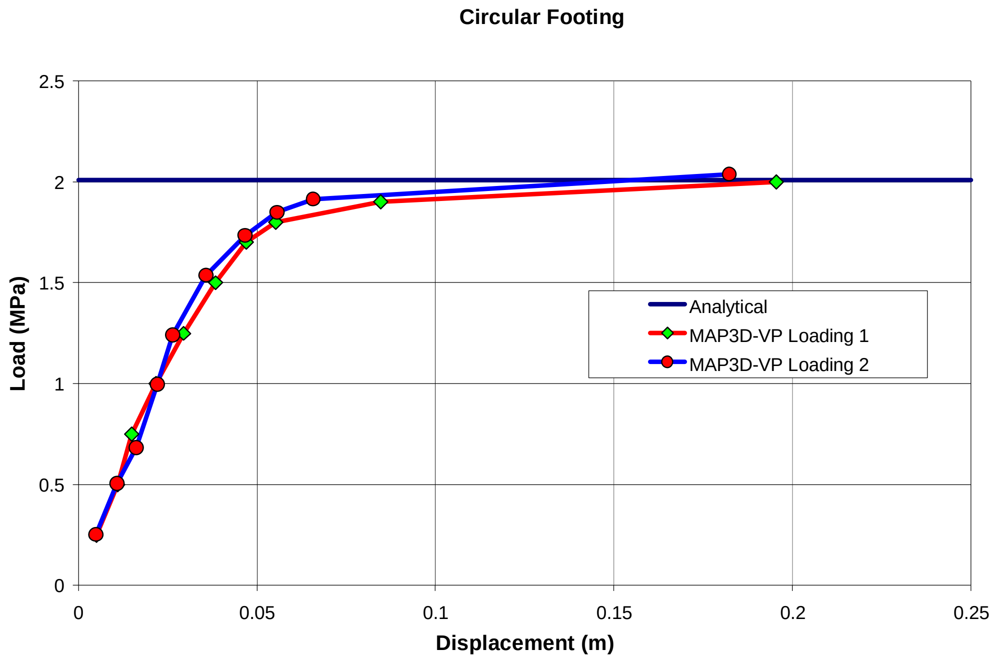

Figure 3. Load vs. displacement response for a circular footing on a Mohr-Coulomb material (includes two different loading paths for comparison).

The MAP3D-VP results are in very close agreement with the analytical solution.

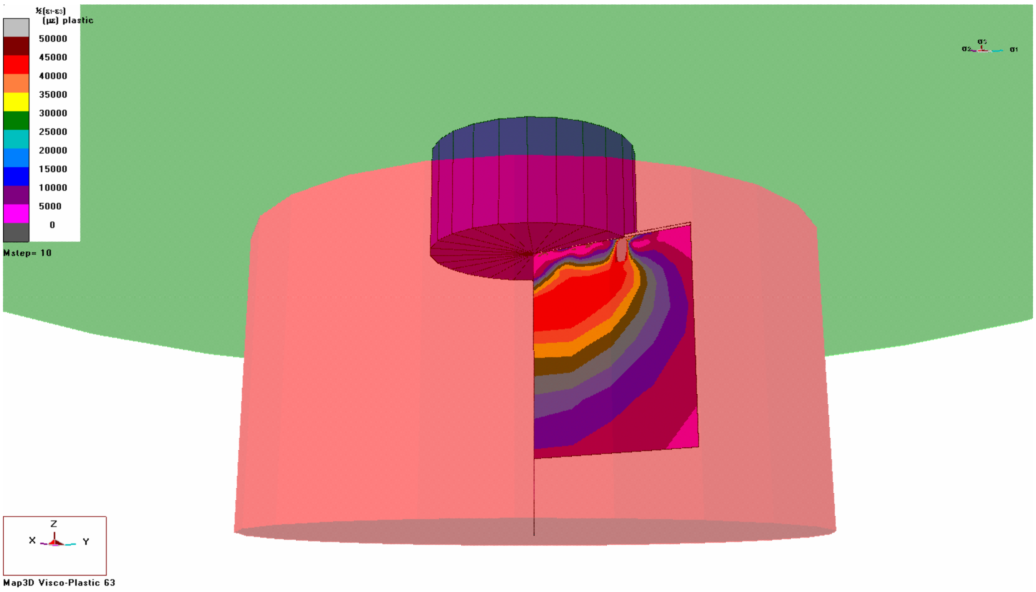

Figure 5. Contours of plastic strain beneath the circular footing at the bearing capacity (MS10). Hidden geometry is shown as translucent.

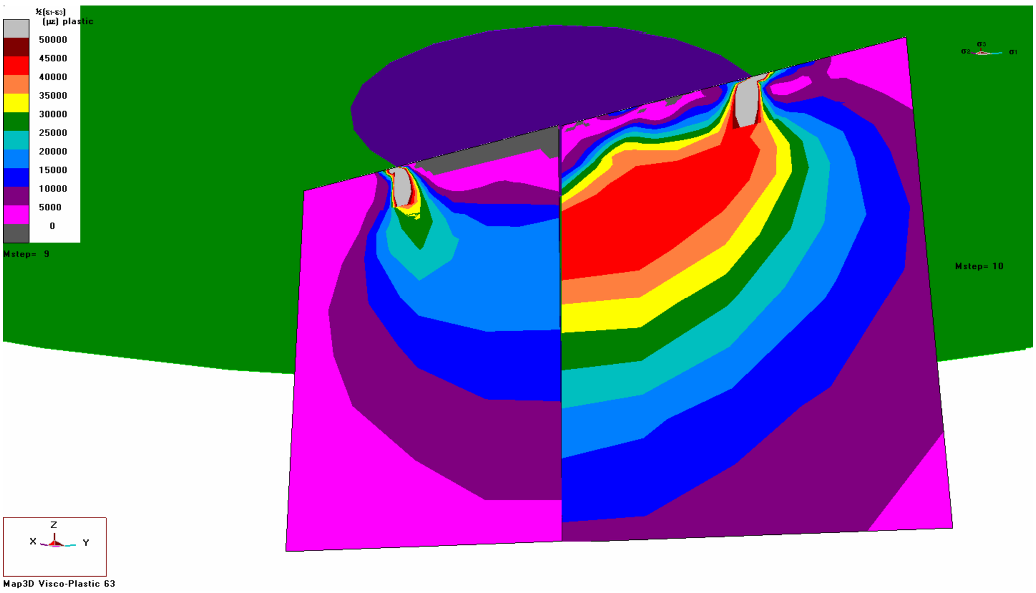

Figure 6. Contours of plastic strain beneath the circular footing prior (LHS), and at (RHS), the bearing capacity for MS9 and MS10 respectively.

References

Chen, W.-F. (1975) Bearing Capacity of Square, Rectangular and Circular Footings, in Limit Analysis and Soil Plasticity, Developments in Geotechnical Engineering 7, Ch. 7, pp. 295-340, New York: Elsevier Scientific Publishing Co.

Cox, A. D., G. Eason and H. G. Hopkins. (1961) Axially Symmetric Plastic Deformation in Soils. Phys. Trans. Royal Soc.London, Series A, 254 (1036), 1-45