Triaxial Test using Barcelona Basic Model

Keywords

2D, Axisymmetric, Barcelona Basic Model.

Problem Description

A drained triaxial compression test is modelled at three different suctions, as described in [1]. Due to the uniform stress field in this problem the size does not affect the results, so a sample of unit height has been used.

Discretisation

The triaxial tests were undertaken using a single QAX8P 2D quadrilateral element.

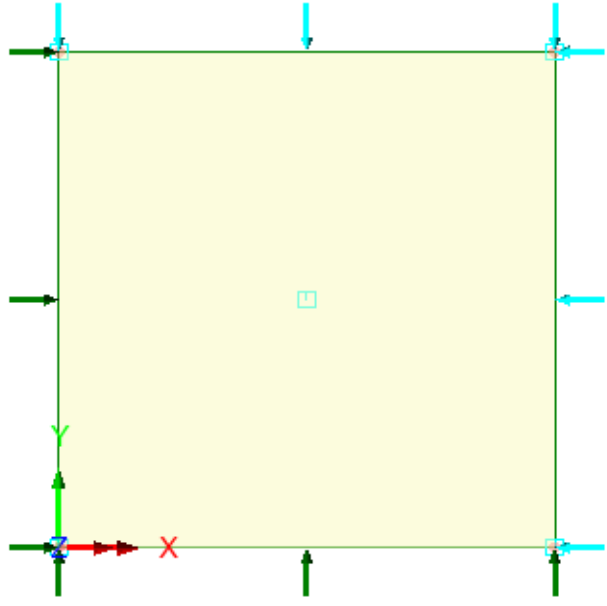

Figure 1: Finite element mesh showing supports.

Material Properties

The soil is modelled using the Barcelona Basic Model (BBM). Table 1 gives the material properties for the BBM. Table 2 gives two phase properties.

Table 1: Barcelona Basic material properties

Compression index at fully saturated state, λ_0	Swelling index, κ	Poisson's ratio, ν	Gradient of critical state line, M	Stiffness at infinite suction control, r
0.1	0.02	0.3	0.772	0.75
Increase in stiffness with suction control, β	Reference pressure p_{c0}	Elastic stiffness due to suction κ_s	Atmospheric pressure p_{atm}	Pre-consolidation pressure p_c
0.012	1	1E-8	1	24
Initial void ratio, e	Density			
1.157	1000			

The two-phase properties do not affect the result in this example as there is no fluid flow, however they must be defined so that an effective stress is calculated. The following are what are used in the model file.

Table 2: Two Phase material properties

Solid bulk modulus, K_s	Bulk modulus of fluid phase, K_f (absolute value)	Hydraulic conductivity in global X direction, k_x	Hydraulic conductivity in global Y direction, k_y	Hydraulic conductivity in global Z direction, k_z
Incompressible	2E9	4.41299E-6	4.41299E-6	4.41299E-6
Density of fluid	Irreducible saturation	Degree of saturation to be considered as fully saturated	Partially saturated	Fitting parameter for rate of water extraction
1 t/m^3	0	1	Analytical	1.414
Weight factor	Fitting parameter for air entry	Parameter for permeability		
1	-0.333	0.0		

Loading Conditions

The left-hand side of the sample is restrained in the horizontal direction (axis of symmetry) and the bottom of the sample is restrained in the vertical direction. The pore water pressure is fixed throughout each test. A face load of 20kPa is applied to the top and right-hand edges of the sample before an applied vertical displacement is introduced to the top edge using load curves up to an axial strain of 50%.

Theory

Critical state theory states that the deviatoric stress (Q) can be calculated from the mean pressure (P) and the slope of the critical state line (M) as

$$Q = P\frac{3M}{3-M} \qquad (1)$$

Modelling Hints

For the three cases, the initial stresses and void ratios are different. This is to represent a sample of the same soil which has undergone isotropic compression due to the change in effective stress from the application of suction. These starting values are shown in Table 3.

Table 3: Initial conditions

Applied suction, u	Initial mean pressure, P	Initial void ratio, e
0kPa	20.00kPa	1.191
100kPa	44.20kPa	1.157
200kPa	56.38kPa	1.146

Comparison

Using (1), the critical state deviatoric stresses for the triaxial tests with suctions of 0kPa, 100kPa and 200kPa can be calculated to be 20.79kPa, 45.95kPa and 58.61kPa respectively. It can be seen in Figure 1 that these values asymptotically approached in the simulation.

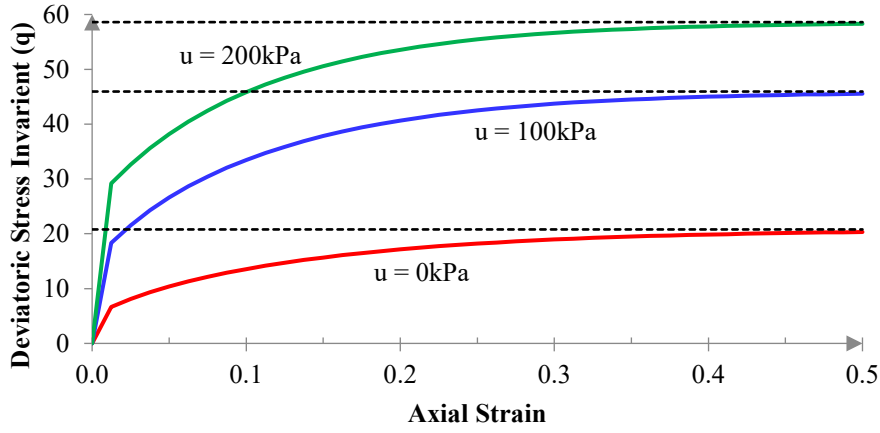

Figure 2: Change in deviatoric stress invariant with increase in axial strain.

Figures 2 and 3 show how this relates to the critical state line and to the void ratio.

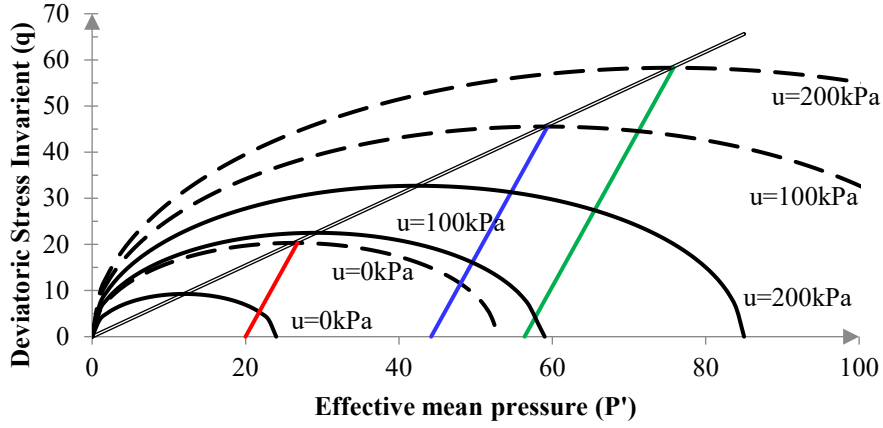

Figure 3: Effective mean pressure plotted against deviatoric stress invariant.

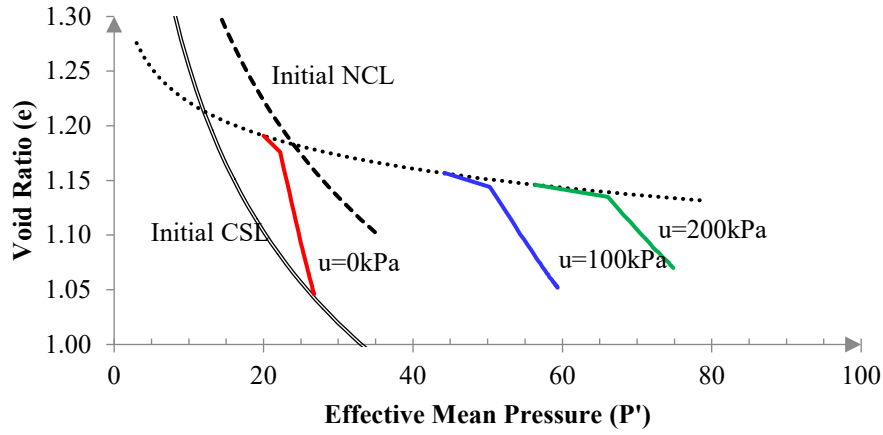

Figure 3: Effective mean pressure plotted against void ratio for the three triaxial tests.

References

[1] Finite element formulation and algorithms for unsaturated soils. Part II: Verification and application Sheng, D, Smith D.W, Sloan, S.W. & Gens, A. Int. J. Numer. Anal. Meth. Geomech., 27:767–790 (2003).

Input Data

Strip Footing on Unsaturated Soil with BBM.lvb