Behaviour of Sand using Duncan-Chang Model

Keywords

Axisymmetric, Duncan-Chang Model, Load Curve.

Problem Description

This example shows how to use the Duncan-Chang material model to replicate nonlinear soil behaviour during a standard drained triaxial compression test including loading, unloading and reloading. The study's findings were taken from Duncan and Chang's 1970 paper [1].

Discretisation

The problem is modelled using a single quadrilateral axisymmetric strain element, QAX4M. Boundary supports are shown in Figure 1.

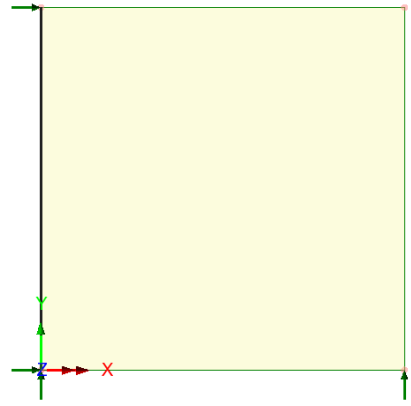

Figure 1: Finite element mesh showing supports.

Material Properties

The nonlinear material behaviour is modelled using a Duncan-Chang criterion. The material properties are as follows:

Table 1: material properties

Cohesion, c	Friction angle, φ	Change of angle of friction	Failure ratio	Density
0 kPa	36.6	0°	0.91	2.7 t/m^3
Atmospheric pressure	Initial Young's modulus number	Elastic Young's modulus number	Initial Young's modulus exponent	Poisson's ratio
101.3 kN/m^2	2000	2120	0.54	0.32
Young's modulus when soil fails	Poisson's ratio when soil fails			
1	0.495			

Loading Conditions

The compression test is conducted on a dense sand specimen at a confining pressure of 294.3 kN/m^2. To study the behaviour of the sand, the specimen is subjected to axial cycles of loading, unloading and reloading.

Theory

Soils have a highly nonlinear mechanical behaviour and their stiffness is stress dependent. The Duncan-Chang model was created to address these features (Duncan and Chang, 1970) [1]. Based on standard tri-axial soil tests, the model approximates the stress-strain variation by the following hyperbolic equation

$$\sigma_1 - \sigma_3 = \frac{\varepsilon_1}{a + b\varepsilon_1}$$

where, a and b are hyperbolic parameters whose application to a triaxial test plot is shown below.

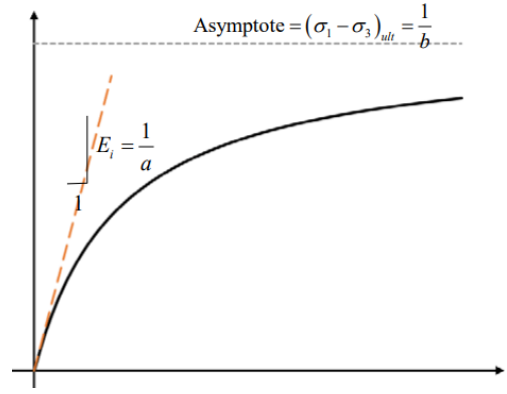

Figure 2: Hyperbolic stress-strain curve

Modelling Hints

In this example the load is applied using load curves. Loads curves are used to describe the variation of the loading in multistep analyses. Two load curves have been used one for the confining stress and the other for the variation of the applied axial pressure during the test.

Comparison

Results for the test can be found in figure 3 which shows the plots of axial strain versus deviatoric stress obtained by LUSAS compared with results obtained by RS2. There is perfect agreement between both sets of results.

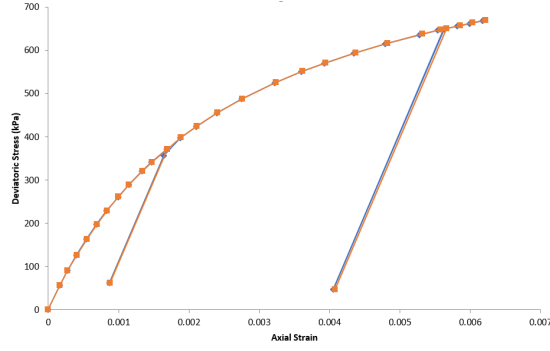

Figure 3: Comparison of LUSAS with RS2

References

[1] J. M. Duncan and C. Y. Chang, Nonlinear analysis of stress and strain in soils, J. of Soil Mech. and Foundation Division, ASCE, 96 (SM5), pp. 1629-1653, 1970.

Input Data

duncan_chang.lvb