

17 Non-Linear Behavior of Sand (Duncan-Chang Model)

17.1 Problem Description

This problem demonstrates the applicability of Duncan-Chang model in simulation of nonlinear behavior of soils. The nonlinear behavior of dense and loose Silica sand in triaxial tests is the focus of this example. The experimental results are taken from an article by Duncan and Chang (1970). The stress paths of the experiments include loading, unloading and reloading of the samples. The Duncan-Chang model parameters for the dense and loose Silica sands are presented in Table 17-1.

Table 17-1 : Duncan Chang model parameters

<i>Parameter</i>	<i>Dense Silica Sand</i>	<i>Loose Silica Sand</i>
Modulus number (K_E)	2000	295
Unloading Modulus (K_{ur})	2120	1090
Modulus exponent (n)	0.54	0.65
Failure ratio (R_f)	0.91	0.90
Cohesion (c)	0 kPa	0 kPa
Friction angle (ϕ)	36.5°	30.4°
Poisson's ratio (ν)	0.32	0.32

17.2 Model information

The drained compressive triaxial tests of the sample were modeled in **RS3** using 4-noded tetrahedral elements. The deviatoric stress is generated in the sample in a load-control process. The axial loading in the z direction increases in a number of stages, and automatic load stepping is considered in each stage. See Figure 17-1 for finite element mesh used in this simulation. See Figure 17-2 for the boundary conditions and an example of the axial and radial loads used.

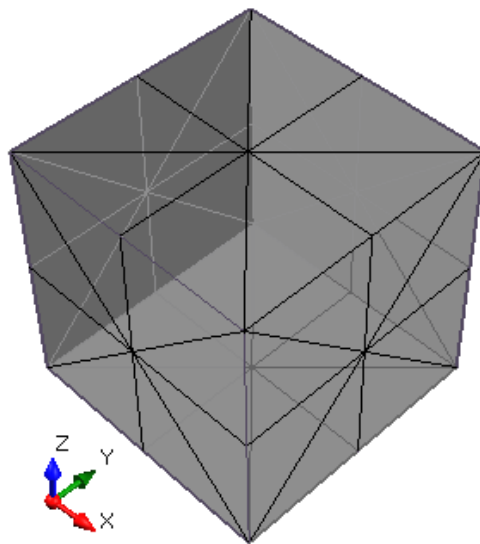


Figure 17-1 Mesh for axisymmetric RS3 analysis

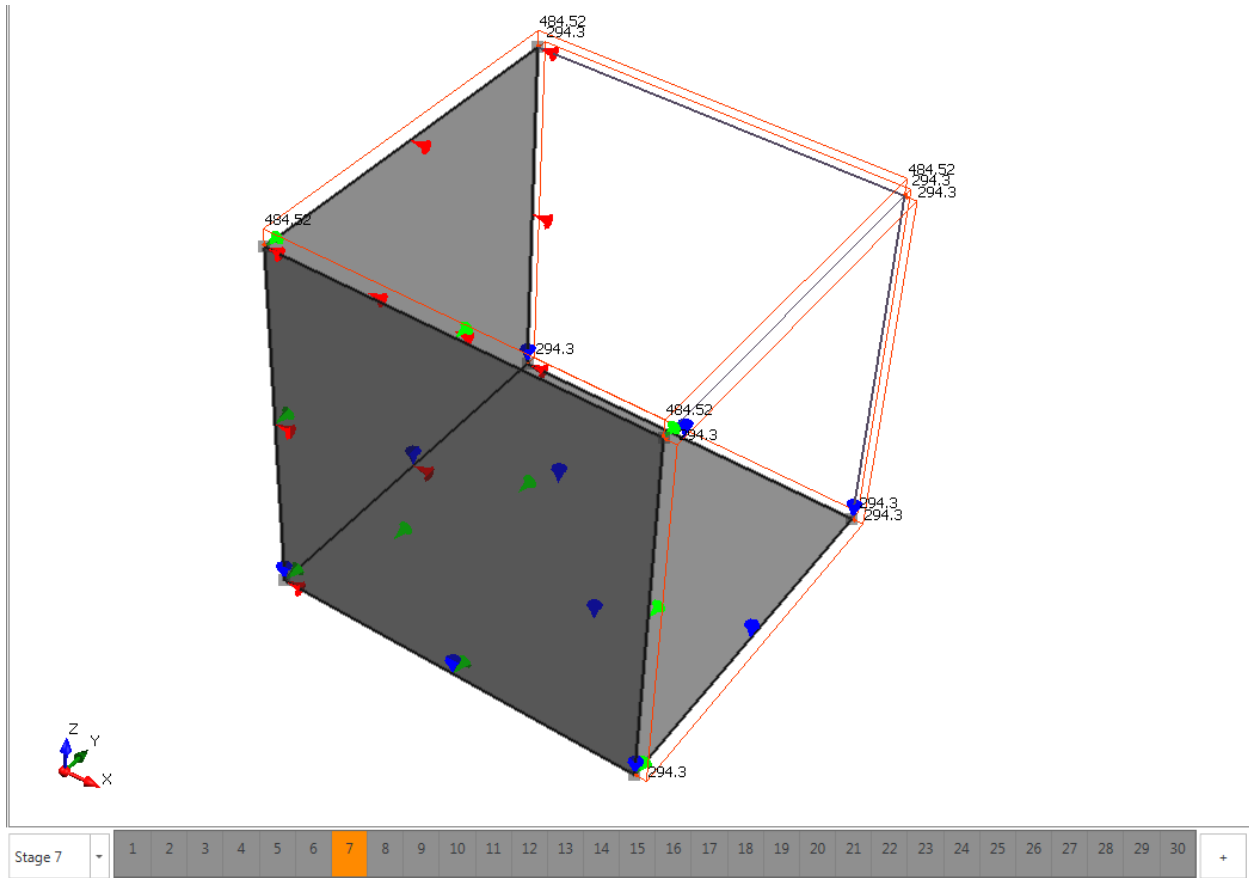


Figure 17-2 Boundary conditions and load for axisymmetric *RS3* analysis

17.3 Results

Figure 17-3 and Figure 17-4 show the plots of $\varepsilon_a - q$ obtained in numerical simulations using *RS3* in comparison with the observed behavior and the numerical results obtained by Duncan and Chang (1970).

There is a good agreement between the experimental data and the numerical results. The difference between the numerical results of *RS3* and the ones presented by Duncan and Chang is because in *RS3* the elastic parameters, from load step n to $n+1$, are calculated based on the state of material at step n while in the latter they are averaged over the increment.

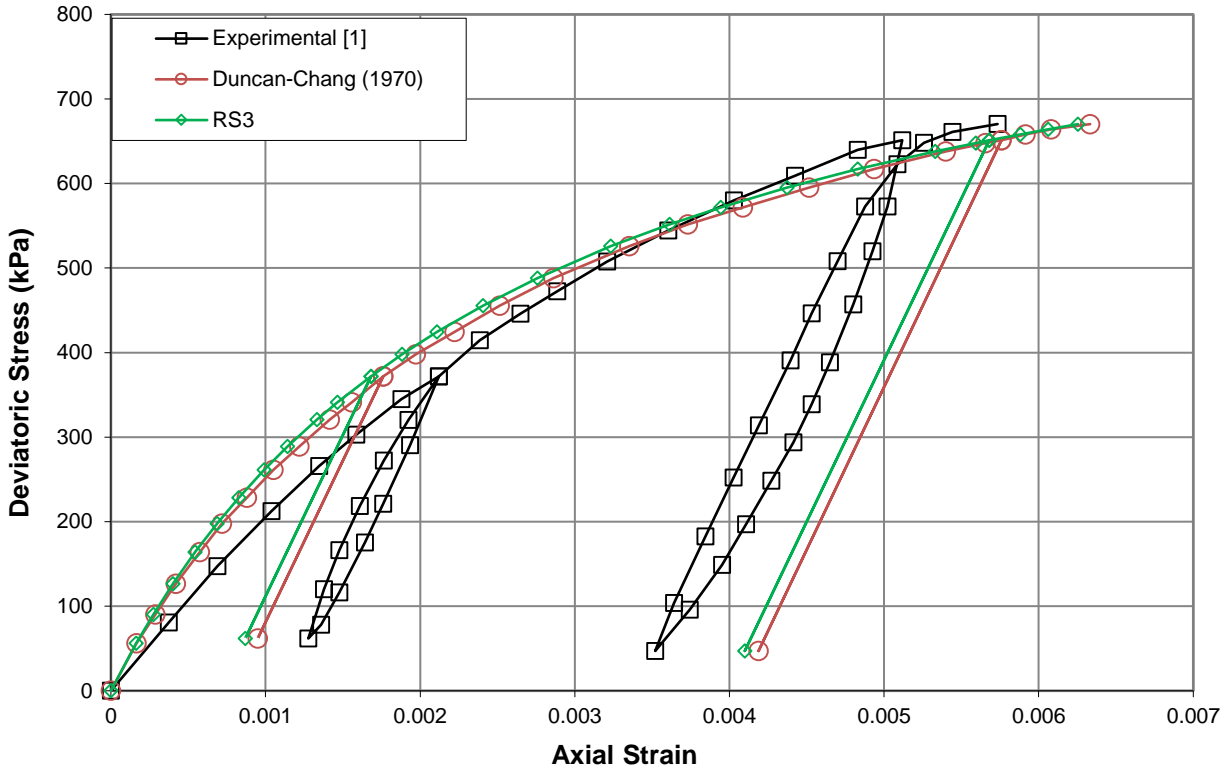


Figure 17-3: Triaxial test on dense Silica sand, variation of deviatoric stress with axial strain

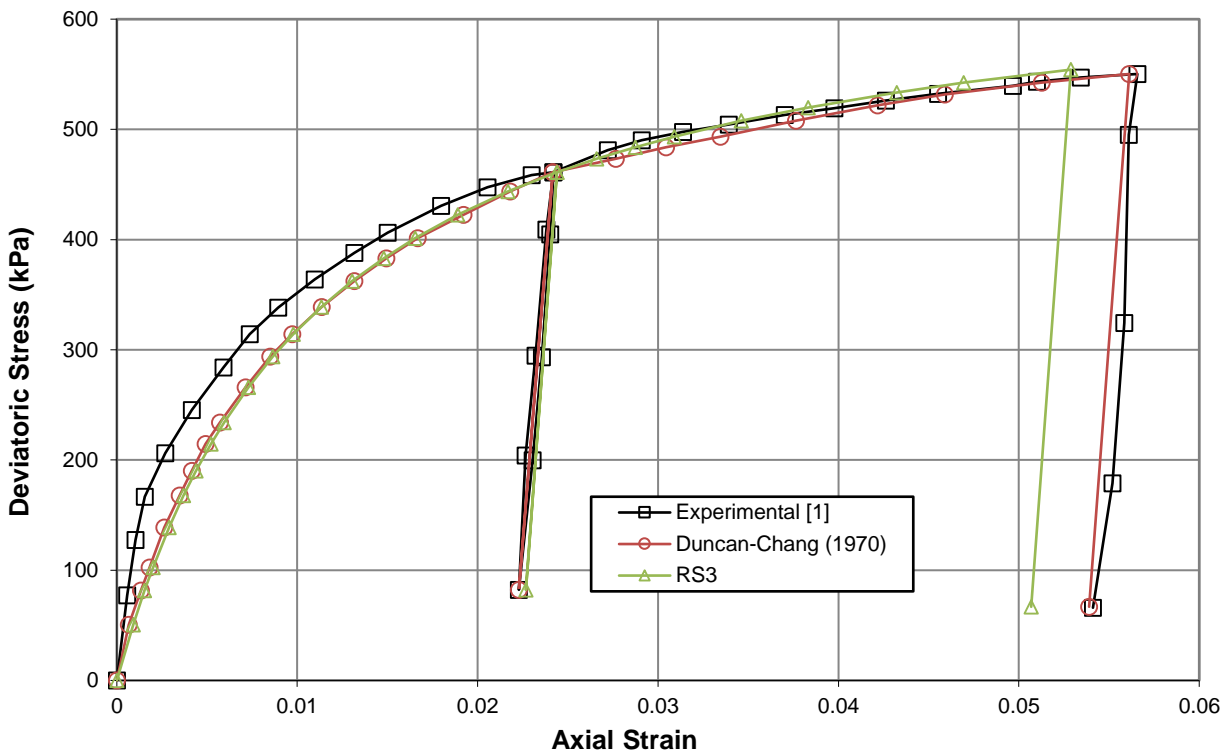


Figure 17-4 : Triaxial test on loose Silica sand, variation of deviatoric stress with axial strain

17.4 References

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

17.5 Data Files

The input data files can be found in the **RS3** installation folder:

- **V017 Dense.rs3model**
- **V017 Loose.rs3model**