14 Uniaxial Tests on a Mohr-Coulomb Material with Ubiquitous Joints

14.1 Problem Description

This problem verifies the uniaxial compressive strength of a Mohr-Coulomb material with varying sets of joints (Zienkiewicz & Pande, 1977). The material is isotropic (elastic-fully plastic) with the following properties:

Young's modulus = 20,000 kPa
Poisson's ratio = 0.3
Cohesion = 100 kPa
Friction angle = 35°
Dilation angle = 35°

The model was built in ***RS3*** and extruded to create a prismatic shape. The jointed rock mass is considered to be composed of an intact material that is intercepted by up to three sets of weak planes. The spacing of the weak planes is such that the overall effects of the sets can be smeared and averaged over the control volume of the material. Such a configuration with one, two or three sets of weak planes is illustrated in Figure 14-1 where the weak planes are oriented at an arbitrary angle θ_1, θ_2 and θ_3 in the rock mass.

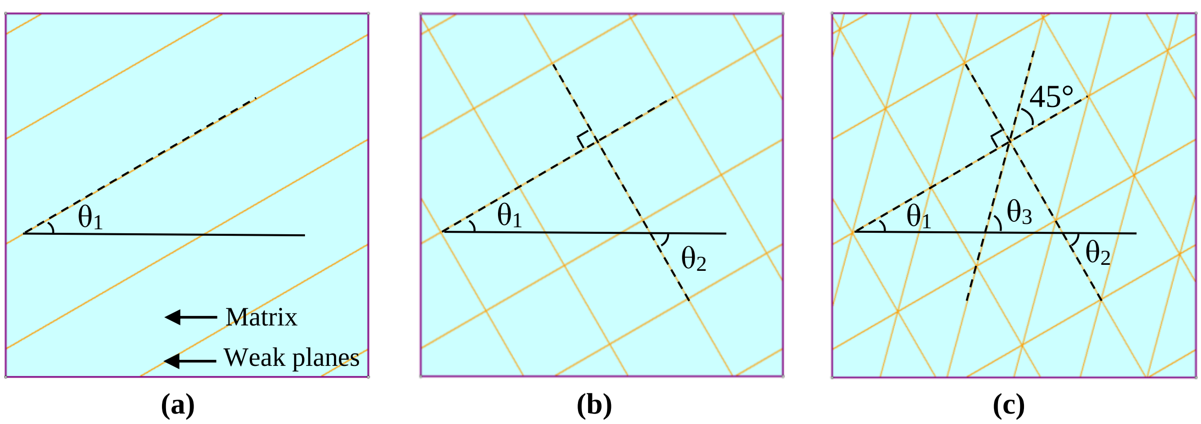

Figure 14-1: Typical material with (a) one set, (b) two sets and (c) three sets of weak planes with inclination angle θ_1, θ_2 and θ_3 respectively.

All joint sets are modeled as Mohr-Coulomb material with the following properties:

Cohesion = 40 kPa
Friction angle = 30°
Dilation angle = 30°

14.2 Analytical Solution

The analytical solution is taken from Pietruszczak (2010) who used a simple evaluation of failure functions for the weak planes and the matrix for different configurations of the model under uniaxial loading.

14.3 Model Properties

The model for this problem is built in ***RS3*** as a typical uniaxial compression test with a graded mesh of 10-noded tetrahedron elements as shown in Figure 14-2. A displacement is applied at the top and increases with each stage. The model has dimensions of 10 cm length, 10 cm width and 20 cm height. No in-situ field stress is applied to the model.

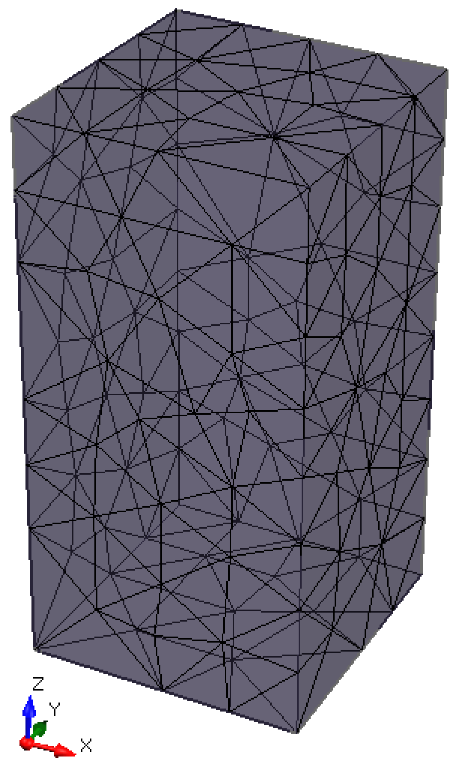

Figure 14-2: Model of uniaxial tests on a Mohr-Coulomb material with ubiquitous joints in *RS3*

14.4 Results and Discussions

Figure 14-3, Figure 14-4 and Figure 14-5 shows the uniaxial compressive strength at different joint inclinations and varying number of joint sets. The ***RS3*** results are in very close agreement with the analytical solution.

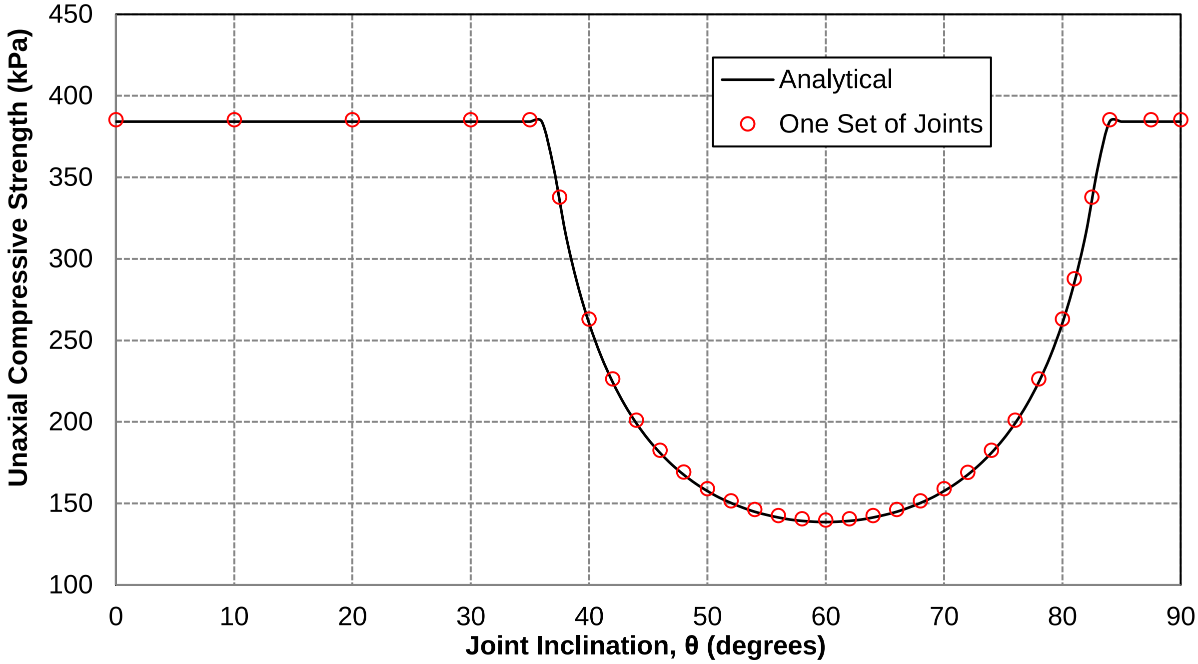

Figure 14-3: Variation of uniaxial compressive strength for one set of joints

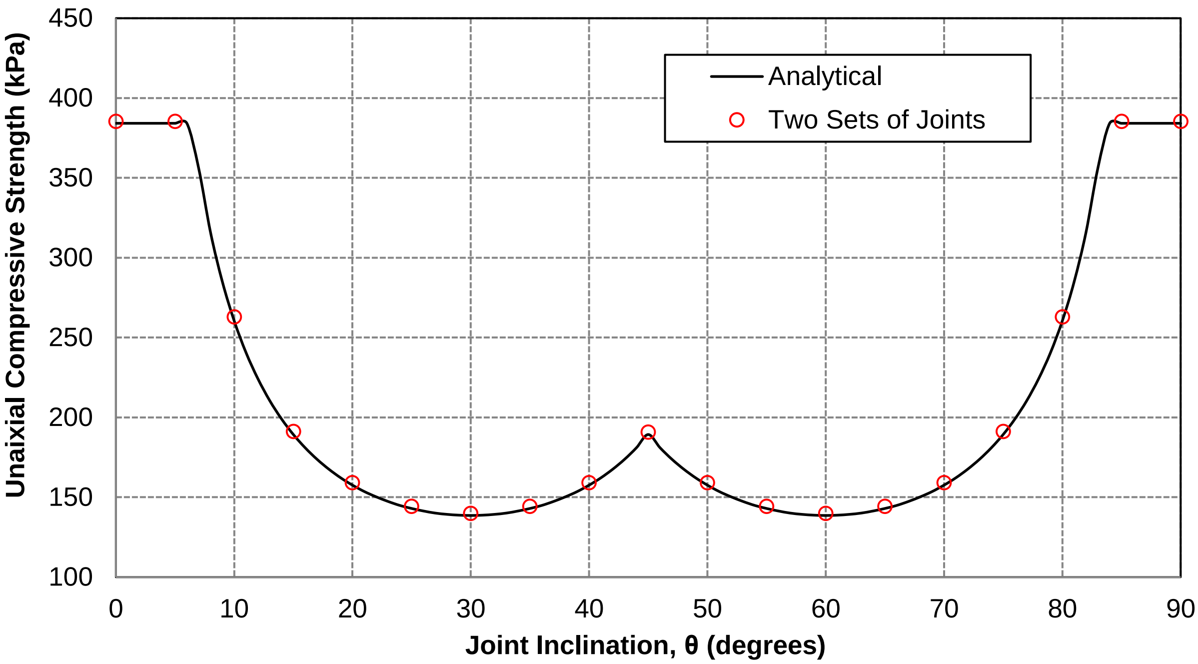

Figure 14-4: Variation of uniaxial compressive strength for two sets of joints

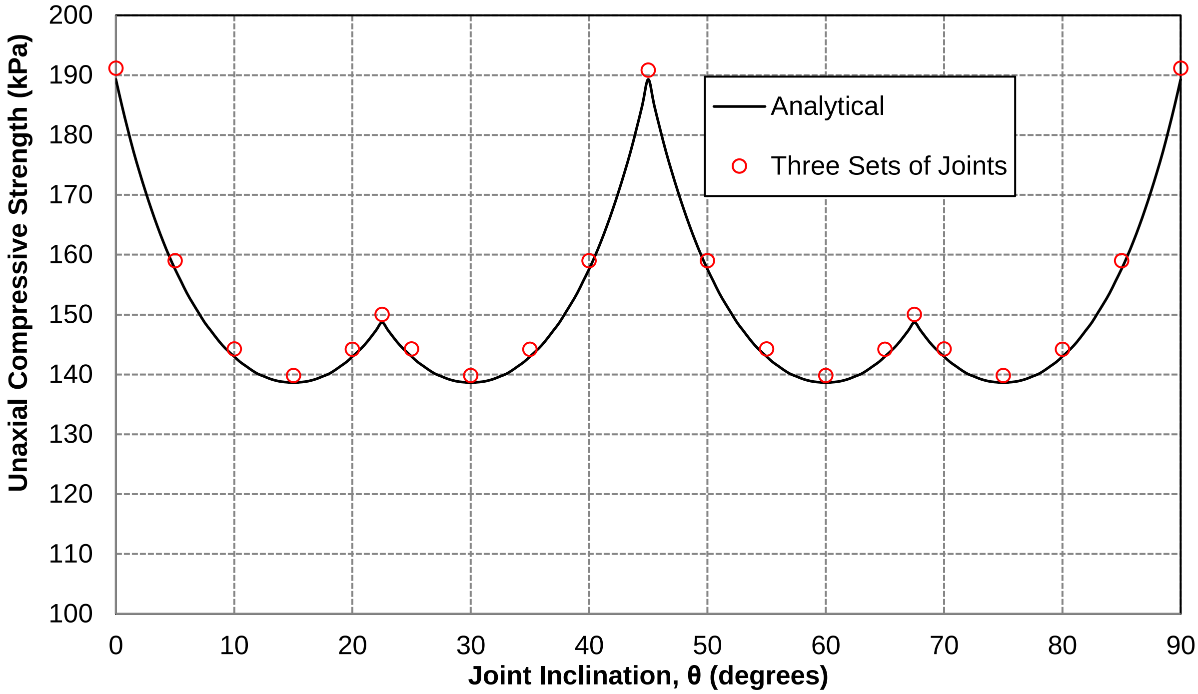

Figure 14-5: Variation of uniaxial compressive strength for three sets of joints

14.5 References

1. Pietruszczak, S. (2010). *Fundamentals of Plasticity in Geomechanics*. CRC Press/Balkema, The Netherlands.

2. Zienkiewicz, O.C. & Pande G.N. (1977). Time-dependent multilaminate model of rocks- A numerical study of deformation and failure of rock masses, *International Journal for Numerical and Analytical Methods in Geomechanics*, 1(3): 219–247.

14.6 Data Files

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

- **V014 Joints1.rs3model**
- **V014 Joints2.rs3model**
- **V014 Joints3.rs3model**