OptumG3

Verification of Mohr-Coulomb model in different soil tests

OPTUM COMPUTATIONAL ENGINEERING

Optum Computational Engineering | Hejrevej 37, 3. floor | 2400 Kbh. NV.
+45 30 11 63 55 | contact@optumce.com

Table of content

1 Introduction

1.1 Failure criterion

The Mohr-Coulomb failure criterion is given by

$$F = \left|\sigma_1 - \sigma_3\right| + (\sigma_1 + \sigma_3)\sin\phi - 2c\cos\phi = 0 \tag{1.1}$$

where c is the cohesion and ϕ is the friction angle. The principal stresses (positive in tension) are ordered as:

$$\sigma_1 \leq \sigma_2 \leq \sigma_3 \tag{1.2}$$

1.2 Elastic law

The Mohr-Coulomb model uses Hooke's law which is given in terms of principal stresses and strains by

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{pmatrix} = \frac{1}{E}\begin{bmatrix} 1 & -\nu & -\nu \\ -\nu & 1 & -\nu \\ -\nu & -\nu & 1 \end{bmatrix}\begin{pmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \end{pmatrix} \tag{1.3}$$

where E is Young's modulus and ν is Poisson's ratio.

1.3 Biaxial test

In biaxial compression, failure occurs when

$$\sigma_{1,f} = \sigma_3 \frac{1+\sin\phi}{1-\sin\phi} - 2c\frac{\cos\phi}{1-\sin\phi} \tag{1.4}$$

1.4 Triaxial tests

In triaxial compression, failure occurs when

$$\sigma_{1,f} = \sigma_3 \frac{1+\sin\phi}{1-\sin\phi} - 2c\frac{\cos\phi}{1-\sin\phi} \tag{1.5}$$

while, in extension, failure occurs when

$$\sigma_{3,f} = \sigma_1 \frac{1-\sin\phi}{1+\sin\phi} + 2c\frac{\cos\phi}{1+\sin\phi} \tag{1.6}$$

In triaxial compression with $\sigma_1 < \sigma_2 = \sigma_3$, the strains below failure are given by

$$\varepsilon_1 = \frac{1}{E}\ \sigma_1 - 2\nu\sigma_3\ \ , \ \ \varepsilon_2 = \varepsilon_3 = \frac{1}{E}\ (1-\nu)\sigma_3 - \nu\sigma_1 \tag{1.7}$$

2 Biaxial test

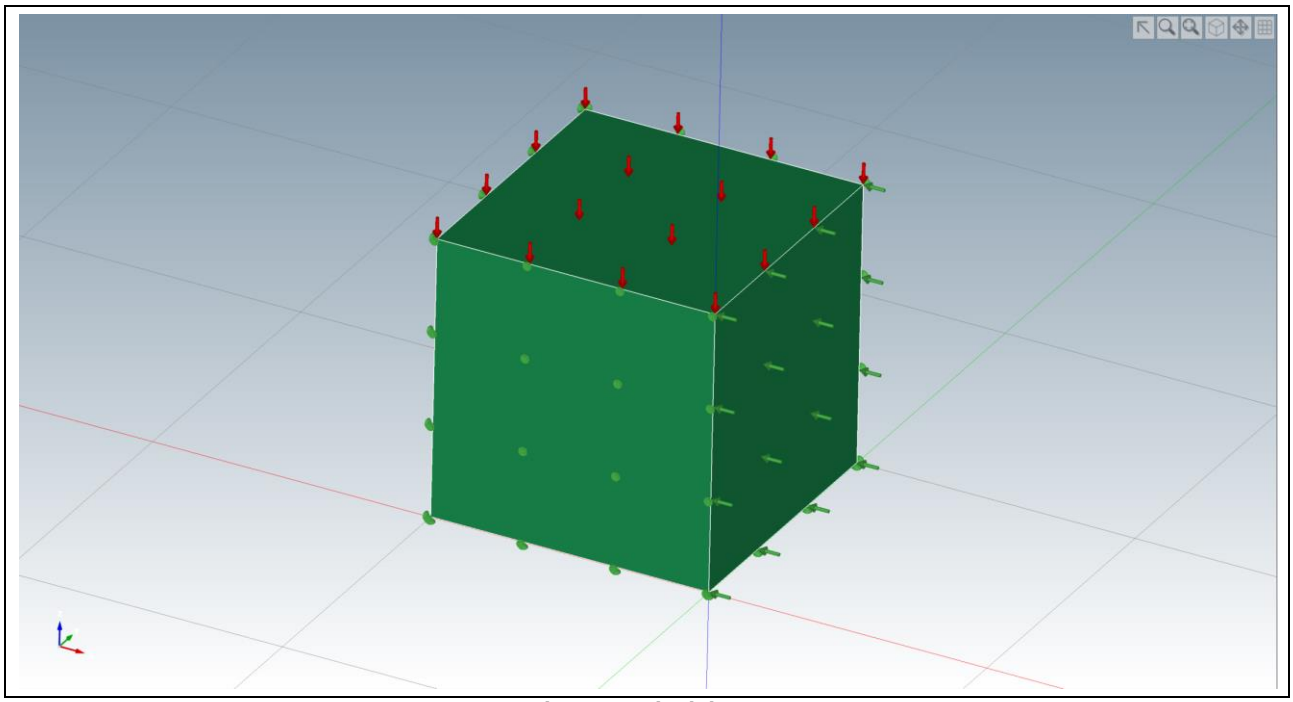

Figure 1: Biaxial test

Benchmark	262.088
Results	262.088
Discrepancy	0.00%

General description:
Cubic 5x5m specimen. Selected sides normally supported to reproduce plane strain conditions. A fixed load of -100 kPa is applied along with a multiplier load of -1kPa. Limit analysis is then used to determine the collapse multiplier.

Material properties:

General	
ID	1
Orientation	FORWARD
Shape type	SOLID

Material	
Name	MC Basic
Color	click to change
Material Model	Mohr-Coulomb
Reducible Strength	Yes

Strength	
c (kPa)	5
ϕ (°)	25

Unit Weight	
γ (kN/m³)	0

Stage settings

Settings	
Element Type	Mixed
No of Elements	1

Mesh	
Mesh Adaptivity	No

3 Triaxial compression test

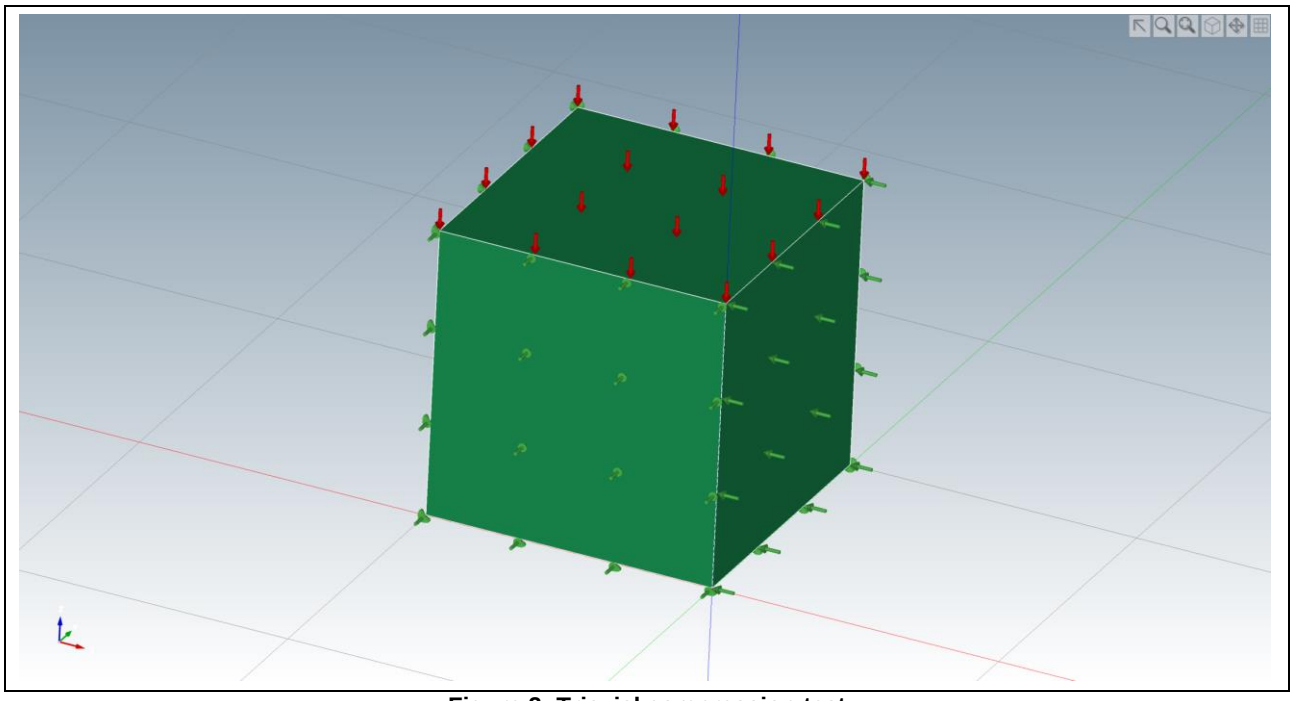

Figure 2: Triaxial compression test

Benchmark	262.088
Result	262.088
Discrepancy	0.00%

General description:
Cubic 5x5m specimen. Selected sides normally supported to reproduce triaxial conditions. Fixed load of -100 kPa are applied along with a multiplier load of -1kPa. Limit analysis is then used to determine the collapse multiplier.

Material properties:

General	
ID	1
Orientation	FORWARD
Shape type	SOLID

Material	
Name	MC Basic
Color	click to change
Material Model	Mohr-Coulomb
Reducible Strength	Yes

Strength	
c (kPa)	5
ϕ (°)	25

Unit Weight	
γ (kN/m³)	0

Stage settings:

4 Triaxial extension test

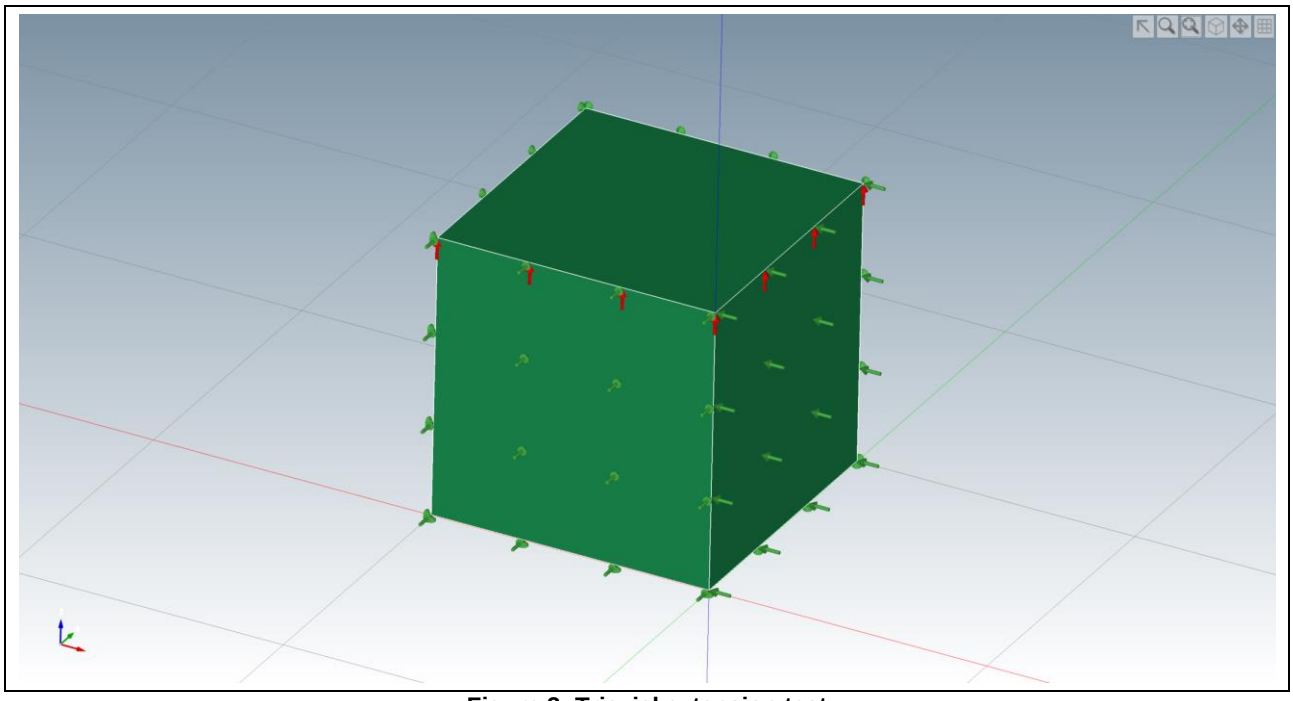

Figure 3: Triaxial extension test

Benchmark	-34.215
Result	-34.215
Discrepancy	0.00%

General description:
Cubic 5x5m specimen. Selected sides normally supported to reproduce triaxial conditions. Fixed load of -100 kPa are applied along with a multiplier load of 1kPa. Limit analysis is then used to determine the collapse multiplier.

Material properties:

General	
ID	1
Orientation	FORWARD
Shape type	SOLID

Material	
Name	MC Basic
Color	click to change
Material Model	Mohr-Coulomb
Reducible Strength	Yes

Strength	
c (kPa)	5
ϕ (°)	25

Unit Weight	
γ (kN/m³)	0

Stage settings:

5 Displacements

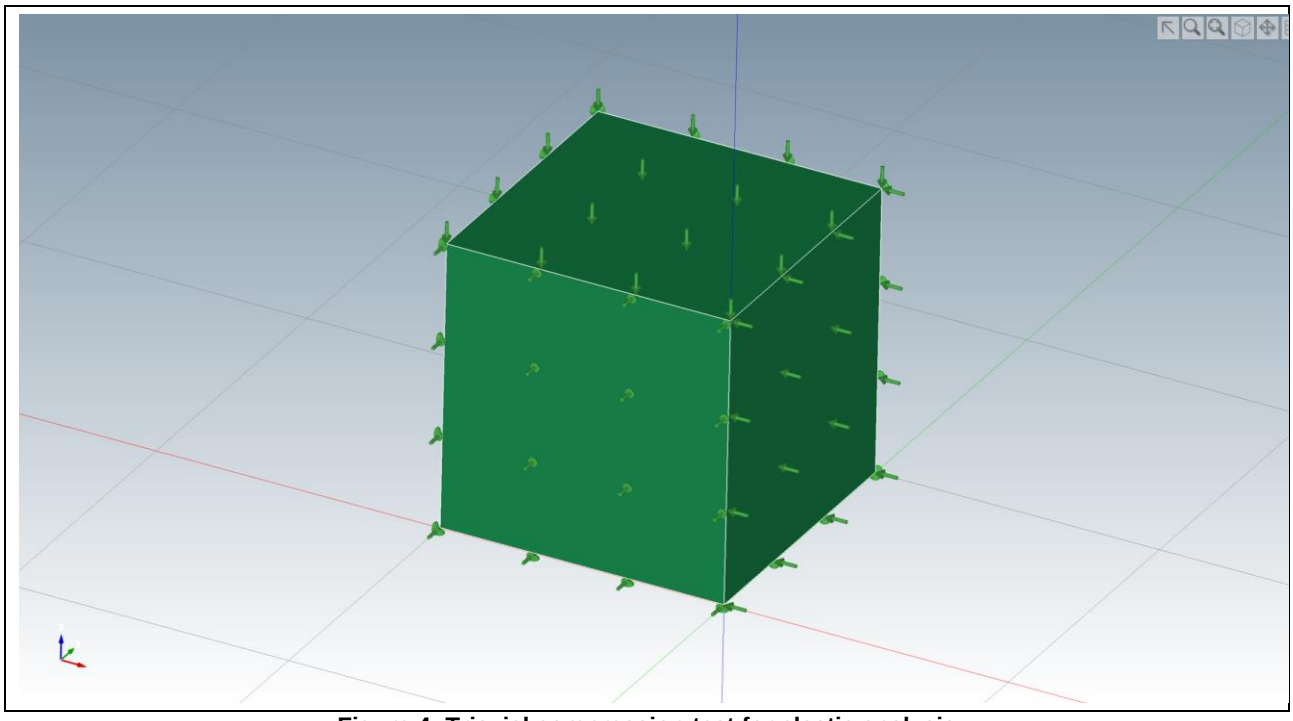

Figure 4: Triaxial compression test for elastic analysis

Results:

	Result	Benchmark	Discrepancy (%)
ε_1	-1.5	-1.5	0.00%
ε_2	-0.25	-0.25	0.00%
ε_3	-0.25	-0.25	0.00%

General description:
Cubic 5x5m specimen. Selected sides normally supported to reproduce triaxial conditions. Fixed load of -100 kPa are applied horizontally along with a fixed load of -200 vertically. Elastic analysis is then used to determine the displacements.

Material properties:

Material	
Name	MC Basic
Color	click to change
Material Model	Mohr-Coulomb
Reducible Strength	Yes

Strength	
c (kPa)	5
ϕ (°)	25

Unit Weight	
γ (kN/m³)	0

Tension Cut-Off

Flow Rule

Stiffness	
Parameter Set	A
E (MPa)	0.1
ν	0.25

Initial Conditions

Stage settings:

Settings	
Element Type	Mixed
No of Elements	1

Mesh	
Mesh Adaptivity	No