NEW MOHR COULOMB MODELS
IN
SAGE-CRISP VER 4

VALIDATION REPORT

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Summery

Two new Mohr Coulomb models have been introduced in SAGE-CRISP version 4. They are titled:

1- New Mohr Coulomb Elastic-Perfectly Plastic
2- New Mohr Coulomb Elastic-Plastic Hardening

Both models allow for non-associative flow, and use similar stress return and corner handling algorithms.

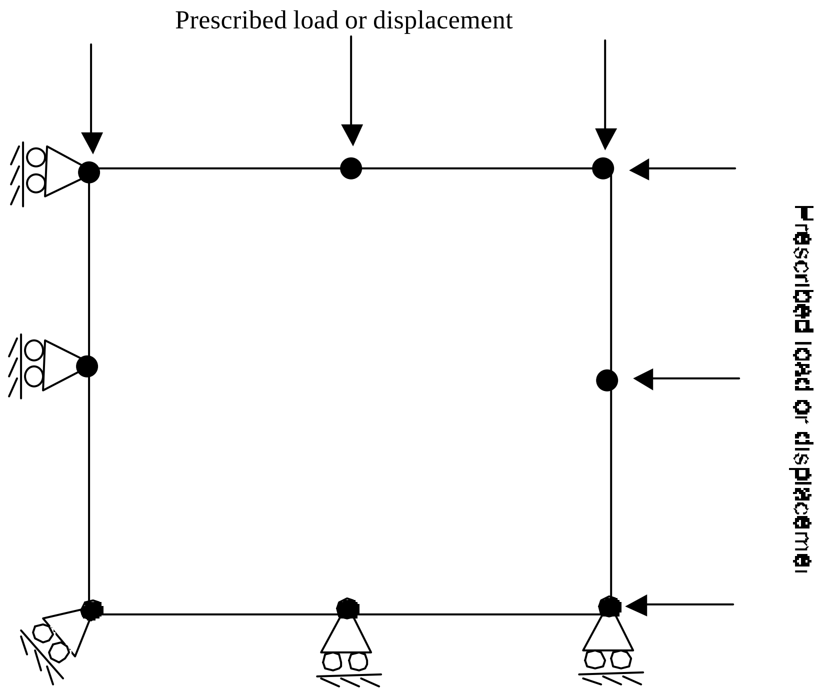
This report present validation tests for

1- single element examples, checked with MathCad solution
2- boundary value problems, checked against classical closed form solutions

The results show that the two Mohr Coulomb models have been correctly coded into SAGE-CRISP

Single Element Validation Tests

A single 8-noded plane strain qudarilateral element with unit dimensions is loaded or displaced so as to produce the prescribed stress or strain path. The boundary conditions for the single element are shown below



1 Elastic strain path

To test elastic model

2 Tensile strain path with elastic perfectly-plastic soil

To test apex singularity

3 Compressive strain path with elastic perfectly-plastic soil

To check elastic model, plastic model and corner singularities

4 Compressive stress path with friction hardening elastic-plastic soil

To check elastic model, plastic model and friction hardening

5 Compressive stress path with cohesion hardening and elasto-plastic soil

To check elastic model, plastic model and cohesion hardening

6 Constant mean pressure stress path

To check elastic model, plastic model, and combined friction and cohesion hardening

7 Cyclic stress path with friction and cohesion hardening elasto-plastic soil

To check elastic model, plastic model and combined friction and cohesion hardening as well as stress reversal

8 Triaxial compression, triaxial extension and pure shear

To check plastic model, friction hardening, and performance over full range of Lode angles

Validation example 1- Elastic strain path

Problem Description

Increments of strain, as detailed below, are applied to a linear elastic soil and the increments of stress are computed.

Increment	Applied $\Delta\varepsilon_x$	Applied $\Delta\varepsilon_y$
1	0.001	0.0005
2	0.001	0.0005

Material parameters

E 50Mpa

v 0.25

Results

	Solution	σ_x (Kpa)	σ_y (Kpa)	γ_{xy} (Kpa)	σ_z (Kpa)
Increment 1	CRISP	70	50	0	30
	Mathcad	70	50	0	30
Increment 2	CRISP	140	100	0	30
	Mathcad	140	100	0	30

Validation example 2- Tensile strain path

Problem Description

Increments of strain, as detailed below, are applied to an elastic-perfectly plastic soil and the increments of stress are computed. The aim is to force the stress point to go beyond the apex of the Mohr-Coulomb yield surface into the tensile region. When this occurs, the stress point should be returned directly to the apex

Increment	Applied $\Delta\varepsilon_x$	Applied $\Delta\varepsilon_y$
1	0.001	0.0015
2	0.001	0.0015

Material parameters

E 50Mpa
ν 0.25
c 0 MPa
ϕ 30°
ψ 4°

Results

Increment	Solution	σ_x (Kpa)	σ_y (Kpa)	γ_{xy} (Kpa)	σ_z (Kpa)
1	CRISP	0	0	0	0
	Mathcad	0	0	0	0
2	CRISP	0	0	0	0
	Mathcad	0	0	0	0

Validation example 3- Compressive strain path with elastic perfectly plastic soil

Problem Description

Increments of strain, as detailed below, are applied to an elastic-perfectly plastic soil and the increments of stress are computed. The first increment maintains the stress inside the elastic region. Subsequent increments of strain force the stress point outside the yield surface. When this occurs, the stress point should be returned to the yield surface

Increment	Applied $\Delta\varepsilon_x$	Applied $\Delta\varepsilon_y$
1	0.0015	0.001
2	0.0010	-0.001
3	0.05	-0.02
4	0.05	-0.02

Material parameters

E	50Mpa
ν	0.25
c	0 MPa
ϕ	30°
ψ	4°

Results

	Solution	σ_x (Kpa)	σ_y (Kpa)	γ_{xy} (Kpa)	σ_z (Kpa)
Increment 1	CRISP	110	90	0	50
	Mathcad	110	90	0	50
Increment 2	CRISP	150	50	0	50
	Mathcad	150	50	0	50
Increment 3	CRISP	1904.6	634.86	0	1070.4
	Mathcad	1904.6	634.86	0	1070.4
Increment 4	CRISP	3861.1	1287	0	1722.6
	Mathcad	3861.1	1287	0	1722.6