



AD FALCON API Manual

Footing on Unsaturated Soils Modeled with the Mohr–Coulomb Framework

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1 Footing on Unsaturated Soils Modeled with the Mohr–Coulomb Framework

1.1 Input File Name

[fem_data_mohr_unsat_fullycoupled.txt](#)

1.2 Problem Description

This study investigates the influence of matric suction on the bearing capacity of a rigid strip footing resting on an unsaturated elastoplastic soil layer. The soil behavior is modeled using the **non-associated Mohr–Coulomb model**, and the simulation is performed using the **Finite Element Method (FEM)**.

Three suction levels (0 kPa, 25 kPa, 300 kPa) are considered to examine how increased suction enhances the load-carrying capacity.

1.3 Model Setup

- **Footing Type:** Smooth rigid strip footing
- **Footing Width:** $B = 2\text{ m}$
- **Material Model:** [Non-Associated Mohr–Coulomb](#)
- **Material Properties:**
 - **Young’s Modulus:** 5000.0 kPa
 - **Poisson’s Ratio:** 0.3
 - **Cohesion:** 1.0 kPa
 - **Friction Angle:** 30°
 - **Dilation Angle:** 10°
 - **Dilatancy Cap:** enabled via `DilationPvCap=0.02` in the `@UMAT:` line (sets dilatancy to zero after the accumulated plastic volumetric strain reaches the cap)
 - **Failure Ratio (Rf):** 0.1

1.4 Initial Stress Field via Gravity

- **Stress Initialization:** Developed through gravity body force only.
- The following suction values are applied by prescribing pore-water pressure at the drainage boundary (top surface) with $p_a = 0$ and $p_w = -\psi$:
 - Case A: $\psi = 0\text{ kPa}$
 - Case B: $\psi = 25\text{ kPa}$
 - Case C: $\psi = 300\text{ kPa}$

1.5 Multiphase and Hydraulic Properties

```
@PhaseChar: Solid rhos 2.7
@SWRC: NonHysteretic alpha_1 98 n 0.28 m 0.98 omega_prime 10.6 SW_max 1
SW_min 0
@EffectiveStress: GhorbaniKodikara Beta1 1.0 Beta2 1.0
@Perm: BrooksCorey lambda 1.5 k_sat 2.5e-12
@PhaseChar: Solid rhos 2.7
@PhaseChar: Liquid rhow 0.997 K_l 2.25e6 l_viscosity 1.0e-6
@PhaseChar: Gas rhog 1.1e-3 k_g 1.1e2 g_viscosity 1.8e-8
@AnisotropicPerm: 1 1 1 0 0 0
```

1.6 FEM Model

- **Element Type:** 6-noded triangular elements
- **Boundary Conditions:**
 - Fixed bottom
 - Horizontal rollers on lateral boundaries
 - Vertical displacement imposed on footing
- The footing is loaded by imposing a **vertical displacement of 1.0B** (2.0 m).



1.7 Numerical Implementation

- **Body Force Applied:**

```
% Body Force
Force 0.0 -9.81 0.0
WaterContribution 0.0 -9.81 0.0
AirContribution 0.0 -9.81 0.0
ElementIDs All
LoadType Ramp Step 1
StartStep 1
Propagate: FinalStep 2
DisplacementReset: End of Step 1
%%%
```

1.8 Results

The load–displacement curves below compare the footing response under varying suction values, plotted up to 2.5 m displacement.

Note: in the current setup, the $\psi = 25$ kPa run may terminate early due to the hysteretic SWRC requiring a positive void ratio throughout the analysis; therefore, the $\psi = 25$ kPa

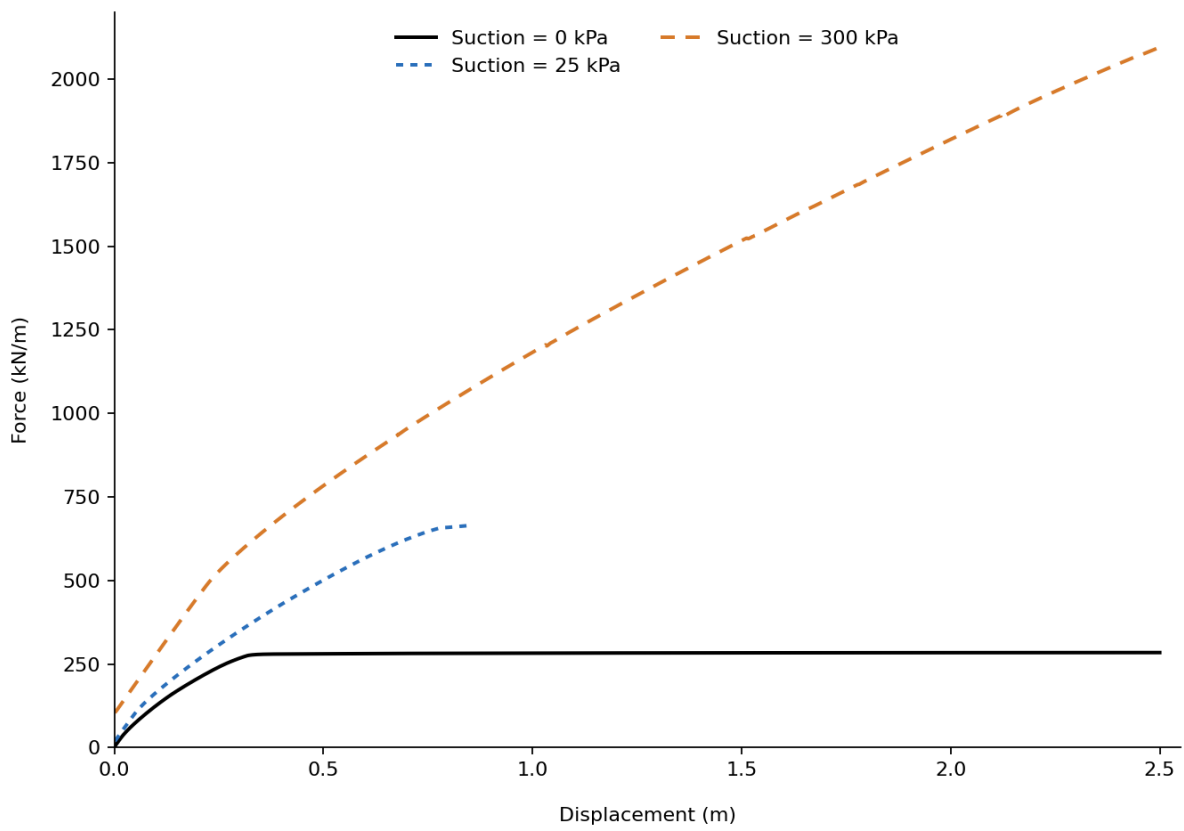


Figure 1: Load-Displacement Curves for Varying Suction Levels

load–displacement curve is shown only up to 0.85 m displacement.

Peak reaction force (over 0–2.5 m displacement):

Suction (kPa)	Peak reaction force (kN/m)
0	284.148
25	664.330
300	2095.130

Degree of saturation along the column ($x = 1.0$ m) at the end of the gravity step:

Suction (kPa)	S_w at $y = 10$ m	S_w at $y = 5$ m	S_w at $y = 0$ m
0	1.000	1.000	1.000
25	0.702	0.988	0.986
300	0.541	0.697	0.993

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