



AD FALCON API Manual

Footing on Soil Modeled by the Non-Associated Mohr–Coulomb Model

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1 Footing on Soil Modeled by the Non-Associated Mohr–Coulomb Model

1.1 Input File Name

fem_MC.txt

1.2 Problem Description

This study investigates the behavior of a **smooth rigid strip footing** resting on an **elastoplastic soil layer** modeled using the **non-associated Mohr–Coulomb model**. The analysis employs the **Finite Element Method (FEM)** to evaluate soil response and footing pressure. The FEM results will be compared with those obtained by **Sheng et al. (2002)**.

1.3 Model Setup

- **Footing Type:** Smooth rigid strip footing
- **Footing Width:** $B = 2m$
- **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°
 - **Rf:** 0.1
 - **Tolerance Parameters:**
 - * **Stress Tolerance (STOL):** 1.0×10^{-5}
 - * **Yield Surface Tolerance (FTOL):** 1.0×10^{-5}
 - * **Loading/Unloading Detection Tolerance (LTOL):** 1.0×10^{-6}

1.4 Initial Stress Field

- The **buoyant unit weight** of the soil is set to 6 kN/m^3 to establish the initial stress distribution.
- Once the initial stress field is computed, a total displacement of $0.075B$ is imposed on the footing, sufficient to **initiate collapse**.

1.5 Finite Element Model

- **Element Type:** 6-noded triangular elements
- **Boundary Conditions:**

- Fixed bottom boundary
 - Lateral boundaries restrained in horizontal direction
 - Footing subjected to **uniform vertical displacements**
- The footing response is computed by summing **vertical nodal reactions** to obtain the **equivalent pressure**.

1.6 Numerical Implementation

The non-associated Mohr–Coulomb model is used in this simulation. ## Comparison with Sheng et al. (2002) The numerical results obtained from FEM simulations will be compared with the results presented in:

Sheng, D., Sloan, S.W., and Abbo, A.J. (2002). *An automatic Newton-Raphson scheme*. International Journal of Geomechanics, 2(4), pp.471-502.

1.7 Results

The results illustrate the effectiveness of the non-associated Mohr–Coulomb model in capturing the footing behavior on an elastoplastic soil layer. The load-displacement curves demonstrate a close agreement between the FEM results and the reference solution by Sheng et al. (2002), validating the accuracy of the numerical implementation.

Additional note: Reaction Force Calculation

The following command calculates the total reaction force in the vertical direction (DisY) for specific nodes beneath the loaded area. This helps in evaluating the footing response and its distribution of forces.

```
% ReactionForceSum
@Nodes 776 782 808 807 817 827 825 828 837 839 841
@Steps 1
@DOFs DisY
@OutputFile path/to/rname_your_csv_file.csv
```

This command extracts the vertical reaction forces at each specified node and sums them over the given step (Step 1). The results are then saved to a CSV file for further analysis.

2 Gravity Initialization via Body Force (instead of Field Stress)

2.1 Input File Name

[fem_MC_bf.txt](#)

In this variation, we do not apply an initial stress field directly. Instead, we allow the system to develop the correct stress distribution naturally by applying gravity (body force)

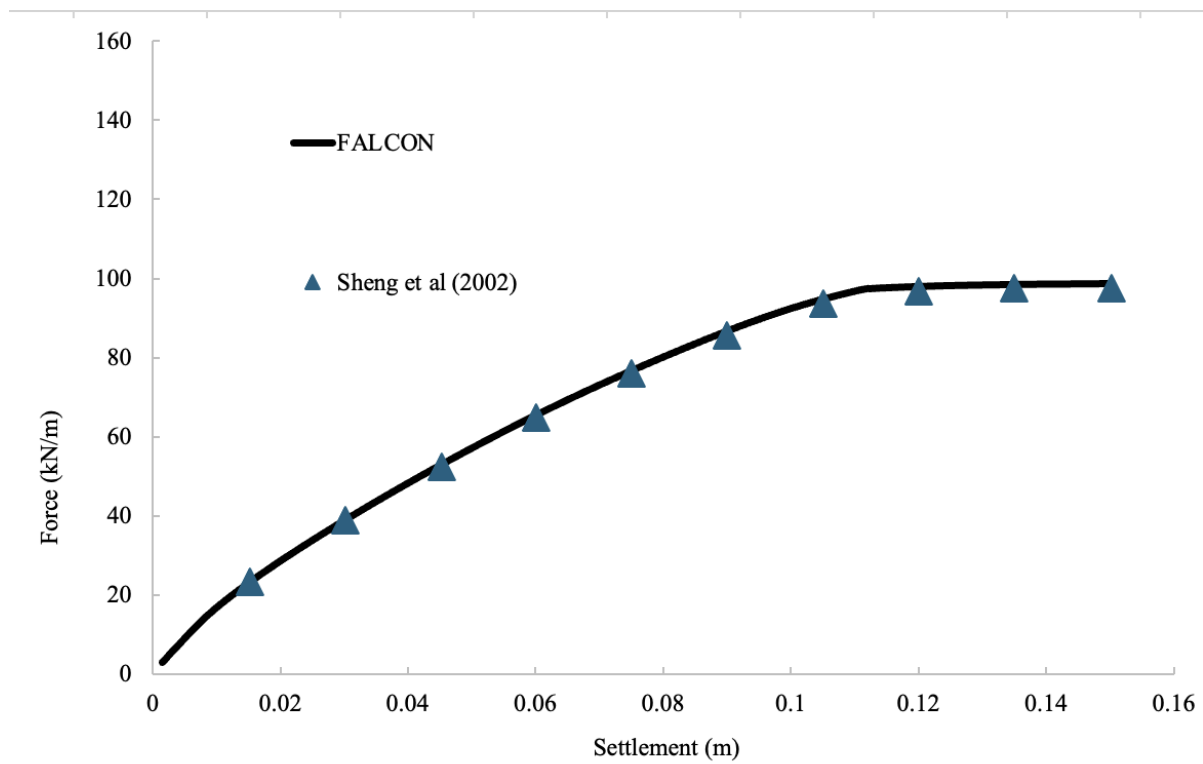


Figure 1: Comparison of Load displacement curves obtained from FALCON and that reported by Sheng et al. 2002

through all phases (solid, water, air) and allowing equilibrium to be established numerically.

2.2 Key Differences from Previous Setup

- **Initial stress field is not set manually.**
- A gravity step is used to allow body forces to generate stress from rest.
- Gravity loading is applied via:

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

- Effective density used for gravitational loading:

$$\rho_{\text{bulk}} = (1 - n)\rho_s + n(S_w\rho_w + (1 - S_w)\rho_a) \approx 600 \text{ kg/m}^3 \quad (1)$$

(based on: $e = 3.4$, $S_w = 0.0$, $\rho_s = 2700 \text{ kg/m}^3$)

2.3 Step-by-Step Description

2.3.1 Step 1 – Gravity Application

- A gravity step is applied.
- The following nodes are not fully constrained in the vertical (DisY) direction to allow the stress field to evolve naturally under self-weight:

776 782 808 807 817 827 825 828 837 839 841

- These degrees of freedom are left temporarily free to prevent artificial constraint of equilibrium during gravity initialization.
- No external mechanical loading is applied in this step.
- The displacement field evolves purely in response to body force effects (gravity-induced).

2.3.2 Step 2 – Kinematic Constraint of Surface Nodes

After the gravity equilibrium has been achieved, surface nodes undergoing prescribed displacement are restrained with vertical displacement constraints:

```
% Restrain Dofs  
Id: 1  
Step: 2  
776 DisY  
782 DisY  
808 DisY  
807 DisY  
817 DisY  
827 DisY  
825 DisY  
828 DisY  
837 DisY  
839 DisY  
841 DisY
```

