AD FALCON API Manual

Effective-Stress-Based Undrained Bearing Capacity of a Flexible Strip Footing

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1 Effective-Stress-Based Undrained Bearing Capacity of a Flexible Strip Footing

1.1 File Names

fem_data undrained_effective_stress_bearing.txt

1.2 Model Geometry and Boundary Conditions

- **Half-width of footing**:

$$B = 1\,\mathrm{m} \tag{1}$$

- **Soil domain**:
  - Plane-strain half-domain (symmetry at $x = 0$): $0 \leq x \leq 16\,\mathrm{m}$
  - Vertical extent: $0 \leq y \leq 8\,\mathrm{m}$ (soil thickness $H = 8\,\mathrm{m}$)

- **Footing**:
  Uniform pressure applied on the top boundary segment $y = 8\,\mathrm{m}$ for $0 \leq x \leq B$ (i.e., $0 \leq x \leq 1\,\mathrm{m}$). Outside this segment the top boundary is traction-free.

Boundary Conditions:
- Symmetry boundary ($x = 0$): $u_x = 0$.
- Far boundary ($x = 16\,\mathrm{m}$): $u_x = 0$ (roller).
- Bottom boundary ($y = 0$): $u_y = 0$ (with $u_x = 0$ enforced at the two bottom corners to prevent rigid-body motion).
- Top boundary ($y = 8\,\mathrm{m}$): drained with prescribed pore-water pressure $p_w = 0$. ***

1.3 Consolidation Loading Rate

For the consolidation analyses, the load rate is defined by the dimensionless:

$$\omega = \frac{\Delta q / c'}{\Delta T_v} \tag{2}$$

where the time factor is

$$\Delta T_v = \frac{c_v\,\Delta t}{B^2} \tag{3}$$

and the two-dimensional consolidation coefficient is

$$c_v = \frac{k\,E'}{2\,\gamma_w\,(1+\nu')\,(1-2\nu')} \tag{4}$$

with B the half-width of the footing.

1.4 Undrained Collapse Pressure (Prandtl)

The analytical collapse load for a strip footing is:

$$q_u = 5.14\,C_u \tag{5}$$

$$\Longrightarrow \frac{q_u}{C_u} = 5.14 \tag{6}$$

(or $\frac{q}{c'} = 4.83$)
where q is the applied bearing pressure.

1.5 FALCON Analyses and Parameters

1. **Coupled Undrained (FALCON)**
   - Undrained coupled analysis with $E'/c' = 200$, $\nu = 0.3$, $\phi' = 20^\circ$, $\psi = 0^\circ$, and $w = 150\,\text{kPa}$.

2. **Uncoupled Undrained (Conventional)**
   - Uses E_u, C_u, $\nu_u = 0.499$, $\phi_u = 0^\circ$, $\psi = 0^\circ$.

3. **Coupled Undrained with Dilation Angle Variation**
   - Same as (1) but $\psi = 0^\circ$ and 5°.

4. **Reference 1** (benchmark data)

1.6 Results

- **Figure 1** compares coupled & uncoupled FALCON runs against Reference 1 and Prandtl's solution. The collapse loads match closely, showing good agreement.
- The figure also shows the impact of $\psi = 0^\circ \ldots 5^\circ$ in coupled undrained. Nonzero ψ introduces a response similar to hardening, while still aligning well with benchmark data.

Reference 1: Sloan, S.W. and Abbo, A.J. (1999). *Biot consolidation analysis with automatic time stepping and error control Part 2: Applications. International Journal for Numerical and Analytical Methods in Geomechanics*, **23**(6), pp.493–529.

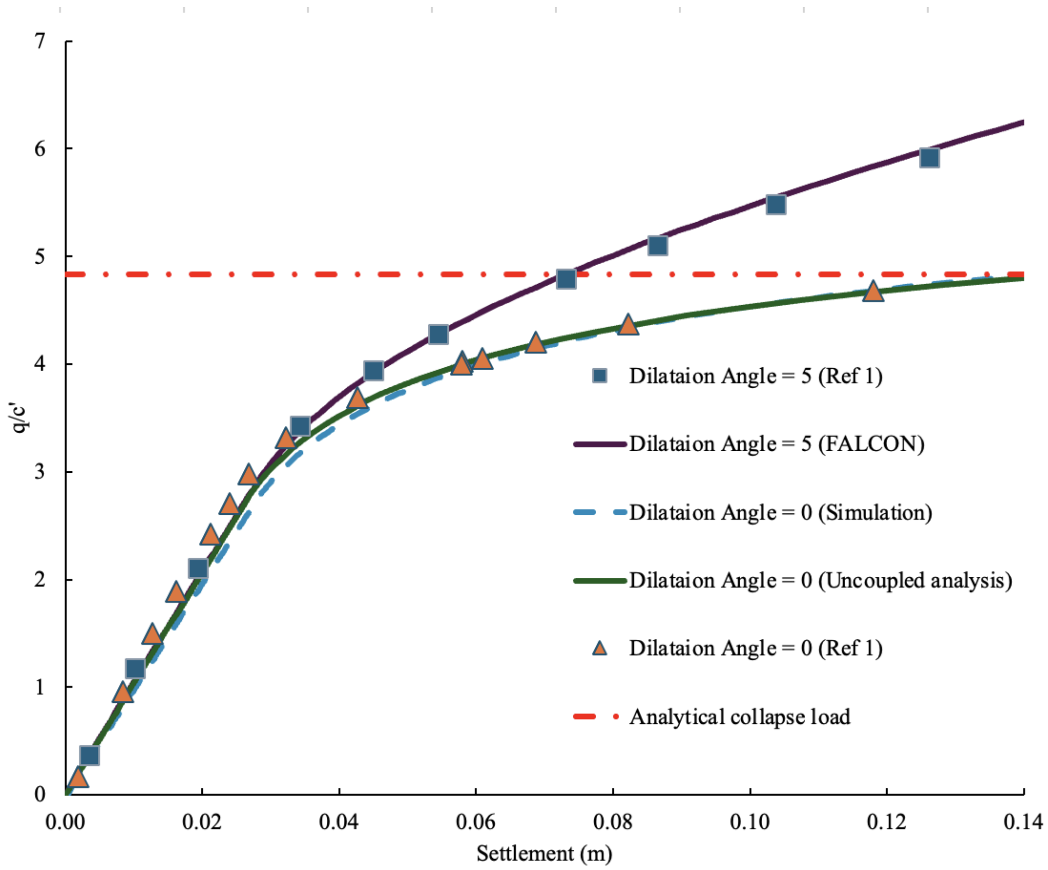

Figure 1: Figure 1. Comparison of undrained bearing capacity from FALCON (coupled and uncoupled) with Reference 1 and the analytical Prandtl solution