AD FALCON API Manual

Rigid Footing with SSLSM Model

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1 Rigid Footing with SSLSM Model

1.1 Problem Description

This example documents a **plane-strain strip-footing** FEM benchmark for the SSLSM model. The footing is loaded by a **prescribed vertical settlement** over a surface patch, and the footing response is recovered from the summed vertical reactions.

The objective is the same as for the other footing demonstrations in the manual:

- define a reproducible geometry and loading program,
- provide the exact input deck and runner,
- and record the resulting load-settlement behavior.

1.2 Input Files

- Footing input deck: `footing_strip_sslsm.txt`

1.3 Geometry and Boundary Conditions

The SSLSM footing benchmark uses the same **10 m × 10 m** plane-strain half-domain geometry as the other rigid-footing examples in the manual.

Geometry

- **Half-width of soil domain:** 10 m
- **Depth of soil domain:** 10 m
- **Half-width of loaded footing patch:** 1 m
- **Full footing width represented by symmetry:** 2 m

The prescribed footing nodes are the top-surface nodes:

- `841, 839, 837, 828, 825, 827, 817, 807, 808, 782, 776`

which correspond to $x = 0.0$ to 1.0 m at $y = 10.0$ m in the input deck.

Boundary conditions

- Left boundary (`x = 0`): symmetry, so `DisX = 0`
- Right boundary (`x = 10`): lateral restraint, `DisX = 0`
- Base (`y = 0`): vertical restraint, `DisY = 0` (with a small number of anchor constraints to remove rigid-body motion)
- Footing nodes: in Step 2, `DisY` is restrained and prescribed as a settlement history

This is a **smooth strip-footing** idealization with symmetry about the footing centerline.

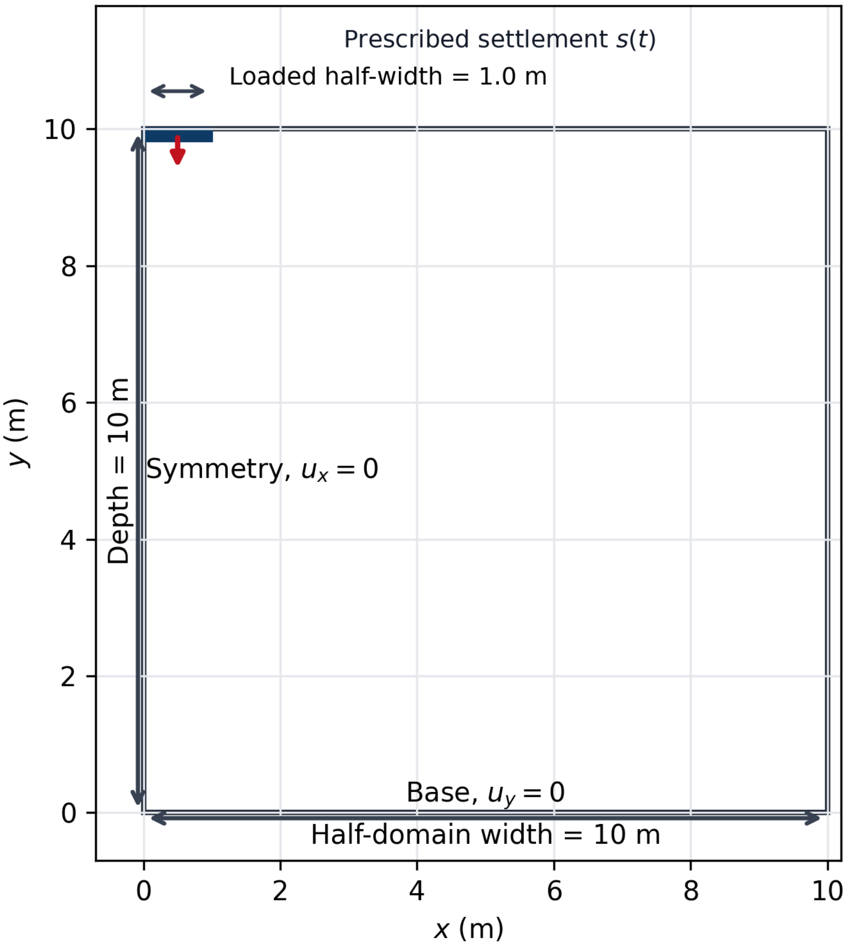

Figure 1: SSLSM strip-footing benchmark domain

1.4 Material Parameters

The soil is modeled with the SSLSM UMAT using:

- **Friction angle** `Phi = 20`
- **Compression index** `Lambda = 0.25`
- **Swelling index** `Kappa = 0.05`
- **Poisson ratio** `Nu = 0.30`
- **Critical-state parameter** `Mmax = 1.0`
- **Reference specific volume** `v_N = 2.6`
- **Subloading evolution parameter** `m_sub = 0.127`
- **Structure evolution parameter** `a_sub = 0.092`
- **Hardening weight** `Ad_sub = 0.95`

Numerical controls in the deck:

- `P_min = 1.0`
- `STOL = 1e-7`
- `FTOL = 1e-6`
- `LTOL = 1e-6`

!!! note "UMAT paths in the input deck" The provided input deck contains a portable placeholder UMAT reference: `@UMAT: path/to/SSLSMModel.cpp path/to/SSLSMModel.hpp ..` .. Replace `path/to/...` with the SSLSM UMAT location used in your installation (source files or a prebuilt library), following the UMAT loading conventions in your FALCON workflow.

1.5 Initial State

The benchmark uses a **K0-like geostatic initial stress guess** (linear with depth) that is assigned directly in the input deck. Because the initial effective stresses are already provided, the loading program **does not** apply a gravity/body-force field in the subsequent settlement step.

```
% Initial Assignments
@Stress: H 0 values -30 -60 -30 0 0 0 H 10 values 0 0 0 0 0 0
@Void: H 0 values 0.8 H 10 values 0.8
@R: H 0 values 0.67 H 10 values 0.67
@RS: H 0 values 1 H 10 values 1
@OCR: H 0 values 10 H 10 values 10
%%%
```

Notes:

- `H=0` is the base (`y=0`) and `H=10` is the surface (`y=10`).

- `OCR` is used by the SSLSM UMAT initialization to set the initial yield surface size (`Isotropic Hardening`, i.e. p_c') from the current mean effective pressure.
- `R` and `RS` control the subloading and superloading similarity ratios in the SSLSM formulation.
- `UpdateVoidRatio` is an optional SSLSM custom variable. If set to `1`, the SSLSM UMAT updates the initial void ratio field to be consistent with the current effective pressure and the initialized hardening state.

1.6 Loading Program

1.6.1 Step 1: Initial Equilibrium

Step 1 is an initial equilibrium pass for the assigned stress field (no body force).

1.6.2 Step 2: Prescribed Settlement

The footing is loaded by **prescribed settlement** on the footing node set:

```
% Prescribed Values
@PrescribedValue Displacement 1
@@DOF: DisY
@@Amplitude: -0.5
@@LoadType: Ramp
@@StartStep: 2
@@NodeIds: 776 782 808 807 817 827 825 828 837 839 841
@@Propagate: Yes
%%%
```

This applies a downward settlement target of 0.5 m over the loaded patch.

1.7 Output and Reaction Summation

The footing response is extracted by summing the vertical reactions on the footing nodes:

```
% ReactionForceSum
@Nodes 776 782 808 807 817 827 825 828 837 839 841
@Steps 2
@DOFs DisY
@OutputFile output/reaction_force_summary_sslsm_footing.csv
%%%
```

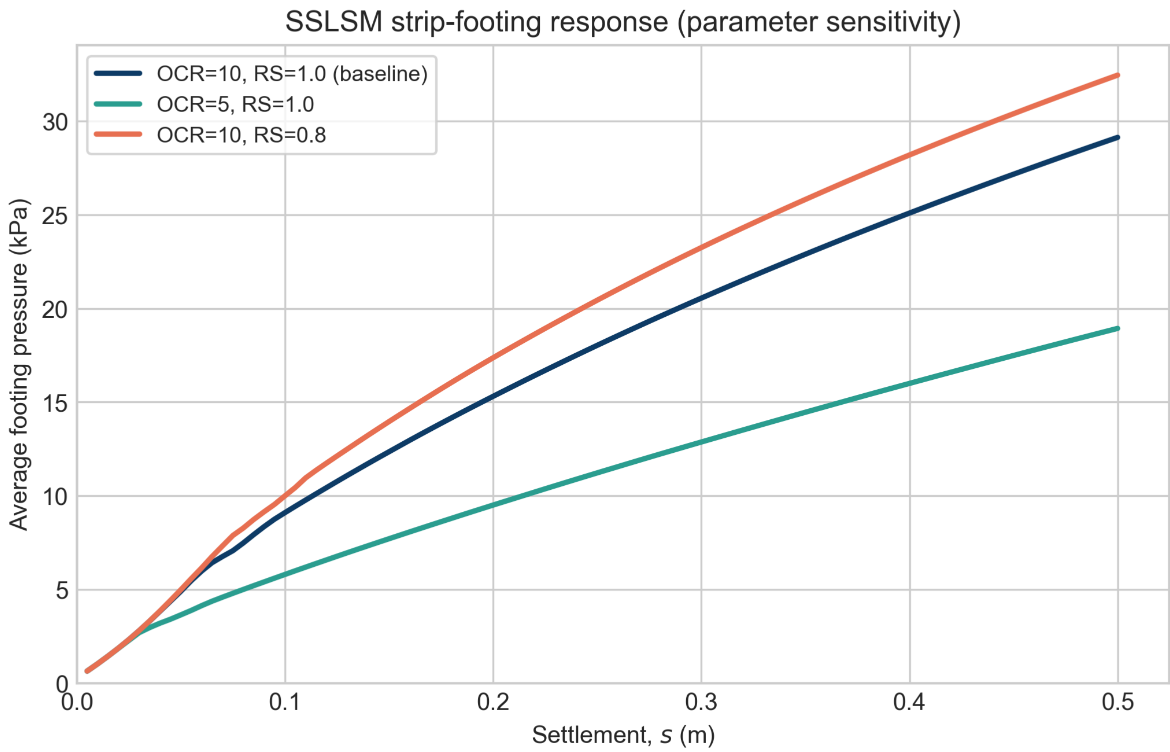

Figure 2: SSLSM strip-footing load-settlement response

The figure reports the average footing pressure (kPa) over the loaded patch, computed from the summed vertical reactions and the loaded patch width.

1.8 Results

1.8.1 Load–Settlement Curves

The load-settlement response is shown below for three initial states (varying `OCR` and `RS`).
