13 Non-Linear Analysis of Strip Footing in Sand

13.1 Problem Description

This problem considers a strip footing in sand subjected to an incrementally increasing load. The sand is assumed to exhibit non-linear elastic behavior according to the Duncan-Chang hyperbolic model. All parameters are drawn from Tomlinson's Foundation Design and Construction [1], which presents experimentally determined settlement result as well as the results of finite element analysis. Figure 13-1 illustrates the problem as implemented in ***RS3***. Dimensions are as indicated. Due to symmetry, only half of the footing is modeled.

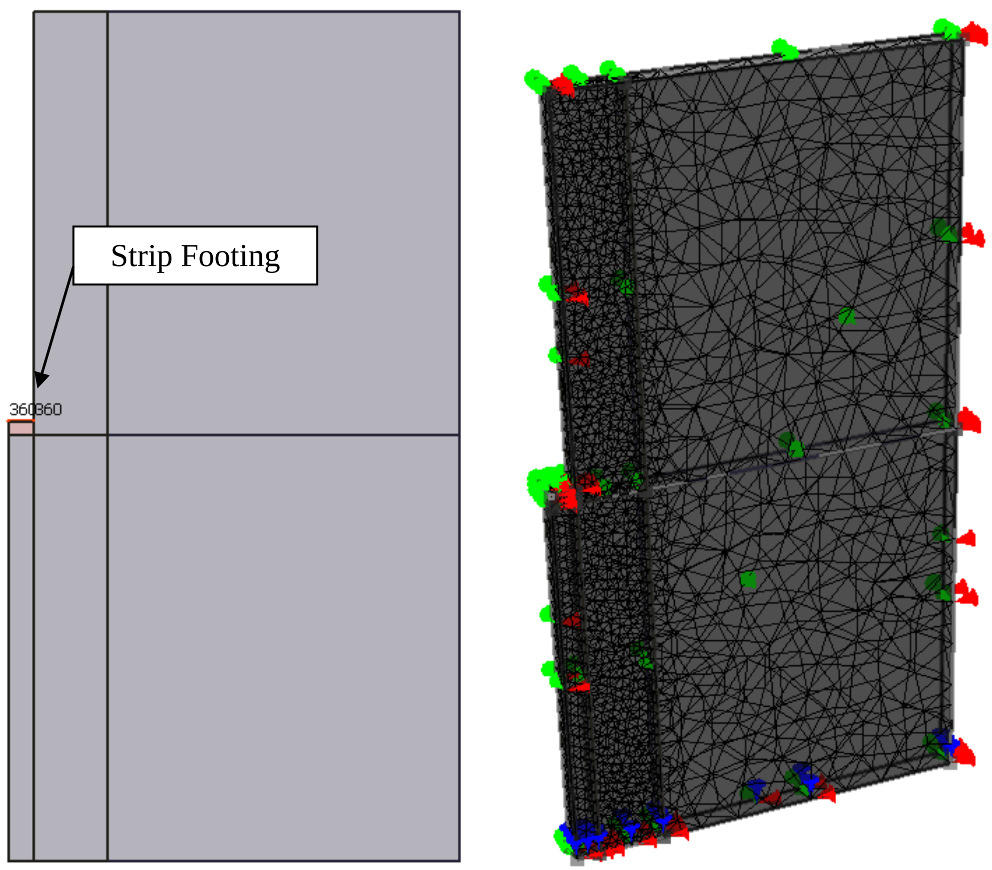

Figure 13-1: Strip footing in sand as constructed in *RS3*

The model shown in Figure 13-1 uses a graded mesh composed of 4-noded tetrahedron elements. Boundary conditions are as illustrated. A small region of stiff material is used to simulate the rigid footing.

Table 13-1 summarizes the model parameters used:

Table 13-1: Model parameters

Parameter	*Value*
Modulus number (K_E)	300
Modulus exponent (n)	0.55
Failure ratio (R_f)	0.83
Cohesion (c)	0 psf
Friction angle (ϕ)	35.5°
Unit weight (γ)	91 lb/ft3
Poisson's ratio (v)	0.35
Footing half-width ($b/2$)	1.22 in

13.2 Duncan-Chang Model

The Duncan-Chang Hyperbolic constitutive model is widely used for the modeling of soils with more generalized stress-strain behavior, and is capable of modeling the stress-dependent strength and stiffness of soils. The Duncan-Chang Hyperbolic elasticity model can only be used in conjunction with the Mohr-Coulomb failure criterion in ***RS3***. The following equations are derived, based on a hyperbolic stress-strain curve and stress-dependent material properties for the Duncan-Chang Hyperbolic model.

The tangential modulus, (E_t), is given by:

$$E_t = \mathrm{K_E} p_{atm} \left(\frac{\sigma_3}{p_{atm}}\right)^n \left[1 - \frac{R_f (1 - \sin \emptyset)(\sigma_1 - \sigma_3)}{2c \cos \emptyset + 2\sigma_3 \sin \emptyset}\right]^2$$

where

p_{atm} = atmospheric pressure

σ_3 = minor principal stress

σ_1 = major principal stress

and other parameters are as identified in Table 13-1.

Tomlinson presents experimental load-settlement results in [1] as well as the results of finite element analysis. These are compared with ***RS3*** results in the next section.

13.3 Results

Figure 13-2 shows settlement as a function of increasing average footing pressure, as predicted by [1] and ***RS3***. It can be seen that ***RS3*** is in good agreement with experimental results.

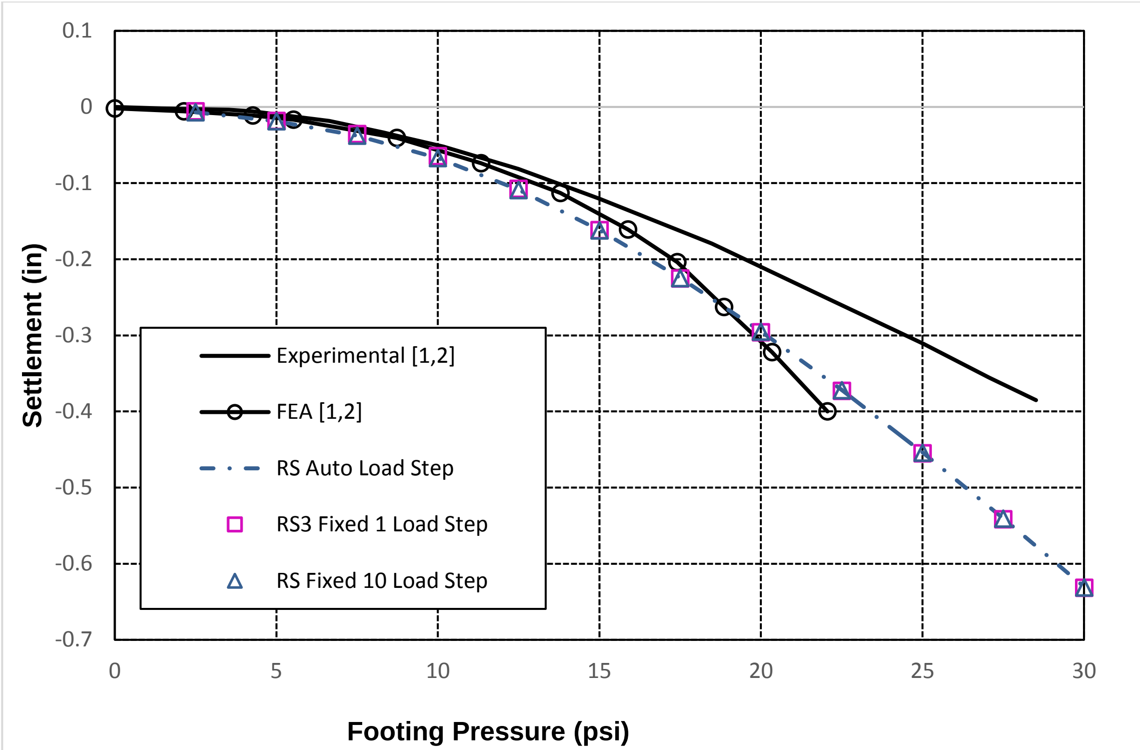

Figure 13-2: Settlement with increasing load as predicted by *RS3* and [1]

13.4 References

1. M. J. Tomlinson (2001), Foundation Design and Construction, 7th Ed., Upper Saddle River, NJ: Prentice Hall.

2. J. M. Duncan and C. Y. Chang (1970), "Nonlinear analysis of stress and strain in soils", J. of Soil Mech. and Foundation Division, ASCE, 96 (SM5), pp. 1629-1653.

13.5 Data Files

The input data files can be found in the ***RS3*** installation folder:

Table 13-2: Input data files for strip footing on Duncan Chang sand

File name	***Load Steps***
V013 Steps1.rs3model	1
V013 Steps10.rs3model	10
V013 -Auto.rs3model	Auto