Benchmark Example No. 44

Undrained Elastic Soil Layer Subjected to Strip Loading

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VERiFiCATiON
BE44 Undrained Elastic Soil Layer Subjected to Strip Loading

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Front Cover

Arnulfsteg, Munich Photo: Hans Gössing

Overview	
Element Type(s):	C2D
Analysis Type(s):	STAT
Procedure(s):	
Topic(s):	SOIL
Module(s):	TALPA
Input file(s):	soil_layer_el_undr.dat

1 Problem Description

The example concerns the behavior of the rectangular soil layer subjected to an uniform strip loading of intensity p acting on the surface. Base of the soil is rigidly fixed while the sides are laterally constrained. Geometry, load and boundary conditions are depicted in Fig. 1. The soil material is elastic, isotropic and saturated with water. Two soil conditions have been analyzed - drained and undrained. The drained and undrained displacements and stresses obtained by the finite element method are compared with the analytical solution.

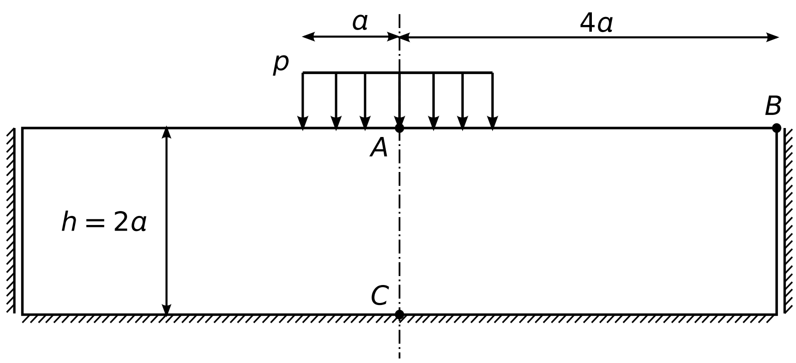


Figure 1: Problem Definition

2 Reference Solution

The analytical solution to the problem obtained using a Fourier series analysis is provided in [1].

3 Model and Results

Elastic, isotropic soil under drained and undrained conditions has been analyzed. Material, geometry and loading properties are summarized in Table 1. The undrained soil condition is considered with the help of the method based on the undrained effective stress (σ') analysis using effective material parameters. G and ν' are effective soil parameters, while B represents the Skempton's B-parameter. Self-weight is not taken into consideration.

Table 1: Model Properties

Material	Geometry	Loading
G, $\nu' = 0.3$	a	p
$B = 0.998$	$h = 4a$	
$\rho = 0.0\ kg/m^3$		

Finite element mesh of the model is shown in Fig. 2. Mesh is regular and consist of quadrilateral finite elements.

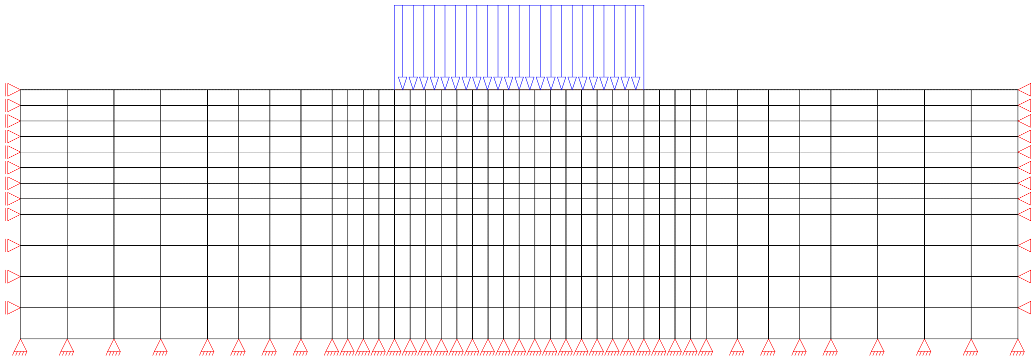


Figure 2: Finite Element Model

The drained and undrained vertical displacement of the surface nodes along the $A-B$ line are compared with the analytical solution from [1] and depicted in Fig. 3.

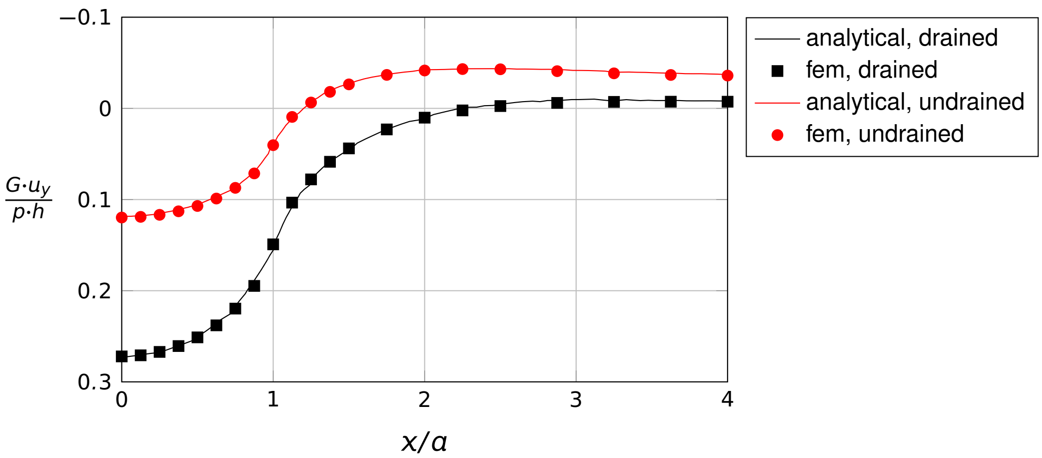
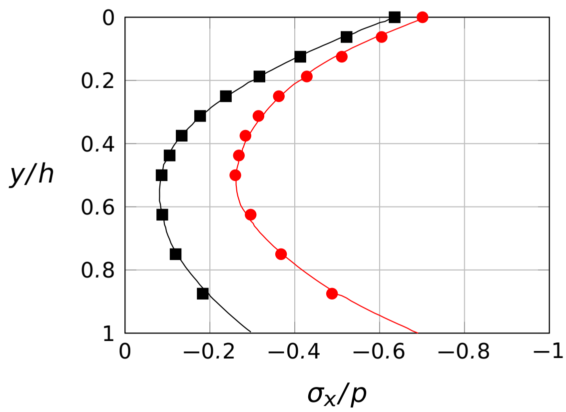
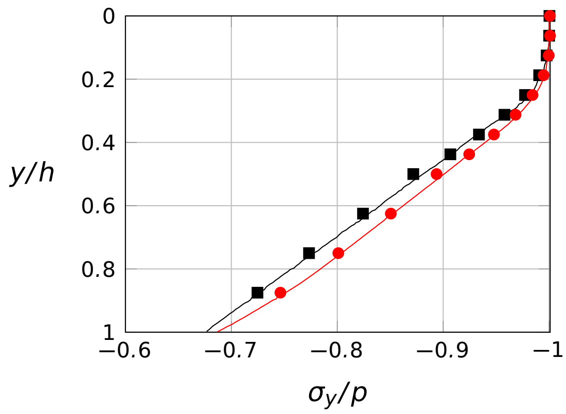


Figure 3: Vertical displacement u_y of the surface

The drained and undrained horizontal and vertical total stresses ($\sigma = \sigma' + p_{we}$) in the nodes along the vertical $A-C$ line have been computed and compared with the analytical ones, as show in Figures 4a and 4b.



(a) Horizontal stress σ_x



(b) Vertical stress σ_y

Figure 4: Stresses beneath footing center

Pore excess pressure (p_{we}) distribution for the undrained condition along the center line ($A-C$) is shown in Fig. 5.

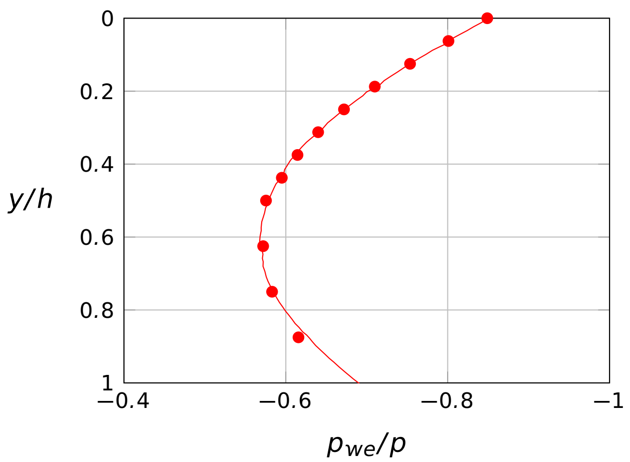


Figure 5: Excess pore pressure p_{we} beneath footing centre

4 Conclusion

This example verifies that the drained and undrained displacements and stresses obtained by the finite element method are in a good agreement with the analytical solution.

5 Literature

[1] J.R. Booker, J.P. Carter, and J.C. Small. "An efficient method of analysis for the drained and undrained behaviour of an elastic soil". In: *International Journal of Solids and Structures* 12.8 (1976), pp. 589 –599.