



Benchmark Example No. 44

## Undrained Elastic Soil Layer Subjected to Strip Loading

**VERiFiCATiON**  
**BE44 Undrained Elastic Soil Layer Subjected to Strip Loading**

VERiFiCATiON Manual, Service Pack 2020-14 Build 134

Copyright © 2022 by SOFiSTiK AG, Nuremberg, Germany.

**SOFiSTiK AG**

HQ Nuremberg  
Flataustraße 14  
90411 Nürnberg  
Germany

T +49 (0)911 39901-0  
F +49(0)911 397904

Office Garching  
Parkring 2  
85748 Garching bei München  
Germany

T +49 (0)89 315878-0  
F +49 (0)89 315878-23

[info@sofistik.com](mailto:info@sofistik.com)  
[www.sofistik.com](http://www.sofistik.com)

This manual is protected by copyright laws. No part of it may be translated, copied or reproduced, in any form or by any means, without written permission from SOFiSTiK AG. SOFiSTiK reserves the right to modify or to release new editions of this manual.

The manual and the program have been thoroughly checked for errors. However, SOFiSTiK does not claim that either one is completely error free. Errors and omissions are corrected as soon as they are detected.

The user of the program is solely responsible for the applications. We strongly encourage the user to test the correctness of all calculations at least by random sampling.

**Front Cover**

Project: Queensferry Crossing | Photo: Bastian Kratzke

### 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.

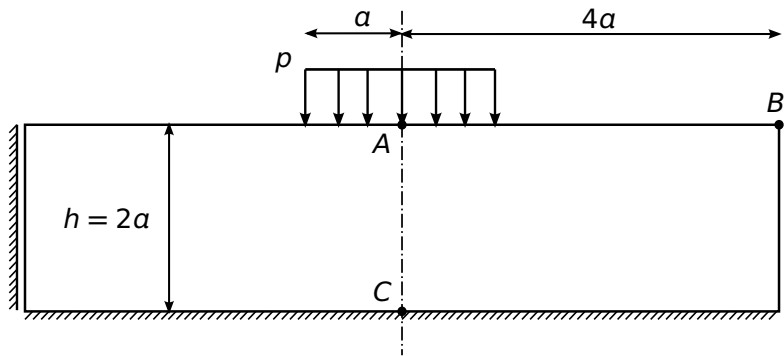


Figure 1: Problem Definition

## 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 ( $\sigma'$ ) analysis using effective material parameters.  $G$  and  $\nu'$  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
$G, \nu' = 0.3$	$a$	$p$
$B = 0.998$	$h = 4a$	
$\rho = 0.0 \text{ kg/m}^3$		

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

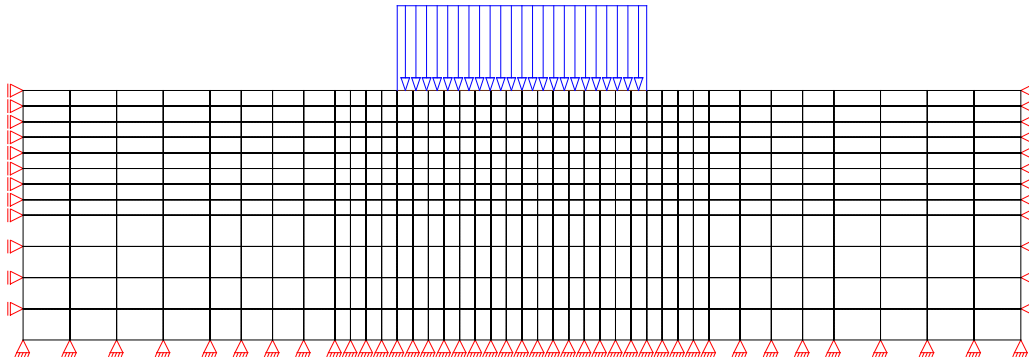


Figure 2: Finite Element Model

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.

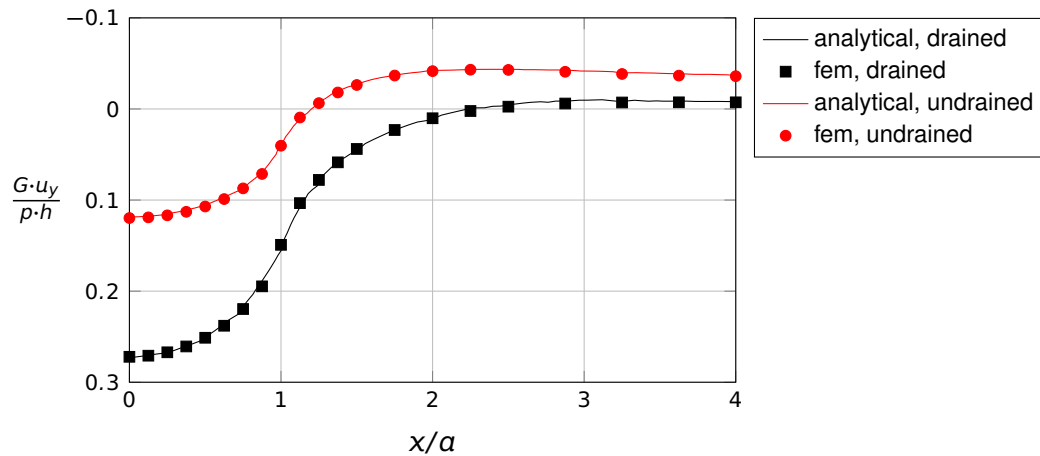


Figure 3: Vertical displacement  $u_y$  of the surface

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.

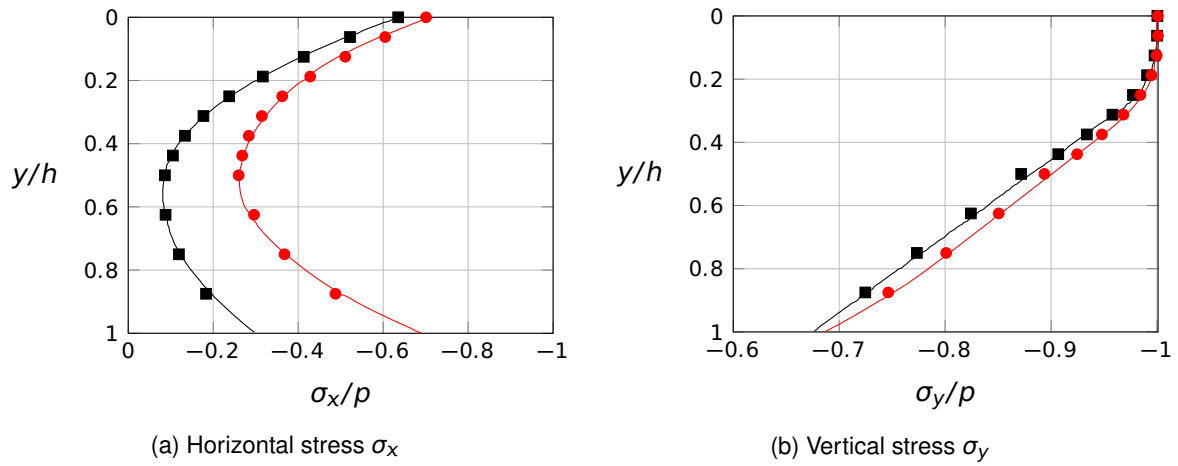
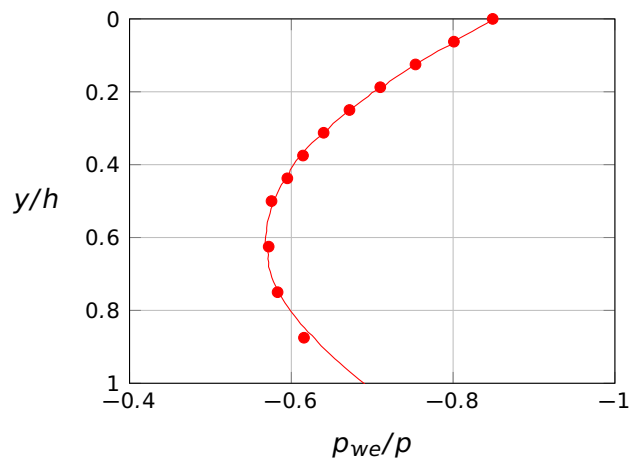


Figure 4: Stresses beneath footing center

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.