Hydro-mechanical drainage of an excavation

Reza Taherdangkoo, Thomas Nagel, Markus Barsch, Christoph Butscher

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TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

Die Ressourcenuniversität. Seit 1765.

Comments to reza.taherdangkoo@ifgt.tu-freiberg.de.

1 Introduction

The problem description is similar to the drainage of an excavation benchmark implemented using the liquid flow process. Herein, we take into account the hydro-mechanical processes to examine the stability of the excavation.

2 Model setup

The 2D model is motivated by the example described by Katzenbach, 2013. The model is implemented in OGS using the hydro-mechanical process. For the fluid flow boundaries, the bottom and lateral sides of the domain are set to no-flow. Likewise, the retaining wall is assumed as impermeable. The pressure at the top left boundary is set to zero. At time $t = 0$, pressure at the top right boundary is $294.3\,\mathrm{kPa}$ (fluid pressure) and is decreased to zero after the excavation to mimic groundwater drawdown.

For mechanical boundary conditions, the vertical displacement at the bottom equals zero. The horizontal displacement at the lateral sides and the wall is fixed to zero. The mechanical load at the top right boundary is $-600.372\,\mathrm{kPa}$ (total stress) at time $t = 0$, and is decreased to zero to mimic excavation. The material properties are listed in Table 1.

Table 1: Material properties.

Fluid	
Density	$1000\,\mathrm{kg\,m^{-3}}$
Viscosity	$10^{-3}\,\mathrm{Pa\,s}$
Solid	
Density	$2600\,\mathrm{kg\,m^{-3}}$
Porosity	0.35
Permeability	$10^{-12}\,\mathrm{m^2}$
Elasticity	
Young's modulus	$3 \cdot 10^9\,\mathrm{Pa}$
Poisson's ratio	0.3
Biot-Willis coefficient	1

3 Input files

The project file is $hm\_drainage.prj$. The input mesh file is $drainage\_quad.vtu$ and the geometry file is $drainage\_geo.gml$. One may change initial and boundary conditions, and geometry and mesh files.

4 Results

Fig. 1 shows the initial hydro- and lithostatic state after the gravity is settled. The water flows downward because of the head difference, called hydraulic gradient. The soil displacement distribution resulting from the excavation, hydraulic head contours and flow streamlines are shown in Fig. 2. As expected, the soil displacement is larger near the outlet. The ground surface displacement can be clearly seen in Fig. 3, with also black arrows displaying the direction. Subsidence can be found on the left side of the wall while the uplifting surface is on the right side.

The effective vertical stress is shown in Fig. 4. Due to the excavation and hydraulic flow, a tension zone (positive effective stress) exists near the wall. This would be indicative of hydraulic failure (HYD). However, the interface conditions and material law in this simulation are too simplistic to enter a detailed interpretation.

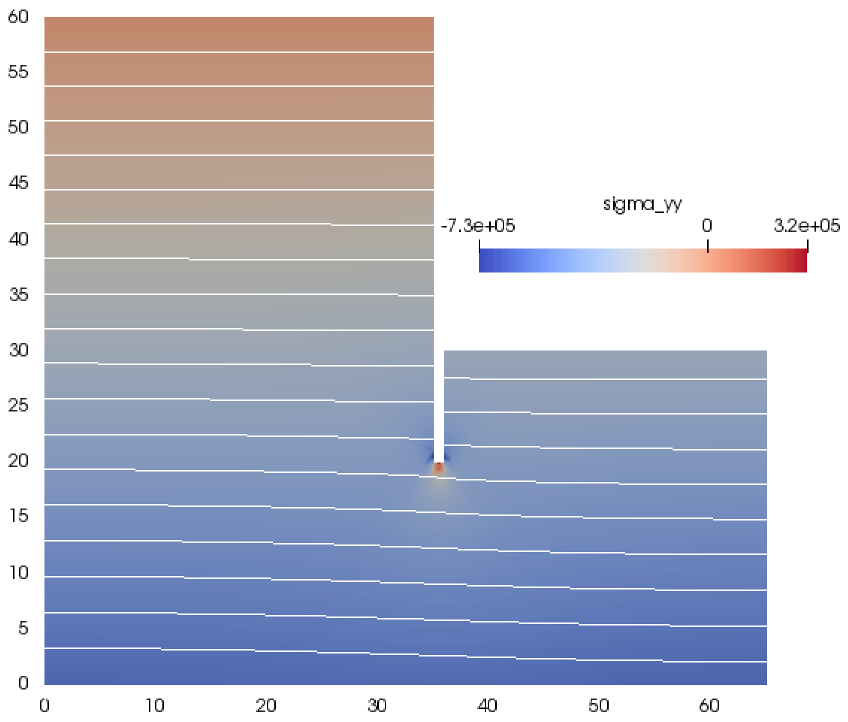

Figure 1: The initial vertical stress and pressure contours.

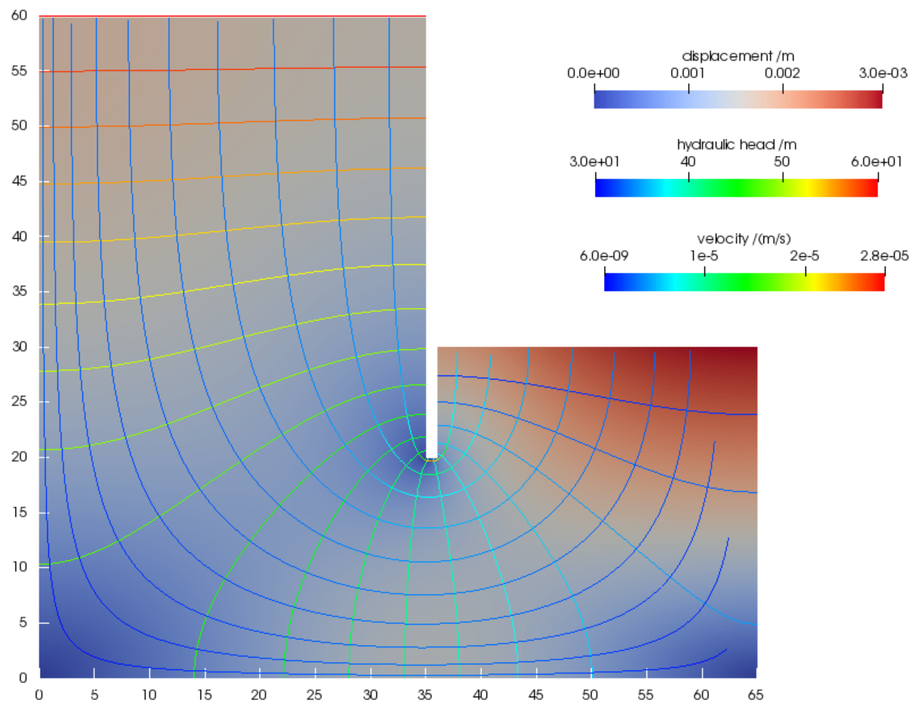

Figure 2: Soil displacement, isohypses and streamlines.

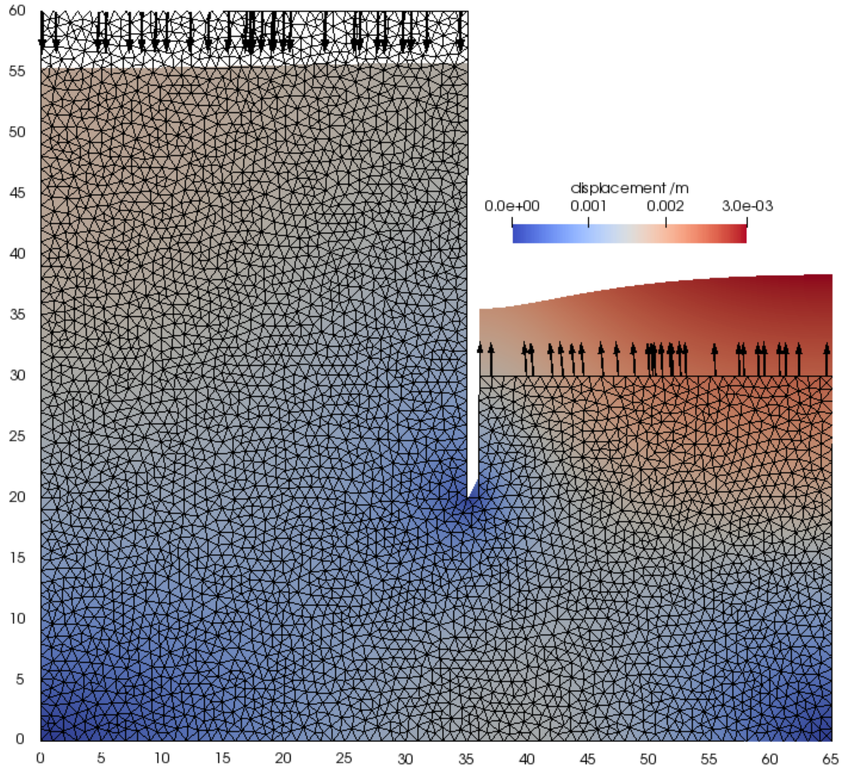

Figure 3: Soil displacement distribution.

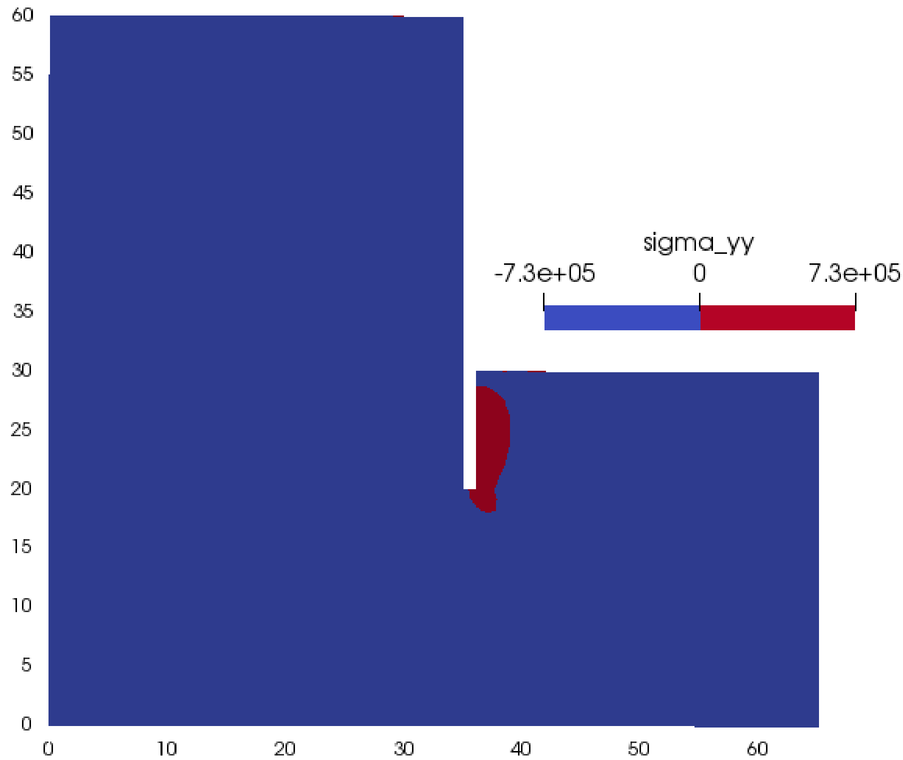

Figure 4: The effective vertical stress.