Master Thesis Project (WI5005)
Section: Numerical Analysis

Compressible vs. incompressible pore water in fully-saturated poroelastic soil

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Project description

A correct description of the behaviour of fully-saturated poroelastic soil is of importance for a wide variety of Civil Engineering problems. The constitutive equations that describe the deformation of fully-saturated poroelastic media are given by Biot [1].

Recent research [3] has shown that the pressure profile in porous media, which is subjected to a harmonic hydraulic load, could be predicted accurately both under the assumption of compressible pore water, as well as incompressible pore water. However, the choice made with respect to the compressibility of pore water significantly impacts the effective stress distribution in the soil, and thereby the degree of elastic deformation.

Finite-element methods are often applied in unison with the assumption of compressible pore water. In order to facilitate a study to the impact of the choice in degree of compressibility on the model predictions, Rijkswaterstaat WVL is interested in developing knowledge on how to simulate the stresses of elastic porous media saturated with incompressible water using the finite-element method. The analysis performed by you will directly contribute to this analysis and thereby on the discussion on what approach is more valid and practically applicable for use in civil engineering practice. More information on the constitutive equations can be found in [2].

For the duration of this thesis project you will join the department of flood defences of Rijkswaterstaat WVL. The department meets once a week on a Tuesday in Utrecht and once a month in Lelystad. You are expected to attend the majority of these departmental days. The rest of the week you can find a place of work of your own choosing, with the possibility to work at a Rijkswaterstaat office nearby. Travel expenses will be covered, and you will receive an internship compensation for the duration of your internship.

Tasks

During this project several tasks have to be completed, which are (at least):

1. Literature research on the compressible pore water model;
2. Literature research applying the finite-element method to the model;
3. Literature report;
4. Adaptation of the model to incompressible pore water;
5. Application the finite-element method to the adapted model;
6. Analysis and comparison of the results;
7. Master Thesis.

References

[1] M. A. Biot. Theory of propagation of elastic waves in a fluid-saturated porous solid. i. low-frequency range. *The Journal of the Acoustical Society of America*, 28(2):168–178, 1956.

[2] Yuanqiang Cai and Honglei Sun. Chapter 1 - basic equations and governing equations. In Y. Cai and H. Sun, editors, *Solutions for Biot's Poroelastic Theory in Key Engineering Fields*, pages 1–8. Butterworth-Heinemann, 2017.

[3] M. Van Damme and D. Den Ouden-Van Der Horst. Methodology for calculating the response of porous media for evaluating grass response to overtopping loads. In *Proceedings of 4th International Seminar on Dam Protections against Overtopping*. Utah State University, 2022.