Theory, model, and method for coupling and interpreting hydromechanical investigations in the laboratory and in the field - Focus on low rock stress, initial results

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Introduction

Large fractures with low effective stress are of central importance for stability and inflow, in rock construction and when extracting or storing natural resources and energy. Fractures, especially large ones, affect geometry and technical execution related to reinforcement and grouting. Superficial, large fractures can be significantly affected if the grout pressure is chosen too high.

Given this, it is of great importance to be able to identify and hydromechanically describe fractures both in the laboratory and in the field. The difficulty of investigating (hydro)mechanical properties in the field makes a field-laboratory coupling particularly relevant.

Aim and hypothesis

The aim of this work is therefore to develop theory, model, and method to describe, couple and interpret hydromechanical investigations, in the laboratory and in the field, for different scales, focusing on fractures with low effective rock stress.

The hypothesis is that this can be done via modelling and hydraulic tests, focusing on stiffness, k, fracture aperture, b, contact point distance, ω, number of contact points and mechanical properties of the rock mass (E, ν). Key references for modeling and coupling of hydromechanical investigations in the laboratory and in the field are Hertz (1896), Witherspoon et al. (1980), Olsson & Barton (2001), Cooper & Jacob (1946) and Doe & Geier (1990).

Initial results

A basic analytical model has been developed and so far tested against a laboratory experiment with known geometry and low rock stress (Thörn & Fransson 2015, Thörn et al. 2015). There is good consistency. Values of stiffness, k, and width, b, for the specific laboratory experiment also coincide with a semi-empirical relation for k and b that has previously been developed based on data from Äspö and Laxemar (Fransson 2014).

References

Cooper Jr, H. H. & Jacob, C. E., 1946: A generalized graphical method for evaluating formation constants and summarizing well-field history. *Eos, Transactions American Geophysical Union 27(4)*, 526-534.

Doe, T. W. & Geier, J. E., 1990: Interpretation of fracture system geometry using well test data (No. STRIPA-TR-91-03). Swedish Nuclear Fuel and Waste Management Co..

Fransson, Å., 2014: The use of basic models to explain in situ hydraulic and hydromechanical tests in fractured rock. *International Journal of Rock Mechanics and Mining Sciences 69*, 105-110.

Hertz, H., 1896: On the contact of elastic solids, In: Miscellaneous Papers, Chapter V, pp.146-162. by Hertz, H. and Lenard P., translated by Jones, D. E. and Schott G.A., London: Macmillan.

Olsson, R. & Barton, N., 2001: An improved model for hydromechanical coupling during shearing of rock joints. *International journal of rock mechanics and mining sciences 38(3)*, 317-329.

Thörn, J. & Fransson, Å., 2015: A new apparatus and methodology for hydromechanical testing and geometry scanning of a rock fracture under low normal stress. *International Journal of Rock Mechanics and Mining Sciences 79*, 216-226.

Thörn, J., Ericsson, L. O. & Fransson, Å., 2015: Hydraulic and hydromechanical laboratory testing of large crystalline rock cores. *Rock Mechanics and Rock Engineering 48*, 61-73.

Witherspoon, P. A., Wang, J. S., Iwai, K. & Gale, J. E., 1980: Validity of cubic law for fluid flow in a deformable rock fracture. *Water resources research 16(6)*, 1016-1024.