Geophysical Research Abstracts
Vol. 20, EGU2018-1272, 2018
EGU General Assembly 2018

Effects of poroelasticity and stress corrosion on large rock slope instability using damage-based time-dependent numerical modelling

Margherita Cecilia Spreafico (1), Federico Agliardi (1), and David Amitrano (2)

(1) Università di Milano - Bicocca, Earth and Environmental Sciences, Italy (margherita.spreafico@unimib.it), (2) ISTerre, Université Grenoble Alpes, Grenoble, France

Large rock slope instabilities are strongly influenced by groundwater conditions. The interplay between applied stress, fluid pressure and rock mass hydro-mechanical properties affects mechanisms and timing of large landslides. Understanding these interplays is a necessary yet difficult task, since the hydraulic properties of heterogeneous rock masses vary in space and time with damage associated with progressive failure processes. In general, damaged rock masses become more permeable and able to host aquifers. These control fluid pressure distributions and modulate further damage as well as time-dependent slope displacements (creep). To simulate the long-term evolution of damaging rocks slopes, Riva et al. (2017) developed Dadyn-RS, a 2D continuum finite-element MatlabTM model which integrates damage and time-to-failure laws. The model is able to account for upscaled rock mass properties and fluid pressure distribution in space and time as a function of damage-dependent dilatancy ad connectivity. However, in the initial stages of progressive failure the validity of the Terzaghi effective stress can be hampered by low crack density or connectivity, and poroelastic effects must be accounted for. Furthermore, in wet conditions the rate of subcritical crack growth and the time to failure of slopes can be more directly influenced by stress corrosion at existing or newly propagating crack tips. A strong influence of these factors on rock mass behaviour was recognised in laboratory tests (Paterson & Wong 2005, Brantut et al. 2013) but not evaluated at slope scale, where these mechanisms and their implications remain unknown.

In this perspective we adapted DaDyn-RS to account for poroelasticity and stress corrosion, to assess their role on mechanisms and timing of long-term rock slope stability. We relate the Biot coefficient of poroelasticity to the amount of accumulated damage at the finite element scale. The effects of stress corrosion were simulated by modifying the parameter controlling the exponential time-to-failure law for wet and dry elements and depending on damage. Published experimental data from laboratory creep tests on intact rocks were simulated to validate the proposed approach. The same was then upscaled to slope conditions by model calibration to field evidence. Model sensitivity was estimated by performing a series of simulations on simplified slope geometries with realistic rock mass properties. Poroelasticity and stress corrosion were shown to have a considerable influence on rockslide mechanisms, slope lifetime and the temporal patterns of damage accumulation, eventually affecting long-term rockslide evolution (steady-state vs catastrophic). Introducing poroelasticity and stress corrosion in our model allows to evaluate their relative influence on real rock slope evolution and to provide more realistic account of hydromechanical coupling and failure mechanisms.

Brantut, N., M.J. Heap, P.G. Meredith, P. Baud (2013). Time-dependent cracking and brittle creep in crustal rocks: A review. J. Struct. Geol. 52, 17-43.

Paterson, M.S., T. Wong (2005). Experimental Rock Deformation - The Brittle Field, Springer-Verlag Berlin Heidelberg, 348 Pages.

Riva, F., F. Agliardi, D. Amitrano, G.B. Crosta (2017). DaDyn-RS: a tool for the time-dependent simulation of damage, fluid pressure and long-term instability in alpine rock slopes. Geophysical Research Abstracts 19, 2017-967.