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Recharge and Transient Pore Pressure Propagation in Steep Alpine Mountain Slopes near Poschiavo, Switzerland

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Within the scope of planning a hydropower pump storage plant in the Poschiavo valley by Lagobianco SA (Repower AG), numerous cored boreholes with depths of 50 to 300 m were drilled at elevations between 963 and 2538 m a.s.l.. In several boreholes Lugeon and transient pressure packer tests were executed at various depths and pore water pressure sensors were properly installed in short monitoring intervals. Several of the boreholes intersect large suspended rock slides showing the characteristic zones of highly fragmented rock mass above a kakirite layer of several tens of meters thickness.

This study presents long term transient pressure records from these deep boreholes and relates them to seasonal recharge trends from snow melt and summer rainstorm events. Annual pore pressure amplitudes at depths between 45 and 278 meters, range between 4 and 40 meters. Recharge from snow melt water production is obtained from the Degree-Day Method (Rango and Martinec, 1995), despite a considerable distance between the meteorological station and the location of the boreholes.

First estimations of storage properties of the aquifers intersected by the boreholes are determined by fitting a combined snow melt and precipitation pressure function to the observed (delayed and attenuated) pore pressure records using a convolution of the one-dimensional pressure diffusion equation for a semi-infinite aquifer of constant thickness (De Marsily, 1986). Initial hydraulic conductivity values were taken directly from hydraulic tests executed by Lagobianco SA in similar rock types (Figi et al., 2014). For most boreholes this strongly simplified approach yields impressively good fits of the transient pressure records and specific storage/yield values, which vary significantly as a function of sensor depth below the piezometric level. Values range from 1e-6 m-1 to 5e-4 m-1 for confined gneiss-schists aquifers and around 3e-2 m-1 for phreatic aquifers, where pore pressure sensors are located only 20-30 m below the phreatic surface.

The obtained values for specific storage and the assumed values for hydraulic conductivity were then verified with a one-dimensional finite element free-surface hydraulic model under steady-state and transient conditions, again fitting the simulated values to the observed pore water pressure records. Boundary conditions were set to constant head at the foot of the column and to infiltration with seepage face review at the top of the column. The results support the observed values for hydraulic conductivity as obtained from the packer tests with low permeabilities in the intact rock mass (K=2e-8 – 3e-10 m/s) and a higher permeability in rock slide masses (around 2e-6 m/s). Furthermore, the values for specific storage found by convolution could be confirmed.

Finally, the complex local hydrogeology of an alpine mountain slope with a large suspended rock slide was investigated with a 2D finite element model under steady state and transient conditions. Preliminary results support the theory of a hydraulic barrier at the base of large rock slides with a perched aquifer above and partially unsaturated conditions below the sliding plane.

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