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Experimental error sources in pore pressure measurement in very low permeability soils.

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Clay sequences represent important components of groundwater systems but traditional groundwater resource investigations have tipically focused on more permeable materials due to obvious reasons of aquifer development. Beside their role of aquitards, in mountain areas fine materials often exhibit high relative proneness to natural instability phenomena which are driven by rainfall induced pore pressure fluctuations. Piezometer measurements are thus required for adequate hydrogeological slope characterization and understanding of landslide mechanisms.

Traditional piezometers require a certain amount of water flux to reach equilibrium conditions after any pore pressure change. Such transient process requires a "time-lag" during which piezometer readings are not representative of the actual pore water pressure in the soil. Time-lag is dependent on the ratio between piezometer area (cross-section) and screen intake and inversely proportional to the hydraulic conductivity (K) of the soil. When K is lower than 1E-9 m/s, time-lag tipically ranges from few months for open standpipes to few days for Casagrande piezometers. Any pore pressure variation shorter than the time-lag would be lost due to adoption of an unsuitable measurement methodology.

The measurement of pore pressure at a point in low permeability soils requires the direct installation of the pressure sensor in the soil and the use of an appropriate soil-sensor interface. This work summarizes the technical experience gained, during the last few years, with pore water pressure monitoring in very low permeability soils. In-situ experimental evidences are supported by laboratory testing aimed to investigate

potential error sources.

Regardless of the nature of the pressure sensor (differential or total), the preferred design includes the underground deployement of the measuring sensor which avoid the presence of long hydraulic circuits increasing sources of potential error and the vulnerability of the system to ground movements.

In case of underground placement of both sensor and surrounding filter, major sources of potential errors derive from flow restriction due to drilling effect and from uncomplete saturation of the measuring device. The effects of sensor accuracy, precision and drift are insignificant for most practical purposes with modern sensors technology. Uncomplete saturation, in particular, proved to be very common and nearly impossible to avoid. Even when accurate sensor saturation is reached prior to installation, there is no certainty that it is mantained during the installation phase and during the exercise phase, when water table can drop below the sensor depth. When air is present within the pressure sensor, any pore pressure change needs to displace a volume of water to/from the sensor in order to accommodate the air volume change of the air, resulting in possible measurement delays. Laboratory tests demonstrate that such error source can significantly impair the measuring capabilities of sensors. Its influence, however, can be significantly reduced by means of simple setup solutions aimed to enlarge the interface between surrounding soil and filter. More particularly, the installation of the pressure sensor within a sand pocket greatly enlarge the flow capacity to/from the sensor and greatly reduces the damping of the response caused by the compressibility of the gas bubbles.

A simple numerical seepage model helps to reproduce the behaviour of in-situ sensors and evidences the important role of the proposed setup solution. The model allow the comparison between the time-scale of pore-pressure propagation from above (rainfall impulse) and the response damping introduced by uncomplete saturation. Results indicate that a small sand pocked (20 cm) surrounding the sensor within the borehole can be enough to get reliable pore pressure measurements.