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Quantifying shrinkage of natural clay samples with an automated high-frequency measurement set-up

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Shrinking and swelling of expansive clay deposits can cause severe damage to infrastructure (Mokhtari & Dehghani, 2012). Volume change depends on the characteristics of the porous material, such as clay content, mineralogy, organic matter content, soil moisture conditions and drying history (Basma et al., 1996 ; Boivin et al., 2004; Puppala et al., 2007). However, predicting the shrinking and swelling of natural clay deposits as a function of material properties and soil moisture conditions is not yet possible. Measuring shrinkage and swelling of natural, undisturbed clay samples in a controlled laboratory setting will provide information on the shrinkage behaviour in the field and can be used to establish models.

To quantify shrinkage and swelling of shallow clay deposits, we have designed a new measurement set-up based on the HYPROP 2 measurement device (UMS, 2012; Schindler et al., 2015), using cylindrical samples (height: 5 cm, diameter 8 cm). The set-up is designed to create minimal disturbance to the samples during air drying in a climate-controlled room, while measuring volume, water content and soil water suction every 10 minutes. The volume measurements are carried out with 5 optical distance sensors that measure the distance to the samples from a rotating robot arm. Distance to the samples is measured at 15 points per sample on the top and 10 from the side while moving along the sample. The distance between measurement points varies between 0.5 (on top) and 0.8 cm (from the side). These point data are converted to volume measurements, assuming cone shaped samples.

The first experiment aims to distinguish shrinkage behaviour of differently prepared samples and to confirm the likeness between three similarly prepared subsamples. In total 8 samples were extracted at 1.5 m depth from a fluvial clay deposit. These samples were saturated for half a year with different solutions: tap water, an instant ocean mix (Cl 16.9 g/L; Ca 0.388 g/L) and a saline calcium solution (Cl 6.20 g/L; Ca 4.76 g/L). The measurements yield a detailed overview of the shrinkage behaviour. Total shrinkage differs within the triplicates up to 1.3% (tap water), 3% (instant ocean solution) and 4.6% (saline Ca solution). The samples saturated with tap water and instant ocean mix totally shrink 42-44%. The samples prepared with the saline Ca solution show similar shrinkage rates to the instant ocean mix samples for the first two weeks of drying. Thereafter, the shrinkage rate of the saline Ca samples declines, resulting into a cumulative shrinkage of 36%.

The experimental set-up is able to capture the different shrinkage rates of the differently prepared samples. The shrinkage rates of the duplicate and triplicate samples agree well, with a maximum shrinkage difference of 4.6% between triplicates. These are very small differences considering that all samples are natural clay sediments without any form of homogenization. Currently, we are investigating the reversibility of the shrinkage and swelling. These results will be used to test a shrinkage-swelling model.

Participation

In-Person

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