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Hydraulic Conductivity of Coarse Sand Affected by Trapped Air Bubbles

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The aim of this study was to experimentally determine a relationship between gas residual saturation (*SGR*) and corresponding hydraulic conductivity (*K*) of two coarse sands. The *SGR* indicates the ratio of volume of entrapped air bubbles to pore volume of the sample.
Series of constant head infiltration-outflow experiments were used to determine the relationship between the *K* and the *SGR*. Air trapping was achieved by repeating drainage and imbibition of water into the initially fully saturated sample. The value of *K* was determined using a constant head infiltration experiment and evaluated by Darcy's law from measured steady-state flux. After the first constant head infiltration run and then after each subsequent infiltration run, the sample was drained under tension (-30 cm, -50 cm) on a sand tank. The *SGR* was determined gravimetrically after each infiltration run. Each infiltration run thus provide one value of *K*(*SGR*).
First batch of experiments were done in a laboratory and *K*(*SGR*) relationship was obtained. Selected five samples were scanned by micro-computed x-ray tomography (CT) to obtain information on entrapped air cluster size, shape and distribution. For the second batch of samples, CT revealed that fractures that occurred in the lower part as a result of deformation of insufficiently rigid supporting textile mesh at the bottom of the sample. Therefore, the experimental setup with more rigid support, formed by thin carbon rods, was designed. The fractures were not observed when improved set-up was used for experiments and the *K*(*SGR*) relationship was similar to first and second batches of samples.
The spatial distribution of air bubbles within the sample, the histogram of air bubble sizes and residual air content were obtained from binarized CT images. It is clearly visible that the bubbles formed in globular cavities in the loosely packed sand. The cavities emerged as a result of sand particles displacement by growing bubbles.
Results confirmed the trend of decreasing *K* with increasing *SGR* for both sands under study. The highest entrapped air content and the largest bubbles were detected in the upper half of the sample. The results confirmed that the trend of the *K*(*SGR*) relationship was a consequence of changes in entrapped air bubbles distribution.

References

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