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Hydrology and Earth System Sciences Discussions

Interactive comment on "Centrifuge modeling of one-step outflow tests for unsaturated parameter estimations" *by* H. Nakajima and A. T. Stadler

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The authors are grateful to the reviewer for his helpful comments on the initial manuscript and it will be revised accordingly for the final manuscript.

In response to the specific comments:

(1)Accuracy of the outflow and soil water pressure head measurements

Volume of the outflow was measured by visualizing water level in the outflow collector using a video camera. Snapshots at given times were taken as 640-480 bitmap images. For each snapshot, number of pixels between the bottom of a section, which outflow was being collected, in the outflow collector and the water level was measured. Then height of the water level was calculated using a correlation factor, i.e., length per unit pixel which was determined from number of pixels between two points of known distance. Therefore, the accuracy of the outflow volume depends on the resolution of the images plus the cross-sectional area of the sections in the outflow collector. The accuracy ranged between $\pm$1.5 to $\pm$0.4 cm^3, and that for outflow per unit area of the sample was between 1.9$\times$ 10^{-2} and 4.9$\times$ 10^{-3} cm^3/cm^2, which we thought sufficiently accurate.

In this study, pore water pressures were measured using temperature compensated gage pressure sensors (Honeywell 26PCB) through a 12 bit signal conditioner. From calibration tests, it was confirmed that the sensors maintained their linear output and the measurement accuracy was as much as 20 kPa (2 mm in pressure head) even at 40g.

(2)Initial parameter values which were used in the inverse modeling

As the initial guess of the parameter set, we used the values obtained from the conventional tests. We also attempted other initial parameter sets and faced convergence errors several times. As the reviewer indicated Ottawa sand we used has a large n value in the van Genuchten model. The convergence error and optimized parameters were particularly sensitive to the input n value.

(3)Possibility of the proposed methodology for loamy and clayey textures

We think the proposed methodology is applicable to loamy and clayey soils. However, it should be reminded that such soils may be consolidated in the centrifuge fields due to increase of self-weight of the soil. The self-weight consolidation may change pore structure. One way to evaluate significance of the self-weight consolidation is to conduct the centrifuge tests with different sample heights and to compare the optimized parameters. On the other hand, producing non-uniform pore structure due to the self-weight in the centrifuge model may be useful to study water movement and estimate the hydraulic parameters for a relatively large scale (order of 10^0 to 10^1 meters).

(4)Multi-step tests coupling with centrifuge modeling technique

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We completely agree that conducting multi-step tests in the same manner will increase the reliability and versatility of the centrifuge modeling technique. One way to conduct the multi-step centrifuge tests is to subsequently change the lower boundary condition. This would be possible with some modifications of the experimental setup. Another way is to repeat one-step tests at subsequently increased centrifugal acceleration fields. This is similar to the work by Simunek and Nimmo (2005). However, the centrifuge apparatus we used for this study takes a few minutes to change the acceleration and to be stable. During the transition and at a new gravity field, redistribution of the pore water will occur, and the water distribution will be no longer the same as that at the last gravity field. If the redistribution of pore water is included in the inverse analysis, this would be much simpler and the proposed method would be more attractive. This is beyond the scope of this study but we would like to extend the investigation.

(5)Extra financial investment required compared to the small centrifuge apparatus

The geotechnical centrifuge apparatuses used to be special experimental tools which only limited number of schools and institutes owned. However, nowadays there are more than a hundred of geotechnical centrifuges with different sizes in the world. Although we do not know how many small centrifuge similar to Simunek and Nimmo (2005) used are available, accessibilities to use either of the apparatuses may not be very different. Expenses for conducting centrifuge tests largely depend on size of the centrifuge. Obviously a very large centrifuge would be unnecessary for this type of experiments. Centrifuges up to 2-meter radius may be appropriate and operation cost may be comparable to small centrifuges. As described in the manuscript, the experimental setup we built did not require extremely specialized equipments. Once the experimental setup was built, it took only one and a half days by one experimenter to prepare and complete a single test.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 731, 2006.