Standardized hydraulic conductivity testing of compacted sand-bentonite mixtures used for groundwater protection

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Abstract. Compacted clay liners (CCLs) are commonly required as engineered barriers in waste containment applications to protect groundwater from waste derived leachate. In this regard, achieving a suitably low hydraulic conductivity (k) of the CCL generally is the primary consideration in order to minimize the amount of leachate percolating through the CCL. Also, in cases where suitable natural clay is not available for use as a CCL, a compacted mixture of sand with a low percentage of sodium bentonite (≤ 15 % by dry weight) often is considered as an alternative CCL. Based on these considerations, a study was undertaken to evaluate the effects of several factors on the measurement of the k of compacted sand-bentonite (S-B) mixtures in accordance with the ASTM standard for measuring the k of saturated porous materials using a flexible-wall permeameter (i.e., ASTM D5084). Eight duplicated flexible-wall k tests were conducted to evaluate the applicability of ASTM D5084 to compacted S-B mixtures with respect to bentonite content (5, 10, and 15 %), magnitude of hydraulic gradient (30 vs. 60), manner of imposing hydraulic gradient (constant head vs. falling headwater and rising tailwater (FHW-RTW)), length of specimen (29.1, 58.2, and 116.4 mm), and type of permeant water (tap water vs. "standard water" or 0.01 M $CaCl_2$). The base case for comparison of results was considered to be the test with a 58.2-mm-length specimen containing 10 % bentonite content (by dry weight) and permeated via constant-head conditions with tap water using an applied hydraulic gradient of 30. The results to date indicate that testing of specimens with low bentonite contents (i.e., 5 %) can be problematic due to issues with particle migration, such that the hydraulic gradient had to be applied gradually in order to prevent a sudden pressure change to the specimen that could induce particle migration before the bentonite became sufficiently hydrated. However, for specimens with 10 % bentonite content, a higher hydraulic gradient (60), the FHW-RTW gradient application, and shorter or longer specimen (i.e., 29.1 mm and 116.4 mm) all resulted in k values on the same order of magnitude as that for the base case. In addition, the measurement of k beyond the time required on the basis of the termination criteria specified in ASTM D5084 resulted in a final measured k value that was equal or lower than that based on the standard termination criteria. Finally, the time corresponding to the standard termination criteria generally correlated with very small pore volumes of flow (≤ 0.60), such that only a fraction of the total volume of the specimen was exposed to the permeant liquid. The results of this study indicate that some revisions to ASTM D5084 may be in order in the case of application of the standard to the measurement of k for compacted sand-bentonite mixtures.