

## DISCUSSION

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*D. Rath*<sup>1</sup> (*written discussion*)—What kind of cement is recommended for slurry walls and what consideration is given to possible reactions which may occur between the bentonite and cement type used?

*S. A. Gill and B. R. Christopher* (*authors' closure*)—The type of cement will depend on the quality of water and does not appear to be directly related to the type of bentonite. However, no studies were made for this project. To our knowledge, there is no published data on the effect of cement on bentonite. Typically ASTM Type I cement (ASTM C 150) is used in slurry walls with regular bentonite. Type III cement (ASTM C 150) is recommended in aggressive environments where typically "Saline Seal" bentonite is used.

*J. Evans*<sup>2</sup> (*written discussion*)—No permeability data were presented; did any of the mix designs achieve the desired permeability of  $1 \times 10^{-7}$  cm/s?

*S. A. Gill and B. R. Christopher* (*authors' closure*)—Coefficients of permeability of all mixtures was in the range of 0.1 to 0.01  $\mu\text{m/s}$ . Within the range of material proportions tested, it appears difficult to obtain permeabilities less than 0.01  $\mu\text{m/s}$ . It may be unrealistic to expect a 0.01  $\mu\text{m/s}$  permeability from cement-bentonite mixtures within the trench. However, the possibility of a bentonite "cake" of a much lower permeability forming along the walls of the trench should be evaluated with respect to the permeability of the entire wall. Thus the effective permeability of the wall including the cake may provide an overall effective permeability of less than 0.01  $\mu\text{m/s}$ .

*P. M. Jarrett*<sup>3</sup> (*written discussion*)—The unconsolidated-drained test is a most unconventional form of test to use! One would expect results to be completely dependent on sample size. Could the authors comment on the reasons for the use of this test, the analysis of results, and the procedure used? Was pore water pressure monitored?

*S. A. Gill and B. R. Christopher* (*authors' closure*)—No doubt the unconsolidated-drained test is inappropriate for analysis of strength. However, the test is valid to simulate as-placed conditions, to evaluate hydraulic fracture potential, and to evaluate the influence of rapid pore water pressure decrease on permeability. In the field, the slurry wall will be subjected to consolidation after it has been completed as the dam is being constructed over it. The concern in such construction is whether the wall can tolerate loads during construction of the dam without fracturing, thus under an unconsolidated-

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drained condition. Since the ultimate criteria is to achieve a desired permeability after such conditions have been imposed, it would also appear appropriate to perform permeability tests after the specimen has been exposed to such conditions.

An additional reason for performing this type of test was to demonstrate the inadequacy of the specification in defining the test procedures. Since no procedure was defined, we felt it necessary to demonstrate that the required strains could easily be obtained in an unconsolidated-drained test even though they could not be obtained in a more conventional consolidated-drained test. Pore water pressure was not monitored and in actuality the test was an unconsolidated, partially drained test.

*V. P. Drnevich*<sup>4</sup> (*written discussion*)—Was any attempt made to study the effects of chamber fluid on test results? For long-term tests (more than a few days long), will not osmotic pressures through the membranes affect results?

*S. A. Gill and B. R. Christopher (authors' closure)*—As relatively short-term (three to four days) tests were performed in this study, no attempt was made to study the effects of chamber fluid on test results. The possibility of osmotic pressures through the membrane affecting test results is an interesting question and merits further research for long-term tests in flexible-wall permeameters.

*Y. Acar (additional closure)*—This author would like to reemphasize the importance of this specific testing consideration. Figure 4 of our paper indicates that effluent concentration reached only 25 to 30% of the influent concentration even after 10 to 14 pore volumes of permeation which took about 3 to 4 months of testing. We have found that a significant portion of the contaminant migrated into the cell water through the latex membrane. If provisions are not taken to avoid such an occurrence, it is expected that tests in flexible-wall permeameters using low concentration of contaminants as permeant are not expected to demonstrate the full effect of the contaminant on the soil.

*B. S. Beattie*<sup>5</sup> (*written discussion*)—Since cement poisons the active bentonite during curing, why was a high yield, more expensive clay preferred over a standard American Petroleum Institute (API) 13a drilling mud-type clay?

*S. A. Gill and B. R. Christopher (authors' closure)*—We are not aware of harmful effects of cement on bentonite. The use of bentonite panels as a waterproofing membrane along concrete walls is widespread with no reported cases (to our knowledge) of long-term deterioration. Cement and normal bentonite are compatible. Bentonite is also used in cement-water grouts to increase fluidity and to minimize shrinkage on setting. In this particular case, it was considered more economical to use Ultra Gel 180 bentonite as compared with a lower yield bentonite. The bentonite used did meet the requirements of API Standards 13a.

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<sup>5</sup>Federal Bentonite, Montgomery, IL 60538.

*Anonymous (written discussion)*—Did you conduct any freeze-thaw tests for this project? What were the results? Are they public?

*S. A. Gill and B. R. Christopher (authors' closure)*—No freeze-thaw tests were performed for this project. In our opinion, such tests are irrelevant as the cutoff was to be covered by the dam and would not be subjected to ambient freeze-thaw conditions.