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## **Engineering Properties of Cement-Bentonite Grout Mix**

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There is very limited data in the public domain on the engineering properties (hydraulic conductivity and shear strength) of cement-bentonite grout mixes. The primary goal of this research was to expand the database by providing results from advanced laboratory tests. Building on the work of Contreras, et.al 2007 and others, the Unconfined Compressive Strength (USC), hydraulic conductivity and cure time differences of the water:cement:bentonite ratios were analyzed focusing on field use of the grout.

Multiple mixtures were chosen and tested for permeability and unconfined compressive strength in order to expand the current database of water:cement:bentonite grout mixes to correspond with various types of soils. Providing a larger database of grout mixture options for use in multiple types of soils would decrease test times by having the ability to access additional possible mixtures with the desired permeability and unconfined compressive strength. Additional ratios and altering of the procedures from previous testing included expanding the testing to occur after 7, 14, and 21 days. Tests focused on maintaining adequate permeability and achieving minimum hydraulic time lags while ensuring quick response to the changes in pore water pressure. To assure consistency with previous database controls and to assure the validity of the data, a continued use of materials with similar properties included potable water, Type 1 Portland cement and sodium bentonite powder. Materials were measured by weight per ratio. Procedures were consistent with Mikkelsen's 2002 studies. Mixtures were cured to 7, 14, and 21 days with the final samples tested within one hour of removal from cylinders.

The Unconfined Compressive Strength tests were done on three samples per ratio period and results ranged from 350-535 kPa. Results noted that as the hydration period of cement increased, the permeability decreased. More cement in the mixture and the longer cure time, created less void ratio resulting in lower permeability. The Unconfined Compressive Strength decreased with the increase of water:cement ratio; but at the same time, the Unconfined Compressive Strength increased as the hydration time increased.

The research answers questions and provides options available for grout mixture's optional use in the field. It expands the database currently available but notes that the database is still very limited. Additional data will be needed to further increase field use options to improve efficacy.