Controlled-Rate-of-Strain Consolidation Testing of Clays

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The controlled-rate-of-strain (CRS) test is a very useful one-dimensional consolidation test. The CRS test performs the same task as a normal one-dimensional undrained, incremental loading consolidation test, except that instead of taking days to complete a test, an entire test can be completed in about five hours.
The theory used to analyze the data obtained from this test comes from the former ASTM standard D4186-82 developed by Wissa et al. (1971) and modified by Armour and Drnevich (1988).

The loading device for the CRS test is a gear-driven loading press that allows different strain rates with the changing of the gear ratios that raise the platform of the press. A load cell is installed at the top to monitor the load that is applied to the sample. An LVDT is attached to the top of the loading piston to monitor the displacement of the sample. Two pressure transducers are attached at the base of the apparatus. One measures the pressure in the cell while the other measures the excess pore pressure under the sample. The two transducers are used to do a B-check in checking for full saturation. An air pressure regulator controls the back-pressure applied at the top of the sample, and a pressure gauge is installed to monitor this air pressure. A low-friction seal guides the piston into the chamber. A reservoir (not pictured) is used to fill the chamber with water after the seating pressure has been applied.

A Sensotec analog-signal receiving unit is used to measure the signals put out by the four measuring devices. This unit allows zero and gain adjusters to assimilate the analog readings from the measuring devices to useful engineering units. A Keithley unit with an AMM2 board is used to do the analog-to-digital conversion of the output signals, and Viewdac is utilized to obtain and record the digital signals as voltage from the Keithley unit, and programs are written to calibrate the voltage outputs to engineering units.

Before test 3b, for which the data in this report is presented, all of the tests were inconclusive because the pore pressure never built beyond the initial state attained in the B-value check. The problem seemed to be the o-ring that sealed the consolidating ring to the base of the chamber. Many attempts were made to insure proper alignment with no success. Finally, the groove that the o-ring is placed in was machined deeper into the base, allowing the consolidation ring to fit just down into the groove. The ring was then fastened in place like this using two bolts. This method of preparation makes measuring the initial height and volume of the sample complicated. In the data analysis, the assumption was made that the initial height of the sample was equal to the height of the ring minus the measured depth of the groove into which it was placed. This seemed to provide accurate results in the tests performed.

The data analysis was performed according to ASTM D 4186-82 (updated version). Using the measured values of load, displacement, and excess pore pressure, the total stress, effective stress, pore pressure ratio, and coefficients of consolidation were calculated using the equations from ASTM D 4186-82. The time intervals for data acquisition were also obtained from ASTM D

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4186-82. Plots of pore pressure ratio vs. effective stressand void ratio vs. effective stress for test 3b (performed 12/14/99) are shown on the following pages. Although the maximum pore pressure ratio did not reach the level that was hoped for, which was approximately 30%, the data seems to accurately describe the properties of Kaolinite clay. Adjusting the loading press to a higher strain rate will display higher maximum pore pressure ratios. This means that the use of this apparatus in testing other less well-known clays should provide us with a better understanding of the properties of these clays.