Florida Department of Transportation Research

Development of a Smear Proof Horizontal and Vertical Permeability Probe

BDK75 977-35

Permeability is a measure of how well a porous medium conducts a fluid. For water, this property is called hydraulic conductivity, and it is important for projects that depend on properties of soil and strata, such as earthen dams, retention ponds, dewatering systems, hydraulic structures, wells, landfills, and many other engineered facilities that rely on hydraulic conductivity for their proper function. Hydraulic conductivity of soils can vary by many orders of magnitude, from $1x10^{-2}$ cm/sec for highly permeable sands to $1x10^{-7}$ cm/sec for practically impermeable clays.

Hydraulic conductivity is difficult to measure. Soil composition, orientation of soil particles, and voids or impermeable materials can vary greatly over short distances. Because soils are layered, vertical and horizontal permeabilities can differ strongly. Thus, retention ponds are of special interest because water exits these basins in two stages: an initial stage due to vertical infiltration and a second stage of mainly horizontal flow. Accurate determination of hydraulic conductivity in both directions is critical to correctly balancing effectiveness and economy of design.

Technicians perform lab tests (left) using the final probe design (right).

While field methods for determining hydraulic conductivity seem best technically, current methods for such tests are both time consuming and expensive. In a previous project for the Florida Department of Transportation (FDOT Project BD545-15), University of Florida researchers developed a probe, the Vertical and Horizontal In situ Permeameter (VAHIP), that measures both horizontal and vertical permeabilities. In that study, the VAHIP worked well in the field trials; however, water outflow ports on the end and sides of the probe (used to test vertical and horizontal permeabilities) often clogged. When the probe penetrated a weak clay layer, soil would smear the probe's sides. If the probe was then pushed into sand, it would not measure permeability accurately. An important goal of this project was to refine the VAHIP device and make it "smear-proof."

Through a succession of prototypes, researchers tested a variety of methods to either prevent or resolve clogged ports. Eventually, they arrived at a design in which the probe has a retractable inner core. In the extended position used for pushing the probe into the ground, the core closes the tip of the device and holds 12 keys in place to block the slits in the side of the probe, preventing soil intrusion. When retracted, the end and side ports open, allowing outflow of water for testing. The final design is easy to break down and reassemble, if cleaning is needed in the field.

During the numerous cycles of design, testing, and verification of the probe and its supporting equipment, the researchers worked closely with FDOT to resolve design and operational concerns, which led to numerous improvements found in the final design. For example, the researchers developed a dial that addressed concerns of FDOT workers who wanted to know the probe's rotation and depth during tests. Testing and data reduction procedures for the final design were documented in a manual included the project's final report, and a computer program was developed to analyze results.

Project Manager: David Horhota, FDOT Materials Office
Principal Investigator: Raphael W. Crowley, University of Florida
For more information, visit http://www.dot.state.fl.us/research-center