Development and Testing of a Permeameter to Simulate Vertical Fluid Seepage within Assorted Soil Specimens

Soil Mechanics Laboratory

NYU-poly
POLYTECHNIC INSTITUTE OF NYU

Abstract:

This research explored the characteristics and properties of assorted soil samples by running falling head tests in a permeability chamber. Permeability is the ease in which water can flow through a soil volume, and is extremely important because it is one of the main variables that affects the strength and behavior of soils. It is of major concern in the design and construction of buildings and/or underground structures where groundwater needs to be controlled. Particular attention was paid to the utilization of transparent soil mixtures of aquabeads and fused quartz as they allow for a greater visualization of the particle behaviors during flow.

A new permeameter device was constructed. The chamber design was based upon a factory constructed permeameter from ELE Corporation. Initially, its design was done by using Google SketchUp, and then machined of cast acrylic tubes and sheets that were compressed with the addition of threaded rods. The Parallax BasicStamp2 was utilized to measure the rate of falling head and thereby deriving the rate of flow in the different samples.

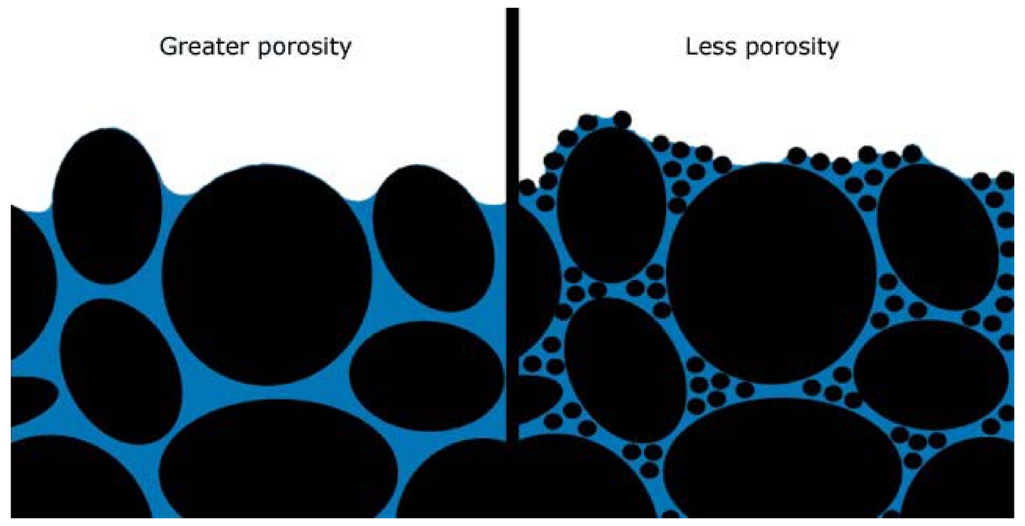
Research Goals

- Development and testing of an inexpensive permeameter to simulate fluid seepage within soil specimens;
- Developing a P-Basic program for automation of the measurement of permeability within falling head tests;
- Exploring properties of assorted soil specimens;
- Comparing coefficient of permeability of field collected soil specimens.

- Addition of actuators will allow for fully automated permeability tests in laboratory settings
- Ease and neatness in testing integrity within assorted classroom settings

Motivations and Potential Applications of permeameters

- Bringing civil engineering to K-12 classrooms
- Understanding soil behavior
- 3-D mapping of contaminant seepage in soils
- Sensor networks for automated hydration and contaminant control

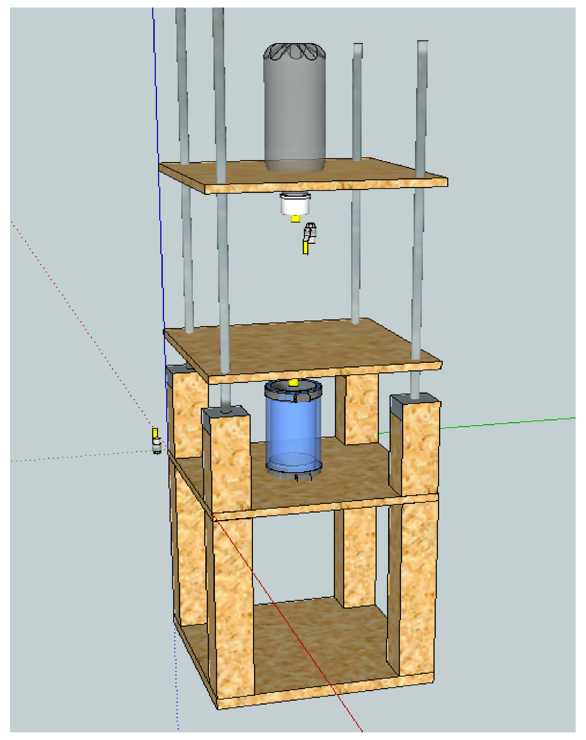


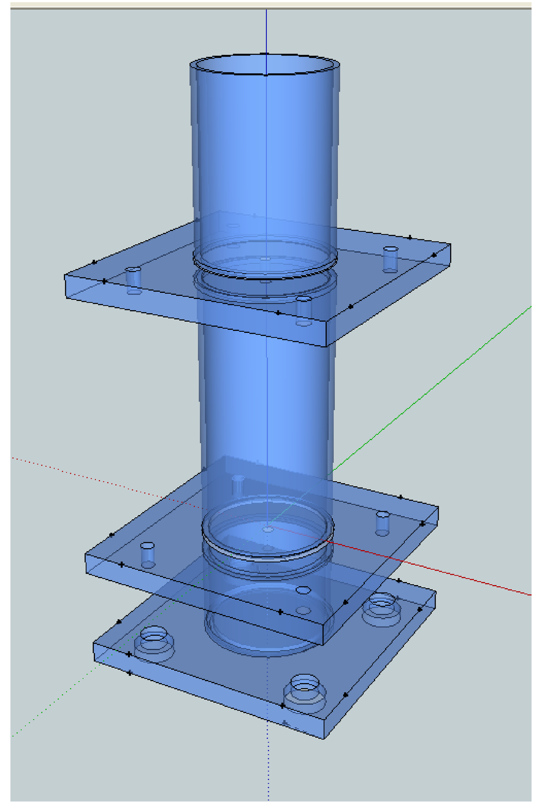
Understanding of porosity and permeability gives students a greater appreciation of construction and engineering projects that often go unseen.

Computer Aided Design

The design of a permeameter is realized using the Computer Aided Design (CAD) software *Google SketchUp*.

Shown (right) is a simplified schematic of the original design and another (below) based upon an ELE International permeameter.





The tube on each level of sheeting was glued using a special solvent that bonds acrylic pieces together.

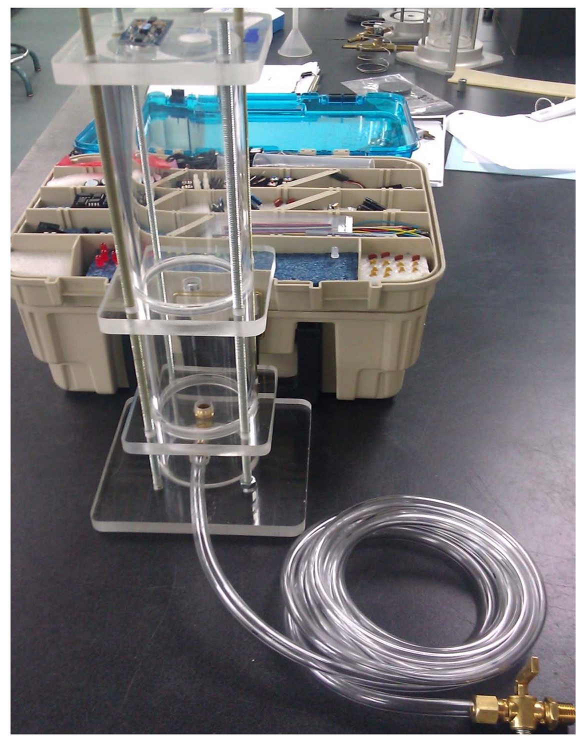
The completed units were kept water-tight with threaded rods that applied tension from top to bottom.

Machining was carried out on cast acrylic tubes and sheets to create a light, portable unit.

Shown (below) is the lathe that was used to create grooves to enable a water-tight seal between different levels on the permeameter.

Porous stones needed to be on either end of the soil specimen to prevent degradation and flow from the sample.

Brass fitting and rubber tubes allowed water to flow from the permeameter into a collection chamber, such as a beaker or graduated cylinder.



Manufacturing

The permeameter measured flow rate using a Parallax Basic Stamp 2 microcontroller with a Ping))) ultrasonic sensor.

The acrylic top was milled to allow the sensor to sit flush and reduce the possibility of getting water damage in the circuit.

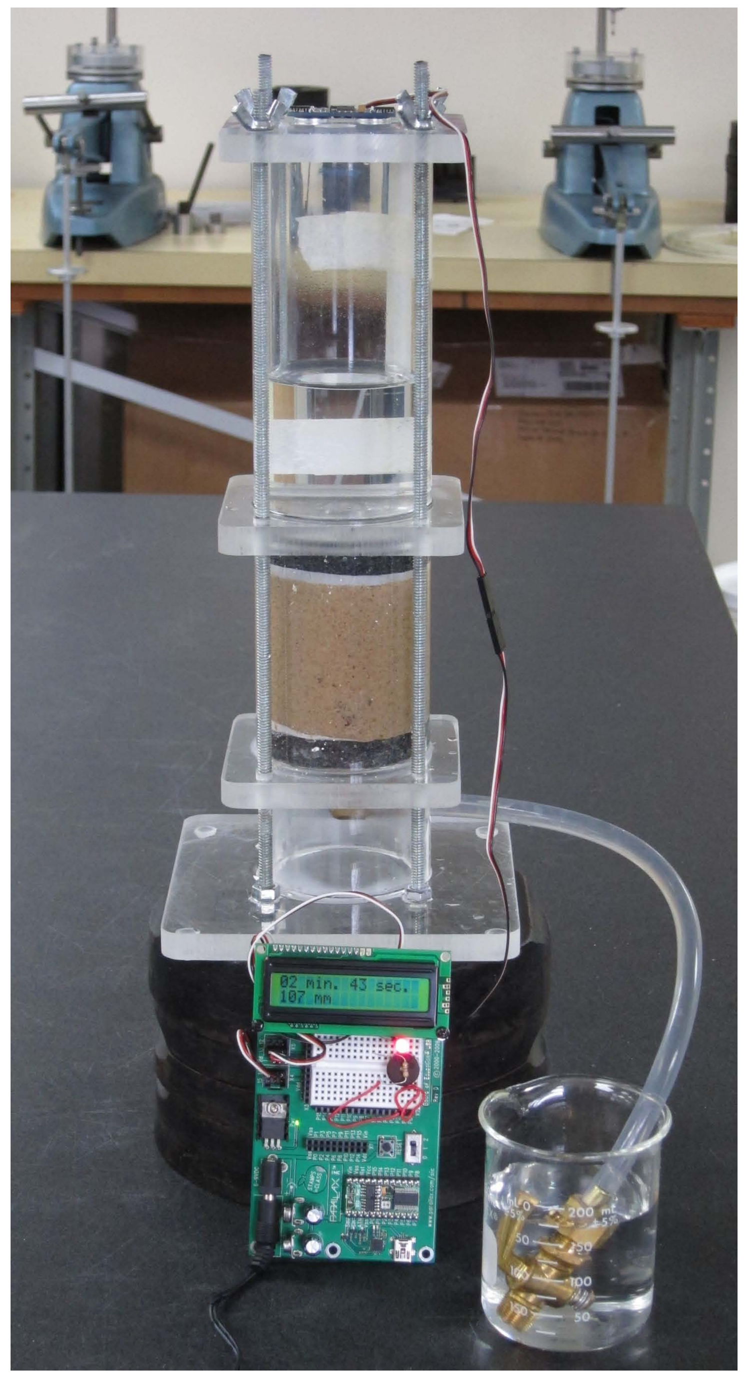
Mechatronic Permeameter

Basic Stamp Editor V2.5 was used to program the Parallax Basic Stamp 2 microcontroller.

Water displacement levels were measured using the PING))) ultrasonic sensor.

Values of time and flow rate were calculated and displayed on an LCD.

LED and Piezo speaker were used to signal beginning and end of the measuring process.



Comparative Analysis

As six new permeameters were completed a comparison of several soil specimens could be executed simultaneously. Fused quartz and two natural sands were analyzed in the lab.

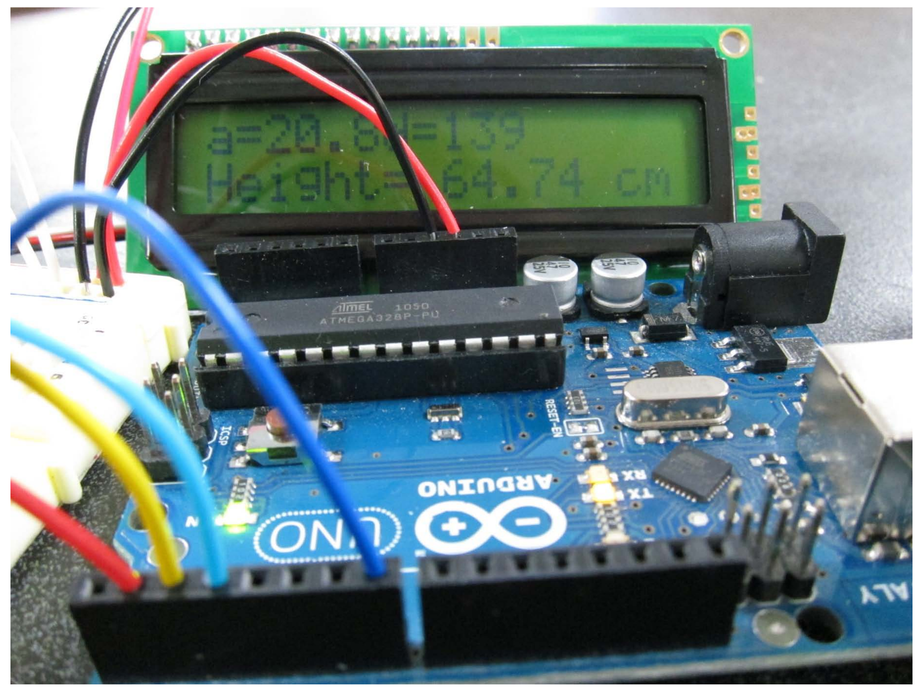
Glass marbles, plastic pellets, aquabeads, and fused quartz were studied to explore seepage within transparent porous media.

Poorly graded samples such as Fire Island sand and the glass marbles have a higher porosity and, therefore, a higher permeability.

Future Work

Dyes need to be examined to model ground flow contaminant seepage. This flow within soils can now be fully visualized with the use of different transparent media.

The Arduino shown (right) seems to be more versatile and allow for a greater expansion of sensors and actuators to fully automate monitoring and execute proactive measures.



Acknowledgements: This work is supported in part by the National Science Foundation under a Research Experience for Teachers (RET) Site grant EEC-0807286. We thank the Mechatronics Lab and the Soil Mechanics Lab for hosting us during our summer research program.

The authors are thankful to Prof. Iskander, Andrew Cave, Eduardo Suescún, Iván Guzmán, and Sina Kashuk , as well as Jared Alan Frank, David Lopez, and Ryan Caeti from the Mechatronics Lab, and Alessandro Betti, the machinist for the Mechanical Engineering Dept.