Hydraulic Properties of Unsaturated Clay Shale Mixed with Light Weight Aggregates

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ABSTRACT

Shale is a sedimentary rock, and it is widely distributed in the U.S. and all over the world. It is well known for being one of the common source rocks for gas and oil. However, due to its lamination and fissility with rich clay minerals, its properties may change significantly when it is weathered and exposed to water. As a result, shale is usually not considered an appropriate material for construction. Nevertheless, engineers have been trying to utilize substandard materials like shale by mixing it with additives to improve its properties. One of such frequent efforts is mixing coarser materials and improving the engineering properties of the raw substandard materials such as hydraulic properties, shear strengths, or volumetric changes. In this study, clay shale is mixed with lightweight aggregates in different ratios and its saturated and unsaturated hydraulic properties are investigated.

The clay shale was collected near the surface at an excavation site in Rapid City, SD. The samples were air-dried, crushed, and sieved through No. 40 sieve (mesh size = 0.425 mm) (Dayioglu et al., 2017). In order to investigate the effect of coarser materials to the unsaturated hydraulic characteristics, the screened materials are mixed with lightweight aggregates. The lightweight aggregates are fine expanded slate lightweight aggregates formed from volcanic ash. These aggregates are processed in high temperatures and have a specific gravity (wetted surface dry) of 1.88 according to the manufacturer (Maloof & Smith, 2019).

The samples were prepared by mixing the air-dried clay shale with 25%, 75% and 100% of lightweight aggregate by weight at the moisture content of 20% and compacted to the dry unit weight of 1.30 g/cm^3. Subsequently, the samples were saturated and tested for

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their saturated hydraulic conductivity. Afterwards, the saturated samples were set up with a HYPROP 2 device as shown in Figure 1 to determine the soil water characteristic curve (SWCC, also known as water retention curve) and unsaturated hydraulic conductivity (METER, 2018). Furthermore, the mixed samples were prepared for the different water contents and tested with WP4C, which is a chilled-mirror dew-point hygrometer determining the suction-water content relationships in dry side (ASTM Standard D 6836 - 12, 2016; METER, 2021).

As a result, a series of SWCCs were constructed, as shown in Figure 1. Decrease in the suction was observed with the increase in the amount of lightweight aggregates, which is expected with coarser particles in the aggregates. The automatic system is proven to be effective in obtaining a SWCC with a single sample and less intervention. However, additional supervision is necessary in preparing the experiments due to the sensitivity of the sensors compared to the typical methods using the axis translation technique. The SWCCs in a complete range and corresponding relationships between the hydraulic conductivity will be obtained in the future.

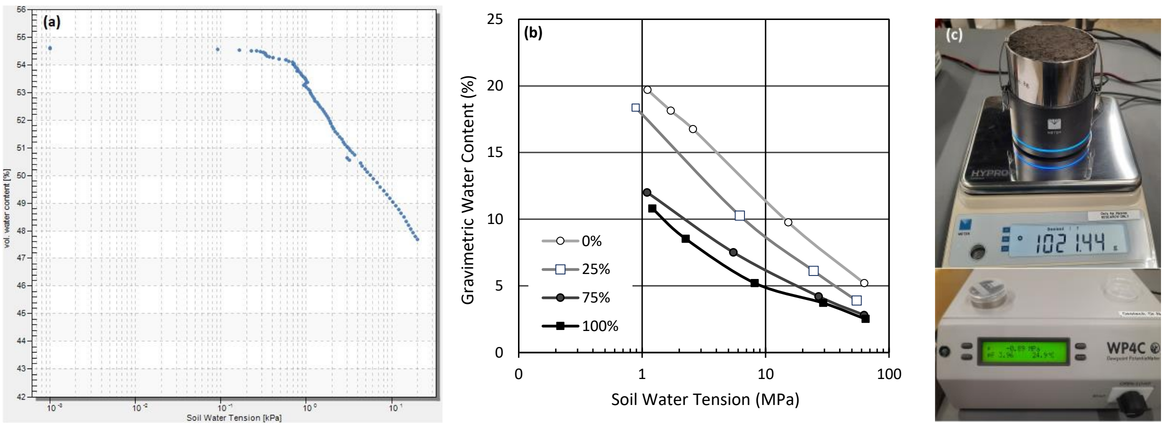

Figure 1. (a) Partial SWCC for 1:1 mix (100%) with γ_d =1.30 g/cm^3. (b) Partial SWCCs for the different amounts of FLWA by weight, and (c) Measuring devices (HYPROP2 and WP4C)

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