Permeability Measurement and Seepage Modeling of Tropical Volcanic Island Soils

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ABSTRACT

The coefficient of permeability plays a crucial role in geotechnical engineering, yet it is seldom reported for chemically weathered volcanic soils from tropical regions such as Hawaii, or for marine sediments that are equally fine-grained and in some cases share similar clay constituents. Volcanic soils from the University of Hawaii Manoa campus were tested using a variety of direct and indirect laboratory methods. The results indicate relationships with plasticity, clay fraction and in situ void ratio. Deep-sea sediments also reveal that permeability is related to void ratio and plasticity, but results vary somewhat between sediments from the Atlantic and Pacific oceans. Increasing carbonate content is seen to increase permeability.

KEY WORDS: Permeability, marine sediments, volcanic soils

INTRODUCTION

The Manoa campus of the University of Hawaii has seen its share of costly infrastructure problems from water runoff and associated seepage flows. These have caused flooding of several buildings during intense and prolonged rainfall events, as well as structural damage to building foundations and interiors. One four-story concrete building, heavily used for instruction and research, had to be closed due to seepage-induced weakening of footings and concrete floor slabs. While repairs are contemplated, their long-term success cannot be judged properly without addressing the manner in which water flows towards and through the affected structures.

The Upper Loop of the campus (Figure 1) is located on an elevated ridge at the entrance to Manoa Valley. This ridge was formed by the Sugar Loaf-Round Top lava flow some 67,000 years ago (Stearns, 1985). In addition to basalt rock from the lava flow, there are also pyroclastic sand and gravel deposits associated with periods of violent eruption, as well as subsequent alluvial silts and clays deposited by the Manoa Stream. The two black arrows in Figure 1 indicate the general direction of subsurface water flow, which coincides broadly with the surface topography of the study area.

Figure 1. Upper Loop of the University of Hawaii Manoa campus, showing the direction of subsurface seepage flows and location of new soil borings (Contour elevations are shown in meters above sea level)

The groundwater elevations in a set of soil borings adjacent to the closed building, indicated in Figure 1 by the white circle, suggest a direct correspondence with precipitation measured in nearby rainfall gauges for a recent 6-month period. This is observed in Figure 2, where spikes in the depth to groundwater correlate to increases in daily precipitation. There is a slight offset between the two curves, about a few hours to a couple of days, due to the time lag between precipitation and seepage through the upper soils toward the observation wells. Water eventually reaches the deeper basalt bedrock and flows toward the lower part of campus, where it is seen to emerge from a vertical rock face in the bedrock at the location of an old quarry.