HIGHLIGHTER

INTERPRETATION OF IN SITU TESTS AS AFFECTED BY SOIL SUCTION

May 2017

OVERVIEW In situ testing of soil with invasive methods, such as the Cone Penetration Test (CPT), are increasingly used in geotechnical engineering practice. However, there has been very little work to develop methods for interpreting results of these tests when performed in unsaturated soil. It is important to develop such methods because the in situ test results in unsaturated soil will depend on the moisture conditions at the time of testing and may not reflect the soil behavior corresponding to the moisture conditions during the life of supported structures.

RESULTS This research effort involved conducting in situ tests at two test sites, containing lean to fat clayey soils, at various times of the year. The purpose was to investigate the influence of changes in moisture conditions and soil suction on the test response. In situ testing included the Cone Penetration Test (CPT), Standard Penetration Test (SPT) and Pre-bored Pressuremeter Test (PMT). Test sites were characterized by sampling and laboratory testing to determine important soil properties and moisture content profiles. Additionally, test sites were instrumented with weather monitoring equipment and sensors to measure temporal variations in soil moisture with depth. Another goal was to evaluate two commercially available computer programs to evaluate their predictive ability with respect to soil moisture change. The PMT, CPT and SPT parameters determined from standard interpretation of the results were compared to total suction measured at corresponding depths obtained from measurements on samples obtained in the field using a chilled mirror hygrometer. At both sites, the suction had a profound impact on the in situ test parameters, especially at total suction in excess of approximately 150 psi, which generally corresponded to shallow test depths. At both sites, for the shallow depths there was a noticeable trend of increasing magnitude of in situ test parameters with increasing suction, as expected. Plots (e.g. Figure 1) of normalized in situ test parameters against suction show expected, albeit weak, correlations for the two

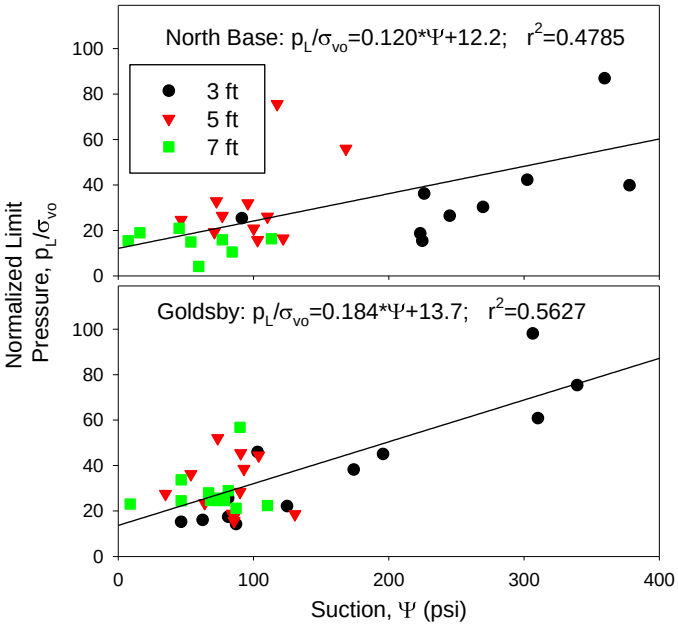

Figure 1 Normalized PMT Limit Pressure versus Suction

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test sites. These correlations give a sense of the variation of in situ parameters that might be expected for similar soils under changing suction conditions.

Two commercial software packages were used to predict the changes in soil moisture content due to weather conditions over a period of about two years. The volumetric water content values at 3 different depths obtained using VADOSE/W and SVFlux were compared with the recorded field data to evaluate the predictive capability of both numerical models. The unsaturated seepage modeling was found to provide reasonable comparisons to measured soil moisture profiles, as shown in Figure 2.

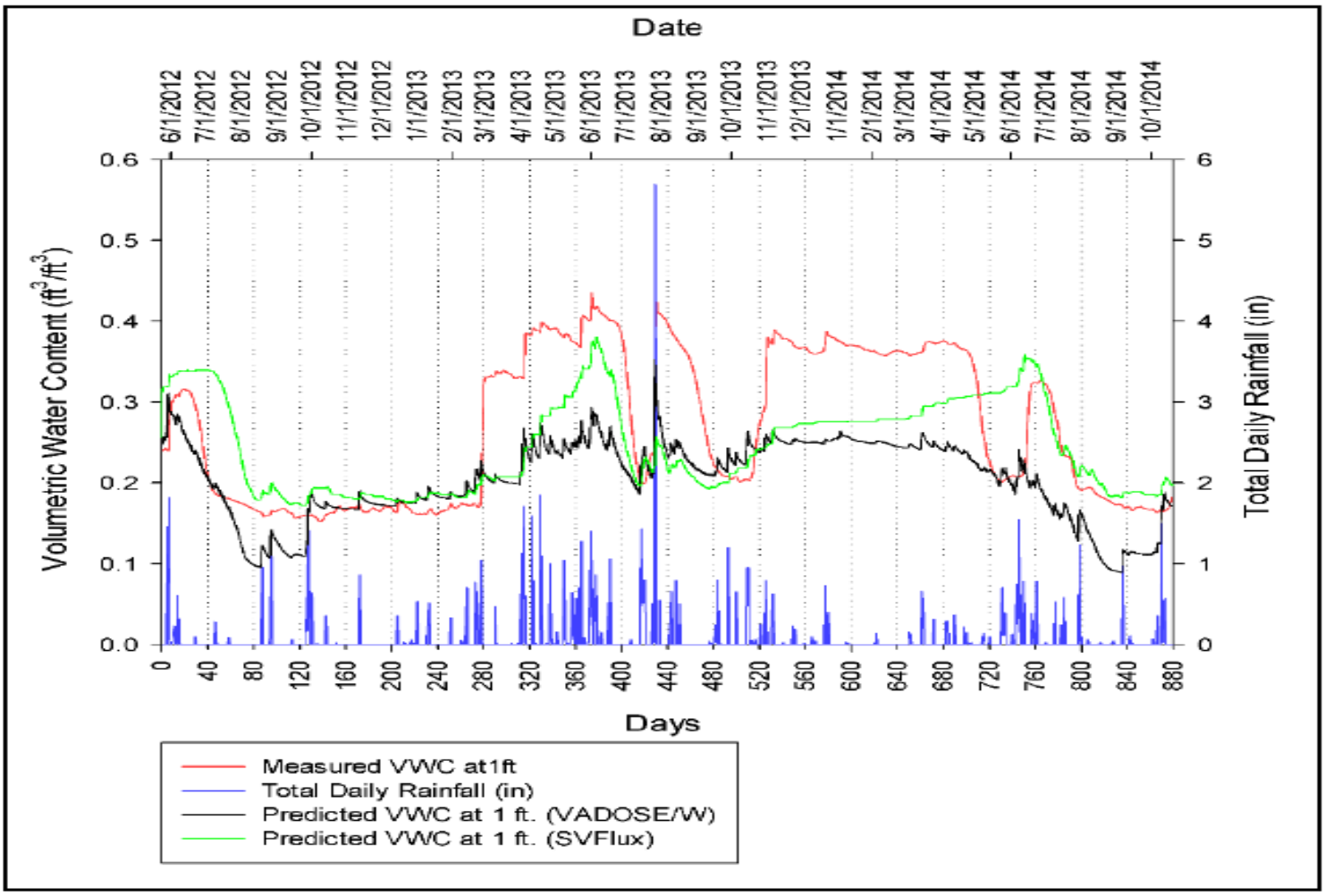

Figure 2 Measured vs. Predicted Volumetric Water Content (VWC) values using Software (SVFlux and VADOSE/W)

The study demonstrated how correlations for PMT, CPT and SPT parameters with suction can be used to roughly predict possible changes in *in situ* parameters as a result of suction changes. While these correlations should not be used to determine design parameters, they do allow engineers to develop insight regarding the importance of suction changes. Such information can then be used to decide whether additional lab and/or field testing may be warranted. Or in the case of relatively small projects, more caution can be exercised in developing factors of safety, or load and resistance factors. The effort also provided general recommendations for interpreting in situ test results in unsaturated soil as well as using unsaturated seepage modeling software for predicting variations in moisture contents in soil profiles.

POTENTIAL BENEFITS This research contributes important knowledge about the influence of matric suction on in situ test results. In accomplishing this goal, a valuable set of experimental data was established in an area of soil mechanics with limited information for results obtained in unsaturated soils. Results will provide engineers with better understanding of, and approaches to addressing, the influence of moisture conditions and matric suction on results from in situ tests.