Development of SPT-Torque Test Correlations for Glacial Till

Introduction

The standard penetration test (SPT) is the most commonly used in situ test for site investigation. The test procedure consists of driving a standard split-spoon sampler into the ground and measuring the number of blows required for penetration of the sampler at specific depths. Disturbed samples are retrieved and used for soil identification in the field and for performing index tests in the laboratory. Over time, many sources of errors were identified regarding the SPT equipment and testing procedure. The SPT-Torque test (SPT-T) is a modification of the original SPT procedure and consists of rotating the standard sampler while torque is measured after it is driven the required 0.45 meters. Purdue University developed the first automated torqueing hardware prototype in 2010 as part of this INDOT/JTRP-funded research project.

Glacial deposits are found across the majority of the state of Indiana. Glacial till is a highly variable soil due to the type of source material that it is composed of and the vast area that it covers. The developed SPT-Torque equipment was selected by INDOT for use in glacial till soils found within the state of Indiana. By performing torque tests, additional in situ data is collected, thereby improving engineering design.

In this research, data collected from side-by-side field testing (SPT, SPT-T and CPT) at various sites in the state of Indiana were used in the development of blow count, torque, and cone resistance correlations for Indiana soils.

Study Objectives

The main objectives of the proposed research were to (1) develop SPT-Torque hardware and software that are compatible with INDOT SPT equipment; (2) collect in situ SPT-Torque data for multiple sites composed of glacial till; (3) develop relationships between laboratory and field test data, including cone penetration test results; and (4) properly train INDOT personnel on how to operate the fabricated equipment to reduce site investigation, design, and construction costs to INDOT. The research focused on the development of SPT-T interpretation methods and shear strength correlations for glacial tills, beyond development of the SPT-T equipment itself.

Findings

Development of various correlations between the blow count number, cone resistance, torque ratio, and shear strength were explored based on the data collected for different Indiana soils. Reasonably high coefficients of determination were obtained for the normalized equations developed for clayey soils and saturated non-plastic silt. Low coefficients of determination were obtained for saturated and unsaturated sandy soils. The low coefficients of determination values are attributed to the small population dataset for sandy soils and the difficulty of adequately determining the degree of saturation for unsaturated non-plastic soil types due to the soil structure destruction with sampling. Overall, it was
found that the relationships are stronger for clay and saturated non-plastic silt, and hence it is recommended that further data be collected to continue to strengthen all relationships, especially those for sand and unsaturated non-plastic silt.

Implementation

Use of the SPT-T equipment is recommended in connection with SPT site investigations done by INDOT for sites with fine-grained soils for which the developed correlations between torque measurements and shear strength are reliable. Additional data can be collected in the context of INDOT projects to verify and refine the correlations provided in this report. If fabrication of other SPT-T hardware is required by INDOT, improvements can be made to the current SPT-Torque prototype. Use of a more expensive but lighter alloy material can be explored in order to reduce the current size and weight of the hardware while at the same time keeping it sturdy. A storage box could be fabricated to safely transport and store the hardware when not in use by the INDOT drilling crew. A cost-benefit analysis could be done to determine the cost of production of additional SPT-T units versus benefits due to better site investigations and geotechnical design.

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