RESEARCH
PROJECT CAPSULE [21-1GT]

September 2020

TECHNOLOGY TRANSFER PROGRAM

Internal Friction Angle of Sands with High Fines Content

JUST THE FACTS:

Start Date:
August 1, 2020

Duration:
24 months

End Date:
July 31, 2022

Funding:
80/20 SPR

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used / Implementation Potential

PROBLEM

Louisiana Department of Transportation and Development (DOTD) geotechnical design engineers have reported that some projects (with driven piles in sandy soils with a high percentage of fines) consistently tested to have considerably lower resistance than the design value based on the B-effective stress design method. This condition sometimes results in actual pile length of 15 to 30 ft. longer than the original design lengths. This underestimation of pile length can be attributed to the uncertainty in estimating the internal friction angle of sands with large portion of fines from either Standard Penetration Test (SPT) or Cone Penetration Test (CPT) correlations or the potential reduction of interface friction angle due to the presence of high percent of fines. Unfortunately, it is difficult to obtain undisturbed sandy soil samples; hence, the internal friction angle cannot be accurately estimated in laboratory tests. A practical alternative is to adopt in-situ test methods such as the SPT and CPT. However, the variability of internal friction angle estimation is still significant, and a shortcoming of these methods is that the effect of fines content on the internal friction angle is not considered.

For the design of piles using static analysis methods, the Federal Highway Administration (FHWA) recommends using the α-Tomlinson total stress analysis method in cohesive soils, which is based on the undrained shear strength of the soil; and the Nordlund effective stress method in cohesion less soils, which is based on lateral effective stress that depends on depth. It is possible that the sandy soils after mixed with certain percent of fine contents (threshold) start to behave like cohesive soils rather than cohesion less soils, which shows a need to use the α-Tomlinson method for design of piles in these cases.

OBJECTIVE

There are three main objectives of this study. The first is to evaluate the effect of fines content on the value of internal friction angle of sand soils mixed with fines typically encountered in Louisiana. The second objective is to evaluate the effect of fines content on the interface friction angle between sand soils mixed with fines and both concrete and steel surfaces. Lastly, the study will determine the threshold percent of fines content beyond which the sand soils mixed with fines will behave as cohesive soils, rather than cohesion less soils, and the effect on design of driven piles.

METHODOLOGY

To achieve the objectives of the study, the following tasks will be completed. A literature review on relevant published works will be conducted. Next, a laboratory

testing plan will be outlined and the necessary materials gathered. A small-size direct shear test of sand-fine mixtures will be conducted, followed by a large-size direct shear test of mixed soil-concrete/steel interface. The test results will be analyzed to evaluate the internal friction angle and interface friction angle for sands mixed with fines. SPT and CPT charts will be updated. The threshold of fines content beyond which sand-fine mixtures behave like cohesive soils will be determined. The findings will be verified using project sites with piles driven in sand soil layers mixed with fines. Lastly, a final report and technical summary will be prepared.

IMPLEMENTATION POTENTIAL

The most valuable outcome of this research study is highlighting the likely dependence of internal friction angle/interface angle estimation on fines content considering various factors such as sand type, angularity, particle size distribution, relative density, moisture content, normal stress, and interface roughness. This finding will be further formulated through empirical correlations and possible updating of friction angle versus SPT/CPT charts and tables. The findings of this study will be immediately implemented in the safety design of pile foundations for bridges and other infrastructures when piles are driven into sand layers with fines content.