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Moisture-Strength-Constructability Guidelines for Subgrade Foundation Soils Found in Indiana

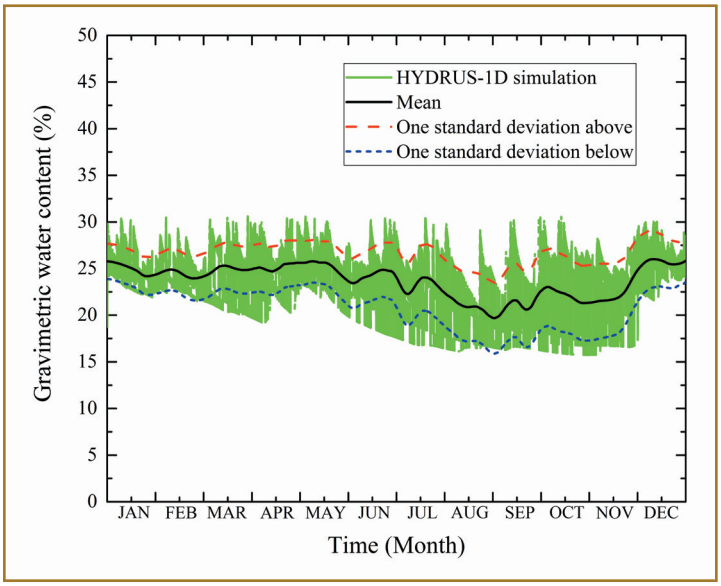
Introduction

One of the most important factors in earthwork-related design is the correct estimation of the water content of in situ soil because its mechanical response to loading and construction activities depends strongly on its water content at the time of construction. However, because the time between site investigation, design and construction phases varies substantially for any given project, initial estimates of soil water content may no longer apply. Occurrence of excessive soil moisture in the in situ soil at the time of construction leads to low strength, which inevitably results in constructability problems, particularly for fine-grained soils. If the strength of the foundation soil is too low, it is not capable of sustaining the loads due to construction activities. Changes in soil moisture over time have led to a larger number of change orders for INDOT. Once a change order is seen as necessary, INDOT engineers and contractors working at a jobsite have to then agree on how to proceed and spend extra time and effort to bring the water content of the in situ soil to the desired level or redo the design for current conditions before the construction process can actually begin.

This report presents a methodology that can be used to estimate the water content of fine-grained soils (A-4, A-6 and A-7-6 according to the AASHTO classification system) found in Indiana near the ground surface (within the top 5 ft. [150 cm]) and to assess the impact of changes in water content of fine-grained soils on their constructability.

Findings

HYDRUS 1D, a free soil moisture flow software, was used to simulate unsaturated soil moisture flow for typical soil profiles of the 92 counties in the state of Indiana. Input data for the simulations were obtained from various government agencies, such as the United States Department of Agriculture (USDA), the Department of Natural Resources (DNR), the Indiana Geological Survey (IGS) and Purdue State Climate (Iclimate). In order to validate the methodology used in this research, results from the soil moisture simulations were compared to measured soil moisture data collected for a period of 3 years from six IGS test sites (in four counties) located across Indiana. Since good agreement was obtained between predicted and measured water content values at these sites, the methodology was used to generate *in situ* soil water content profiles for all 92 counties using as input 10 years of weather and groundwater table data. The 10-year soil moisture simulations were superimposed to get daily ranges for the *in situ* soil water content of representative soil profiles for each county (see figure below). Constructability of soils can be assessed by comparing the estimated *in situ* soil water content with the optimum value required for compaction. Based on INDOT specifications, it is suggested that if the *in situ* soil moisture is above 2% of the optimum water content, then a



poor constructability rating be given to coarse-grained soil. On the other hand, for fine-grained soils, it is suggested that a poor constructability rating be given when the *in situ* soil moisture is 3% above of the optimum water content.

Implementation

In this report, yearly water content plots obtained from the overlapping of HYDRUS 1D soil moisture simulations for a period of 10 years are provided. From these plots, INDOT engineers can obtain the expected daily range for the soil water content of representative soil profiles in each Indiana county. These plots can also be used to obtain the daily range for the *in situ* soil moisture at project locations at any time of the year; the estimated soil water contents can be considered by INDOT engineers when making construction and design decisions at different phases of a project.

The constructability rating given to soils, which is based on the difference between the *in situ* soil moisture at any time of the year and the optimum water content obtained from standard Proctor compaction tests, can be considered when INDOT is preparing construction contracts. The methodology proposed in this report can be further improved by (i) taking into consideration the topography and vegetation at the project locations, (ii) performing additional HYDRUS 1D simulations for all the counties in Indiana for *in situ* soil profiles with specific laboratory characterization of soil properties, and (iii) implementing the developed methodology in pilot projects to fine-tune and refine the water content prediction methodology.

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