DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials

This report describes *in situ* (in place) physical properties of soil and rock that can be measured by available geophysical methods.

Geotechnical/ Structures

February 2018

Project Title:
Geophysical Methods for Geotechnical Site Characterization

Task Number: 2111

Completion Date: March 31, 2017

Task Manager:
William P. Owen
Chief, Geophysics and Geology Branch
bill.owen@dot.ca.gov

WHAT WAS THE NEED?

Despite growing interest in geophysical methods, these methods are underutilized for transportation infrastructure. A major contributing factor is that literature on geophysical methods tend to be either introductory in nature, intended for novice geophysical users, or rather advanced and intended for geophysical specialists in various fields.

WHAT WAS OUR GOAL?

This document summarizes the *in situ* physical properties of soil and rock that can be measured by different geophysical methods. These methods provide crucial subsurface information for geotechnical design of transportation infrastructure on a more comprehensive scale than typical subsurface investigation techniques. This broader scale often allows greater insight of highly variable subsurface soil conditions and can result in reduced risk and uncertainty. This document attempts to fill the gap in literature by providing a comprehensive reference for geotechnical engineers who already possess an introductory knowledge of geophysics. The document emphasizes the measurements obtained using common geophysical techniques (e.g. seismic methods, ground penetrating radar, and electrical resistivity) and the relationships between those measurements and soil and rock properties.

WHAT DID WE DO?

The report compiles and summarizes available literature and describes the derivation of various soil and rock properties using geophysical methods. This literature review includes case histories and comprehensive studies relating physical parameters to geophysical measurements. The report highlights potential knowledge gaps in the literature and addresses issues related to uncertainty in dynamic soil properties. Those discussions highlight

the importance of geophysical measurements and their potential impacts on geotechnical design. Recommendations are also be provided regarding their application to typical Caltrans projects for investigation of the subsurface.

WHAT WAS THE OUTCOME?

The report demonstrates the wide range of capabilities available via geophysics to estimate earth material properties. The methods can guide efforts in many elements of transportation infrastructure, such as foundation design, construction of earth retaining systems, and placement of embankments.

For seismic design and site characterization, methods such as seismic refraction, seismic tomography, Spectral Analysis of Surface Waves (SASW), Multichannel Spectral Analysis of Surface Waves (MASW), and borehole velocity logging provide higher quality information for shear-wave velocity than correlations from Standard Penetration Tests. Additionally, much of the theory central to various geophysical methods form the basis for a number of non-destructive testing (NDT) techniques that are applicable to many highway engineering problems.

Many geophysical correlations are empirical and can exhibit a large amount of scatter. Therefore, future research efforts should consider the natural variability in earth material properties and the statistical confidence of the proposed relationships. There are also earth material properties relevant to transportation projects for which geophysical relationships have not been directly proposed. Future research efforts may bear fruit with new correlations to earth material properties. In that manner, future geophysical testing may be able to increase its efficacy for transportation projects.

Though geophysical methods offer tremendous value for estimating earth material properties in transportation projects, they are by no means a magic bullet. They are not meant to entirely replace standard drilling, sampling, and laboratory testing efforts on geo-related projects. Instead, the goal of a geoprofessional involved with subsurface characterization should be the judicious application of geophysics as a cost-effective approach to augment other exploration efforts.

WHAT IS THE BENEFIT?

Geophysical methods can quickly provide information over a much larger area than subsurface drilling, in situ testing, and laboratory testing of acquired samples. For planning phase projects (i.e., K and 0 phase), geophysics may potentially provide all the information necessary for that early phase of a project. In the design phase (i.e., 1 phase), geophysical methods can aid in tailoring drilling operations and in situ tests. In the latter stages of subsurface exploration, geophysical methods serve a more quantitative role where they can be used to estimate engineering properties of subsurface materials. In all of these cases, proper application of geophysical methods can increase information and provide appreciable savings to a project, in both labor and time.

LEARN MORE

View the Complete Report
https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca17-2111-finalreport-a11y.pdf

IMAGES

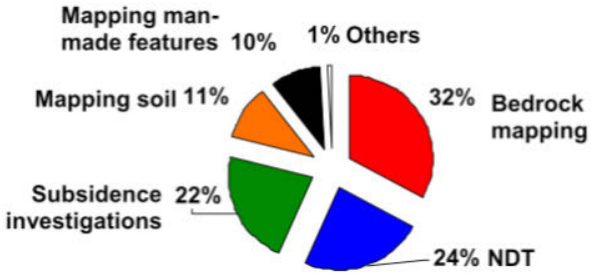

IMAGE 1: Most common application of geophysical methods, based on nationwide survey.

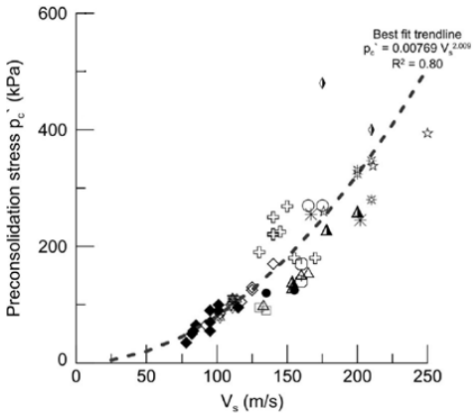

IMAGE 2: Relationship between preconsolidation stress and shear-wave velocity for clay.