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Caltrans Division of Research, Innovation and System Information

Research Notes

Geophysical Methods for Determining the Geotechnical Engineering Properties of Earth Materials

Identify and describe in situ geophysical methods and the soil and rock properties obtained from them for roadway and foundation design.

Geotechnical/ Structures

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Project Title:
Determining In Situ Engineering Properties of Earth Materials

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WHAT IS THE NEED?

Surface and borehole geophysical methods are capable of measuring in-situ properties and structural characteristics of earth materials (for example: shear modulus, bulk density, porosity, fracture orientation, depth to bedrock, and fault location). The appropriate use of those methods in geotechnical investigations can reduce investigation costs, with greater savings realized where improved understanding of foundation materials aids in the design and construction of roadways and highway structures. Such methods, however, are currently underutilized due to limited industry experience with their application to real-world projects.

Numerous references on geophysical applications exist in the literature. However, summaries of the available literature, describing the engineering properties obtained from geophysical methods and written for the practicing engineer and geologist for direct project application, are scarce. Such a reference would fill a gap in the literature, provide the potential to increase the knowledge base within the geotechnical engineering community and provide a means to more efficiently distribute (and even reduce) the cost of geotechnical site characterization and project design through the targeted application of geophysical methods.

WHAT ARE WE DOING?

RThe project is a summary of the state of geophysics practice, consisting of identification of accepted methods, description of promising techniques, recommendations for application, and recommendations for future research and additional avenues of application.

Geophysical methods that are considered in this project scope are: 1) currently in use and 2) tractable for application to geotechnical engineering. Methods may be endorsed or standardized by professional organizations (e.g., ASTM International) or state or federal bodies (e.g. FHWA), but lack of endorsement or standardization does not preclude consideration where

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consensus is apparent within the geophysics industry. Examples include seismic methods for derivation of small-strain elastic moduli and resistivity methods for assessment of corrosion potential. Other methods will be identified as part of the research.

Development of the deliverable will be based predominantly on review of the available subject literature and interviews or correspondence with key researchers and practitioners in the field.

WHAT IS OUR GOAL?

The project goal is the identification and description of appropriate geophysical methods for the measurement or estimation of the engineering properties of soil and rock needed for roadway and structure foundation design. Borehole and surface geophysical methods are included in the project scope. Results will be published as hardcover and electronic copy and made available for distribution to Caltrans engineering and engineering geology personnel.

WHAT IS THE BENEFIT?

The American Association of State Highway Transportation Officials (AASHTO) recognized the benefits of geophysics and devoted considerable discussion of it in their 1988 AASHTO Manual on Subsurface Investigations. In 2015, Under the National Cooperative Highway Research Program (NCHRP), the AASHTO Manual on Subsurface Investigations will be updated to reflect changes in the standards of practice that have occurred since initial publication. A major component in the update will be the incorporation of geophysical measurements into Load and Resistance Factor Design (LRFD). LRFD emphasizes the use of average property values for design, an element that is readily and cost-effectively met via geophysical measurements. For example, the second edition of the AASHTO Guide Specifications for LRFD Seismic Bridge Design relies on the average shear wave velocity in the upper 30 meters (Vs30) to assess the effects of local soil conditions on earthquake ground motions. In addition, it is now widely recognized that the small-strain shear modulus is a key material property for evaluating in situ ground stiffness that may be applied to deformation analyses for shallow footings, piling foundations, embankments, and retaining walls. Our research complements the work being done under AASHTO and will provide specific recommendations for its application in California and the nation.

WHAT IS THE PROGRESS TO DATE?

The bulk of the literature review is complete. Ongoing review is focused on the use of shear wave velocity for evaluation of liquefaction, and to measurement and computation of Vs30 for computing site amplification factors and performing ground response analyses. The research team identified gaps in the current state of practice related to evaluating the uncertainty in seismic geophysical methods. They will continue to incorporate discussion those gaps and others based on the concurrent literature review.

Preparation of the draft report continues and much progress has been made. Sections related to earthwork factors, unconfined compressive strength and unit weight were revised based on additional research. In addition to new sections and material, the draft report was revised to address comments by the research team.

The research team is currently reviewing Caltrans subsurface investigation practices. The research team has developed a list of appropriate contacts with intimate knowledge of Caltrans practices and will conduct interviews with those people on the topic. Based on those results, the research group may distribute a survey to further quantify Caltrans practices for inclusion in the Final Report.