PROJECT SUMMARY

Texas Department of Transportation

0-7008: Advanced Geophysical Tools for Geotechnical Analysis

Background

Texas Department of Transportation (TxDOT) encounters a considerable and yet increasing number of claims and change orders every year that negatively affects project costs and schedules. Insufficient and inaccurate information about the subsurface condition is a critical factor contributing to these cost overruns and delays. The annual cost of change orders resulting from insufficient subsurface information is commonly in order of millions of dollars. This lack of sufficient information is primarily due to the inherent limitation of the conventional geotechnical site investigation methods to provide continuous assessment of subsurface conditions. In other words, the conventional methods only sample and provide information about a small percentage of sample space.

The primary objectives of this research project were to (1) develop an easy-to-use comprehensive manual that provides TxDOT staff with the Electrical Resistivity Imaging (ERI) technique procedures and guidelines for safe and correct implementation of ERI technology, (2) develop sets of equations and charts to investigate the relationship between the soil electrical resistivity and geotechnical properties in Texas, (3) demonstrate the ERI technique in the five TxDOT districts to cover different geotechnical conditions and operational environments, (4) create easy-to-use and instructive text and video training materials for learning workshops and provide TxDOT staff with information about the ERI survey, data collection, and data processing, and (5) perform training workshops in the TxDOT districts to convey the information about the ERI technology and share the research project's findings.

What the Researchers Did

The research project's findings were obtained through an extensive literature review, data collection, and statistical analysis.

- A thorough review of the literature was conducted to assess and document the current state of knowledge and practice pertaining to the ERI technology.
- In total, twenty-seven (27) ERI surveys were demonstrated in various operational environments and geotechnical conditions across the selected TxDOT districts (Beaumont, Corpus Christi, El Paso, Dallas, and Fort Worth). Figure 1 shows the location of the selected districts for ERI demonstration in Texas.

Figure 1. Location of the selected districts for ERI demonstration in Texas.

- Extensive laboratory testing (1093 laboratory electrical resistivity tests) was performed on the collected samples from different locations in the selected TxDOT districts.
- The laboratory testing results were later analyzed to investigate the relationships between the geoelectrical and geotechnical parameters and to provide

Research Performed by:
University of Texas at Arlington

Research Supervisor:
Mohsen Shahandashti, PhD, PE

Researchers:
Sahadat Hossain
Mina Zamanian
Md. Asif Akhtar

Project Completed:
08-31-2021

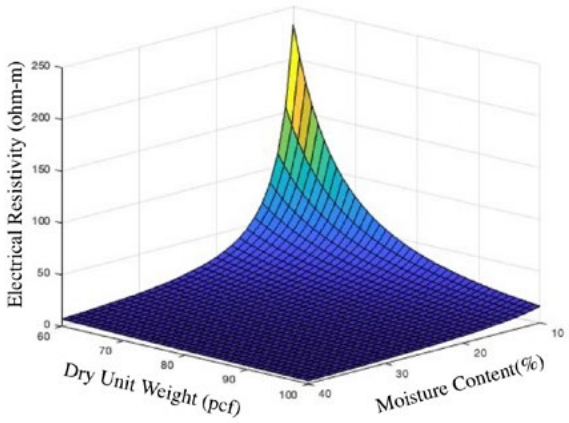

Figure 2. 3D interaction effect surface of moisture content and dry unit weight affecting electrical resistivity of clay soil.

sets of empirical equations and charts using linear regression models. Figure 2 illustrates an example of the developed 3D interaction effect surfaces of geotechnical parameters affecting the electrical resistivity of clayey soils.

- The gained experiences from demonstrating the ERI were translated into a comprehensive, instructive, and practical research manual to offer guidelines and tools for a rapid and continuous assessment of subsurface conditions. The research manual also presents the empirical equations and charts developed based on the extensive laboratory testing results.
- An Excel-based application was also developed to facilitate the computation steps of geotechnical parameters from the proposed equations.
- This research offered training workshops in selected districts to disseminate the knowledge of the applications, data collection, and data interpretation of ERI technology to TxDOT staff.

What They Found

From the extensive demonstration of the ERI in different geotechnical conditions and operational environments across Texas, the researchers identified the best practices for safe and correct implementation of the ERI technique and documented them in the research manual. They also provided some practical considerations and instructions in the research manual to present some challenges that the operators may encounter in the field. The researchers found that interpreting the boring results along with the subsurface resistivity images leads to a comprehensive and reliable assessment of subsurface conditions.

From the extensive laboratory testing and analysis, researchers concluded that the electrical resistivity of subsurface materials is correlated with some geotechnical properties such as water content, dry unit weight, plasticity index, clay content, and fine fraction. They developed sets of equations and chart which allow for estimating the geotechnical parameters using the field electrical resistivity values.

What This Means

The electrical resistivity imaging technology provides a unique opportunity to reduce the cost overruns and delays related to inadequate subsurface information by providing (1) continuous subsurface images along with estimated soil properties and potential anomalies (e.g., karst, void) between the boreholes, and (2) additional information about the required drilling and sampling intervals. The ERI technology helps TxDOT staff prevent inadequate/conservative designs and mitigate risks and unexpected failures due to the lack of adequate subsurface information.

For More Information

Project Manager:
Jade' Adediwura, TxDOT, (512) 486-5061

Research Supervisor:
Dr. Mohsen Shahandashti, UT Arlington, (817) 272-0440

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Research and Technology Implementation Division
Texas Department of Transportation
125 E. 11th Street
Austin, TX 78701-2483

www.txdot.gov
Keyword: Research