PROJECT SUMMARY

Texas Department of Transportation

5-7008: Implementation of Electrical Resistivity Imaging Manual

Background

TTexas Department of Transportation (TxDOT) annually encounters a substantial number of claims and change orders that have a detrimental effect on project costs and schedules. State Departments of Transportation (DOTs) spend approximately $10 million annually on geotechnical-related change orders, accounting for about 7% of the total expenditures associated with claims, change orders, and cost overruns in highway and bridge projects. Insufficient subsurface information and soil mischaracterization significantly contribute to such cost overruns and delays in up to 50% of all infrastructure projects. The lack of adequate and accurate subsurface information results from inherent limitations of conventional geotechnical site investigation methods, as they are unable to provide a continuous assessment of subsurface conditions. Despite the advantages of advanced geophysical methods, such as Electrical Resistivity Imaging (ERI), in enhancing geotechnical analysis, these technologies are underutilized by state DOTs because of a lack of proven implementation details for different applications, geotechnical conditions, and operational environments.

This project aims to enhance TxDOT's existing subsurface investigations by highlighting the potential applications of the ERI technology and offering best practices for a successful implementation of the ERI by (1) implementing the ERI manual developed in TxDOT Project 0-7008 on 10-15 projects in Fort Worth and Dallas districts to improve geotechnical analysis, (2) refining the ERI manual to present lessons learned from the implementation of the ERI on real projects, (3) developing five case studies to illustrate the successful implementation of ERI for various project types and distributing them to all 25 TxDOT districts, (4) conducting cost analysis for implementing the ERI manual for all districts, and (5) conducting outreach activities to present the ERI manual and implementation results to potential TxDOT districts to facilitate the adoption of the manual.

What the Researchers Did

The research team, in collaboration with the TxDOT Fort Worth and Dallas districts, selected 13 locations across these districts to examine the applicability of the ERI technology for various project types and capture implementation challenges and best practices in different geotechnical conditions and operational environments.

- The research team conducted extensive testing —a total of 60 ERI surveys— in the selected locations to gain more insights into the subsurface conditions, especially between the boreholes, and examine the suitability of the ERI technology for the intended applications.
- The research team carefully documented the implementation details, lessons learned, and recommendations for improving future implementation of the ERI manual.
- The research team developed five case studies among 13 projects to illustrate the successful implementation of the ERI manual for various project types and distributed them among potential TxDOT districts.
- The research team also documented successful project planning and management practices for implementing the ERI manual derived from the gained experience and lessons learned by this project.
- The research team develop an approach to estimate detailed costs for implementing the electrical resistivity imaging manual in the TxDOT districts which can be used to establish the annual budget required for manual implementation in each district.
- The research team proposed an approach toward employing electrical resistivity imaging and a machine learning classifier to estimate

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sulfate concentration levels in clayey soils. They established an experimental design and developed a random forest classifier to categorize the sulfate concentration levels into three levels: low (below 3,000 ppm), moderate (between 3,000 and 8,000 ppm), and high (above 8,000 ppm) based on soil electrical resistivity and water content.

- The research team organized and conducted statewide outreach activities in around one-third of the TxDOT districts including the maintenance division and different teams in Abilene, Dallas, El Paso, Fort Worth, Houston, and Paris districts to present the ERI manual and disseminate the implementation results to potential teams to facilitate the manual adoption.

What They Found

As a result of conducting the ERI tests on the selected projects, the researchers highlighted the benefits of the ERI technology in exploring various site investigation challenges. They demonstrated that the ERI technology is useful in identifying the critical sulfate concentration zones (e.g., Figure 1), assessing the stability of slopes, determining the groundwater table, and inspecting the drainage conditions behind the retaining walls. Based on the implementation findings, five case studies were developed to showcase the successful implementation of the ERI manual with various applications to be distributed to different teams in TxDOT. The research team captured the implementation challenges in different geotechnical conditions and operational environments and suggested best practices and recommendations to improve the future implementation of the ERI manual. The researchers identified effective project planning and management practices for the successful implementation of the ERI manual based on valuable experience and lessons learned. These insights aim to foster the widespread adoption of the manual by TxDOT.

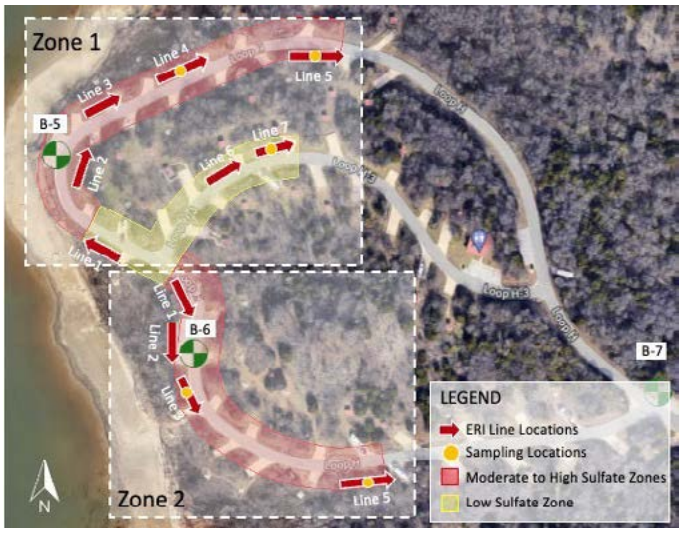

Figure 1. Identifying critical sulfate concentration zones by conducting multiple ERI surveys

Through analysis of laboratory data, the researchers found an approach by leveraging the ERI technology and a machine learning classifier to accurately identify sulfate concentration levels in clayey soils based on electrical resistivity and water content.

What This Means

This project offers a comprehensive record of the benefits and limitations of the ERI technology by implementing the ERI on different geotechnical conditions and operational environments that can serve as a valuable resource for TxDOT. The ERI technology offers an opportunity to help obtain a continuous assessment of subsurface conditions, locate problematic zones that require more consideration, and identify areas where traditional methods of site investigation, which are costly and time-consuming, may be unnecessary. Well-informed decisions can prolong transportation assets' service life and lower maintenance/rehabilitation costs.

For More Information

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