

## Web-Based Tool to Advance Geotechnical Data Interchange and Reliability-Based Site Characterization

### Introduction

Over the past decades, LTRC conducted multiple phases of geotechnical database research to facilitate geotechnical data management practice for the Louisiana Department of Transportation and Development (DOTD). The recent Phase IV project (LTRC Final Report 714) identified and converted existing data into the Bentley geotechnical data management system, HoleBASE/OpenGround Cloud (OpenGround). This framework is primarily for internal use, and may provide features for DOTD's consultants to use, but DOTD has not fully unlocked them at this time.

Historically, DOTD used Bentley's previous geotechnical software, gINT, to manage and transfer geotechnical data between DOTD and its consultants. A previous LTRC research project (Final Report 498) standardized the gINT file format and libraries to facilitate data interchange between consultants and the Department. Bentley and DOTD are moving away from gINT as part of a transition to OpenGround, but DOTD still uses gINT files as a vehicle for data interchange with some consultants. Seequent, the Bentley Subsurface Company, announced that support for existing gINT users will be extended to December 31, 2028. There is a need for a long-term data interchange standard to take over in the absence of gINT and/or when consultants choose not to use OpenGround in the future.

In recent years, an open-source, standardized digital data format supported by the Federal Highway Administration (FHWA) and the American Society of Civil Engineering (ASCE) Geo-Institute was developed; it is called Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS). DIGGS will facilitate data interoperability within an organization or across multiple organizations. DOTD Geotechnical database efforts have followed DIGGS logic, and DOTD has provided preliminary support for developing a web-based DIGGS tool, primarily for proof-of-concept. This tool demonstrates the capabilities of DIGGS by allowing users to import DIGGS files and plot geotechnical data in a web browser. This tool has been demonstrated at various regional and national conferences and has received great interest from the geotechnical community. However, there was no framework to permanently host, develop, and support the tool, so it remained a proof-of-concept. This project expands and formalizes the prototype tool and adds additional functionality to all DOTD projects.

Additionally, the American Association of State Highway Transportation Officials (AASHTO) and its Load and Resistance Factored Design (LRFD) code is undergoing a major rewrite to focus on reliability and data variability. Geotechnical site characterization to determine appropriate resistance factors must account for soil variability across the entire project. The methodologies required to perform site characterization in accordance with the updated code will become computationally more difficult. New tools will be needed to help engineers perform and review the required calculations. A web-based tool using DIGGS and existing DOTD formats (gINT, HoleBASE, and OpenGround) will greatly help the Department and its consultants adopt the upcoming design changes to stay in accordance with the LRFD code.

### Objectives

- **Web-Based Visualization and Data Analysis.** Formalize a web-based platform implemented by DOTD for several large highway and bridge design and construction projects. These larger projects focused on the ability to interactively visualize and interpret data from soil borings, CPTs, geophysical data, and conventional field survey data. This project will standardize this visualization process for all projects within DOTD geotechnical design.

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- **GEC-5.** Demonstrate how geotechnical engineers and consultants can efficiently quantify the uncertainty of site conditions and develop soil design models based on statistical analysis of soil boring data. The uncertainty model can be interactively evaluated based on the methods presented in FHWA's Geotechnical Engineering Circular (GEC) No. 5—Geotechnical Site Characterization, along with upcoming revisions to AASHTO Section 10.
- **DIGGS.** Demonstrate how Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) can be implemented into the web-based platform for standardized geotechnical data exchange. The implementation of DIGGS will efficiently improve the quality of geotechnical data deliverables as digital assets. Other benefits of implementing DIGGS in geotechnical data management will include visualizations and improvements to the DOTD geotechnical design process.

## Conclusions

This project expanded upon a prototype interface initially developed for large, data-rich projects and produced a functional tool that DOTD can use on any digital project within the Department. The new tool, named GDX-plorer, builds upon DOTD's ongoing efforts to modernize geotechnical data management and support the adoption of advanced techniques recommended through the FHWA A-GaME program. The software provides several benefits to DOTD.

- The software can import and analyze geotechnical data from multiple sources, including DOTD's OpenGround dataset, consultant-provided gINT files, and Data Interchange for DIGGS-compliant data.
- The software streamlines the implementation of updated AASHTO Section 10 calculations and FHWA Geotechnical Engineering Circular No. 5 (GEC-5) procedures through a simple, consistent user interface.
- The software incorporates security features that meet or exceed the requirements of Louisiana OTS, ensuring that sensitive project information is handled in accordance with state standards.
- The software provides DOTD and its consultants with a practical method to characterize sites, evaluate the spatial variability of soil properties, and produce appropriate statistical representations so that resistance factors can be selected consistently with AASHTO LRFD methodologies.
- DOTD and its consultant partners can create, save, and share analysis files, allowing project teams to review and confirm selected resistance factors and maintain consistency across geotechnical evaluations.
- The software embraces DIGGS logic and uses API functionality to link, exchange, and organize geotechnical data efficiently across projects.

- In addition, the web-based interface developed through this research improves DOTD's ability to visualize and interpret geotechnical datasets, including SPT, laboratory tests, and other in-situ measurements used to evaluate site conditions and support project delivery.
- By integrating these capabilities into a single platform, the tool enhances DOTD's capacity to incorporate site variability, measurement variability, and design updates from AASHTO and FHWA into everyday geotechnical engineering practice.

Together, these capabilities position the DOTD GDX-plorer as a key component of DOTD's transition toward modern, digital geotechnical design workflows and provides a foundation for future updates as AASHTO Section 10 and LRFD guidance continue to evolve.

## Recommendations

DOTD should fully implement the developed platform, GDX-plorer, for Louisiana projects to ensure appropriate site characterization is made and appropriate resistance factors are determined for design calculations.

As parallel efforts for site characterization with cone penetrometer testing (CPT) are developed, they too should be implemented, and additional resistance factor curves should be added to the GDX-plorer software.

The DOTD Geotechnical Design section should implement the training procedures and coordinate with consultants to ensure proper flow, QA/QC, and documentation for the new software.

Other efforts to advance the DOTD Geotechnical Data Management efforts should continue in future research to further advance DOTD and LTRC efforts.

- Scanning and Digitization (upcoming LTRC 26-2GT)
- Pile load test data
- CPT-Pile analysis
- Metadata for previous file versions and upgrades
- Potential enhancements could include the development of intuitive data entry and editing interfaces, enabling users to directly update, validate, and manage a wide range of geotechnical datasets, including deep foundation information.
- All data editing and input processes could be seamlessly connected to the OpenGround Cloud database, ensuring consistency, accessibility, and real-time synchronization across systems.
- These improvements would further streamline workflows, reduce manual effort, and enhance collaboration, providing DOTD with a single source of truth for geotechnical data that supports more efficient and accurate decision-making across all projects.