

NHDOT SPR2 PROGRAM

RESEARCH PROGRESS REPORT

Project # SPR 42372F		Report Period Year 2024 <input checked="" type="checkbox"/> Q1 (Jan-Mar) <input type="checkbox"/> Q2 (Apr-Jun) <input type="checkbox"/> Q3 (Jul-Sep) <input type="checkbox"/> Q4 (Oct-Dec)	
Project Title: Use of Drilling Parameters for Enhancing Geotechnical Site Investigations			
Project Investigator: Jean Benoit, PhD		E-mail: jean.benoit@unh.edu	
Phone:			
Project Start Date: May 05, 2021	Project End Date: September 30, 2024	Project schedule status: <input checked="" type="checkbox"/> On schedule <input type="checkbox"/> Ahead of schedule <input type="checkbox"/> Behind schedule	

Brief Project Description:

The standard penetration test (SPT) is a proven tool widely used in providing disturbed soil samples to aid in geotechnical site characterization and estimating soil properties for the design of DOT projects. Testing and sampling are typically done at 5 to 10 feet intervals, and thus between these samples, the use of engineering judgment identifies changes in stratigraphy and the soil's respective properties. The results from these tests are used to develop recommendations and aid in designing the NHDOT Department projects. Continuously performing the SPT is time-consuming, labor-intensive, and not well-suited for many of the soils encountered in New Hampshire and cannot be used to characterize rock. Soils containing large particles such as gravel lead to poor sampling recovery and unreliable results. A technique known as Monitoring-While-Drilling (MWD) makes use of the mechanical response of the drill rig and cutting tools while advancing a borehole. MWD can be used to explore the subsurface in any geological conditions. With such data combined with SPT testing, a continuous quantitative drilling record is produced, and the correlated parameters can be applied more reliably to the design process. Additionally, data to objectively assess site variability is obtained. The drilling parameters collected can provide quality assurance for the soil classifications provided by incomplete testing and sampling exclusively performed by the SPT.

The objectives of this research are as follows:

1. Provide MWD as a tool for geotechnical site characterization to result in a more thorough and accurate representation of subsurface conditions leading to safer and more economical designs. The MWD is an underutilized tool in the process of site characterization for infrastructure projects and is recognized by the Federal Highway Administration EDC-5: Advanced Geotechnical Methods in Exploration (A-GaME) initiative:
https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/geotech_methods.cfm
2. Support more efficient use of design and construction resources and reduce the chance of delays due to unexpected subsurface conditions. This effort will contribute to the overall goal of improving the efficiency of the NHDOT by increasing the delivery time of subsurface conditions and decreasing the time it takes to complete.
3. Provide data to other efforts: a) depth of bedrock which is of interest to other parties for mapping efforts and water quality studies, b) rock properties and joint orientations to support rock slope stability efforts with the Smart Rock technology and, c) estimates of relative permeabilities to support efforts with the Permeafor.

Scope of Work:

The proposed research will assess the use of MWD to be used on roadway and bridge foundation projects for the NHDOT. The scope of work includes the following tasks:

Task 1- UNH MWD update:

Update the existing UNH MWD system with the latest generation Lutz equipment. This will require the purchase of a new control and recording unit, junction box, and associated software.

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Task 2 – MWD installation:

Install MWD system on one of the NHDOT drill rigs and perform an initial evaluation on a site with both soil and rock.

Task 3 – Torque sensor design:

Design or purchase a torque sensor to be fitted to the mechanically driven drill rig operated by the NHDOT. This design will collaborate with the Montana DOT, the University of Florida, and the Jean Lutz company.

Task 4 – MWD testing:

Using project sites determined with a NHDOT technical advisory group, drilling parameters recorded will be compared to measurements traditionally collected by SPT and the associated soil samples, along with rock cores for deep foundations. The following parameters will be collected: thrust on drilling tool, rotation rate, drilling fluid rate, advance rate, torque, fluid injection pressure, and drilling fluid return rate. In addition, other non-controlled parameters will be documented to include tool wear and changes in drilling fluid composition.

Task 5 – MWD data evaluation:

MWD data obtained in conjunction with key NHDOT projects identified as high-risk projects will be evaluated to determine direct methods to correlate values to specific design parameters and be documented for use on future NHDOT projects.

Task 6 – Collaboration with other users:

Collaborate with other DOT MWD users to develop a database of information for best practices for drilling under various soil and rock conditions.

Task 7- Final report:

Provide a final report summarizing the research and recommendations for implementing the MWD in the everyday site and soil exploration. The information will be summarized to be included in the DOT Geotechnical Manual.

Progress this Quarter (include meetings, installations, equipment purchases, significant progress, etc.):

An initial Technical Advisory Group (TAG) meeting was held over Zoom on June 16, 2021, at 10:30 am. The following items were discussed: 1) Review of the research program and implementation strategy; 2) Review of research needs; 3) Review of project.

In the second Quarter of 2022, we had an amendment to our CPA approved to obtain two newly developed torque sensors that would be capable of measuring torque directly at the top of the drill string, all done wirelessly. We evaluated two torque sensors: the TICOR sensor, developed by Jean Lutz, and the instrumented drill rod, manufactured by MWD One. Wireless torque sensors are pertinent in this project as they provide more information to calculate compound parameters for subsurface characterization, taking advantage of the torque measurements.

The TICOR sensor was designed to measure torque, down force and rotation rate. The TICOR sensor was initially delivered to the NHDOT in November 2022. After an initial attempt to use the TICOR in North Hampton on December 22, 2022, we identified issues in the communication between the sensor and the DIALOG tablet. The TICOR was then repaired and delivered back to UNH in mid-May 2023. The sensor was re-installed on June 8, 2023, and additional tests were performed in Durham/NH in July to implement the sensor in MWD operations. We have been communicating with Jean Lutz and identified that the TICOR was still not fully operational, with issues in the load cell that measures the down force. The TICOR was shipped back to Jean Lutz France in September 2023 for further repairs.

In November 2023, we purchased a wireless sensor from MWD One which measures the torque and thrust at the top of the drill string. The new sensor was tested in Loudon, NH. The new sensor easily communicates with the Jean Lutz DIALOG system already in place. This new instrumented rod provides more accurate thrust measurements and replaces the initially tested TICOR sensor by Jean Lutz.

Following the data collection in Durham, Newington, NH, Seabrook, and Loudon, NH, further testing was performed in Derry this Quarter. The data from Q1 were successfully collected by Adam Carr and Christian Buerkle (NHDOT). We are currently analyzing all obtained data and comparing them to results from conventional geotechnical tests.

We recently wrote two papers on MWD data collection and assessment, which were recently accepted for presentation at the International Conference on Geotechnical and Geophysical Site Characterization (ISC'7) in Barcelona, Spain, in June

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2024. The first includes MWD, SPT, and CPT data collected this Summer in Durham and Newington. The second paper validates the portable MWD measurements obtained this Fall in Enfield, NH, and correlates compound parameters to lightweight dynamic penetrometer (PANDA) profiles which can be used by the NHDOT in the future to assist with rockfall evaluations in terms of energy and runout. These papers will be presented at ISC'7 as part of a special session on MWD organized by Professor Benoît and Philippe Reiffsteck of the University Gustave Eiffel in France. In addition, we are currently preparing a short course on MWD that will be given at ISC'7 in person.

Professor Benoît will also be assisting in delivering a workshop on MWD at the IFCEE conference in Dallas on May 8, 2024 alongside engineers from FHWA Resource Center (Ben Rivers and Mary Nodine) and Professor Michael Rodgers of the University of Florida. This event will include field demonstration of the MWD system to further promote this technique to geotechnical engineers for soil/rock exploration as well as foundation design and verification.

In parallel, we have also been working and led the MWD Users Group in collaboration with FHWA. Meetings have been held on the third Wednesdays of each month which has provided an excellent opportunity to exchange experiences, analysis approaches and testing equipment, innovations and standards with other users across the United States and worldwide. Meetings have been held since November 2021, with more than 60 participants each time. The MWD user group has discussed the implementation of a US MWD standard, as well as the diffusion of MWD knowledge to companies and organizations that are still not familiar with the technology. Professor Benoît is also involved in implementing MWD data into DIGGS, a project funded by the Geo-Institute.

Items needed from NHDOT (i.e., Concurrence, Sub-contract, Assignments, Samples, Testing, etc...):

Additional drilling opportunities to collect MWD data from daily drilling activities in the field (drilling and coring), as well as any relevant additional testing results (SPT, grain size distribution, RQD, strength, etc.) will further advance our understanding of drilling parameters in various geological conditions. It is critical that staff on the NHDOT MWD drill rig record as much information as possible during drilling advance which will help with understanding the data collected with the MWD system. The drill rig that the NHDOT is currently planning to purchase will also be equipped with a wireless torque and thrust sensor. We hope to finalize the purchase of the MWD system for this new drill rig in this upcoming quarter.

Anticipated research next three(3) months:

Anticipated work for the next Quarter includes additional MWD measurements during drilling activities to be performed by the NHDOT including using the new MWD One sensor. Additional potential site locations will be determined by the NHDOT, according to their demand and availability. We will also continue to perform data analysis and evaluation. Our collaboration with other users will also continue through the MWD Users Group.

Circumstances affecting project: None.

Tasks (from Work Plan)	Planned % Complete	Actual % Complete
<i>Task 1- UNH MWD update:</i>	100	100
<i>Task 2 – MWD installation:</i>	100	100
<i>Task 3 – Torque sensor design:</i>	100	100
<i>Task 4 – MWD testing:</i>	70	50
<i>Task 5 – MWD data evaluation:</i>	50	40
<i>Task 6 – Collaboration with other users:</i>	85	85
<i>Task 7- Final report:</i>	30	30

Barriers or constraints to implementing research results None.