NHDOT SPR2 PROGRAM
RESEARCH PROGRESS REPORT

Project # SPR 42372F		**Report Period** Year 2023 ☐ Q1 (Jan-Mar) X Q2 (Apr-Jun) ☐ Q3 (Jul-Sep) ☐ Q4 (Oct-Dec)
Project Title: Use of Drilling Parameters for Enhancing Geotechnical Site Investigations		
Project Investigator: Jean Benoit, PhD **Phone:**		**E-mail:** jean.benoit@unh.edu
Project Start Date: May 05, 2021	**Project End Date:** August 31, 2023	**Project schedule status:** **X** On schedule ☐ Ahead of schedule 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.

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 (TICOR) by Jean Lutz, capable of measuring torque directly at the top of the drill string. The TICOR sensor will also measure down pressure directly as well as rotation rate, all done wirelessly. The TICOR sensor was delivered to the NHDOT in the first week of November and was installed in the following weeks, as the NHDOT needed to order two adaptors to securely fit the torque sensor between the drill rig and the drilling rods.

After an initial attempt to use the TICOR on December 22, 2022, in North Hampton, 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. The sensor was installed on June 8, 2023, and we have been communicating with Jean Lutz to ensure it is fully operational. The addition of the TICOR sensor will provide more information to calculate compound parameters for subsurface characterization, taking advantage of the torque measurements.

We have also acquired an instrumented drill rod from Dr. Michael Rodgers, fabricated in the Florida, which will allow us to obtain torque measurements for comparison with the Jean Lutz system. The drill rod presents the advantage of being more compact than the TICOR sensor and also communicates with the Jean Lutz DIALOG system. We have been preparing an extensive experimental campaign in Durham, NH, to compare MWD to SPT data and, rock unconfined strength and RQD.

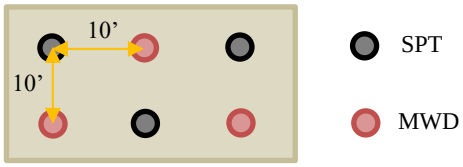
This past quarter, MWD data has been collected in North Hampton. As we wait for more MWD drilling/coring opportunities with the torque sensor, we are working on data analysis. A demonstration of the MWD system with the complete Jean Lutz system was given during the drilling course given by NHI at the NHDOT on June 28.

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. To date, 17 meetings have been held, with as much as 80-90 participants each session. The portable MWD was introduced at the last Users Group meeting, and MWD users demonstrated great interest in this technology. The MWD user group has also 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. We are writing an article on MWD with basic and essential knowledge of MWD, which will be published in GeoStrata later this year.

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

We need 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.). The drill rig that the NHDOT is currently planning to purchase will also be equipped with the TICOR wireless torque sensor or the instrumented rod from Michael Rodgers in Florida. The selection will be based on performance and cost. We have also requested the DOT to redo the welded studs on the drill rig that are used for measuring rotation rate. The existing ones were done hastily and have not performed as expected. We would like to propose a testing program where we would perform three continuous SPT profiles close to three continuous MWD drilling and coring measurements, as shown below. This setup would allow us to make more effective correlations between all the collected data and establish future protocols to conduct MWD measurements. Additional measurements will also be performed with the TICOR sensor and the instrumented drill rod.



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 TICOR sensor and the instrumented drill rod. The next tests will be performed in Durham, NH, where several MWD and SPT profiles will be collected for data comparison between both methods. 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**
Task 1- UNH MWD update:	*100*	*100*
Task 2 – MWD installation:	*100*	*100*
Task 3 – Torque sensor design:	*100*	*90*
Task 4 – MWD testing:	*50*	*20*
Task 5 – MWD data evaluation:	*30*	*20*
Task 6 – Collaboration with other users:	*80*	*80*
Task 7- Final report:	*0*	*0*

Barriers or constraints to implementing research results None.