Organization and Analysis of Measurement While Drilling (MWD) Data

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INTRODUCTION

Measurement while drilling (MWD) is a relatively new application of instrumented drill rigs to characterize subsurface engineering properties used in geotechnical design by recording a suite of continuous drilling measurements such as down pressure, rotation torque and speed, and advance rate. MWD data can be used to complement traditional drilling sampling techniques such as split spoon sampling and rock coring along with driller logs. MWD data are used to establish correlations with desired geotechnical parameters such as unconfined compressive strength (UCS), SPT blow counts and unit weight. Once robust correlations are established, future projects can improve efficiency and cost savings by eliminating or decreasing the frequency of costly and inefficient sampling and coring.

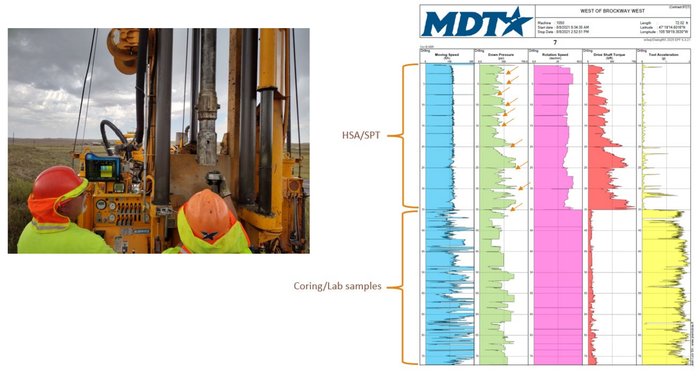

Figure 1. (Left) Photo showing instrumented drill rig on site. (Right) Plot of recorded MWD data with depth showing section for hollow stem auger (HSA) and coring section.

TASK 1 – GIS DATA PORTAL

Implementing the MWD project required organizing and making available large amounts of data of various types. To this end, a GIS data portal was constructed which enabled MDT personnel to upload the different types of data collected. Spreadsheet templates were developed to ensure consistent formats of data entry. MWD data were mainly of two forms:

1. actual MWD data streams and
2. associated drilling data including SPT blow counts and/or coring data.

Additional data that can be included in the portal include driller logs and other testing information. These data are then available to the research team for analysis.

Figure 2. Map segment from GIS data portal showing location of MWD sites along Highway 200 used for analysis.

MAJOR TAKEAWAYS

- Best results for developing correlations of MWD data to geotechnical parameters were achieved with a multiple parameter nonlinear (neural network) approach.
- The GIS data portal developed by MDT is a convenient, user-friendly interface to upload and share metadata with constituent user groups.
- Future MWD projects should focus on a standardized drilling approach with dedicated MWD drillers.
- In addition, drilling a second adjacent borehole specifically for MWD data collections should be explored.

TASK 2 –DATA ANALYSIS AND CORRELATIONS

All MWD data and drilling data were reviewed and subjected to quality control. Two types of drilling data were used for correlation analysis: SPT blow count data from the upper 30 feet and coring data, if available from below 30 feet depth.

MWD data streams used (in various combinations where appropriate) were:

- Depth
- Down pressure
- Rotation torque
- Rotation speed
- Moving speed (advance rate)

A sixth parameter was also used. Called a compound parameter, it consists of a function of four MWD parameters: down pressure, rotation speed, rotation torque and advance rate[1].

The analysis approach consisted of three phases:

1. Single parameter linear and exponential correlations,
2. Multiple parameter linear correlation, and
3. Multiple parameter nonlinear correlation (neural networks).

Except for the phase 1 single parameter analysis, phase 2 and phase 3 analyses investigated all possible combinations of the six inputs: 63 different cases.

Summary results for our three-phase approach are presented in Table 1.

Table 1. Summary results for Phase 1, 2 and 3 analysis. Phase 1 minimum and maximum values were taken from both the linear and exponential correlations. Phase 3 mean values are the average of about five best R^2 results for various neural network architectures and combinations of inputs.

Phase	SPT	UCS	Unit weight
Phase 1 – max	0.51	0.13	0.19
Phase 1 – min	0.01	0.01	0.01
Phase 2 – max	0.65	0.24	0.29
Phase 2 – min	0.01	0.01	0.01
Phase 3 - average	0.89	0.72	0.84

CONCLUSIONS AND RECOMMENDATIONS

1. Successful correlation of MWD data to geotechnical parameters requires careful preprocessing of MWD data and quality control/editing of drilling data such as UCS or SPT N. In addition, any correlations developed will be site specific and closely correlated with the local geology.
2. The geology at MWD sites for the Montana project consisted of intermediate geomaterials (IGMs) categorized as extremely weak rock (35 to 150 psi) and very weak rock (150 to 725 psi). These weak materials present a challenge to the MWD drilling process and ultimately data analysis and correlation development.
3. Future MWD work should focus on controlling the drilling environment to achieve optimized drilling parameters for highest drilling efficiency and optimal core recovery to achieve high quality MWD data [2]. This approach may require dedicated MWD drillers adhering to standards developed by organizations involved. In addition, drilling a second adjacent borehole specifically for MWD data collections should be explored.
4. Our work with MWD data from IGMs indicates that the relationship between MWD drilling parameters and correlations with geotechnical parameters is likely nonlinear.

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