Monitoring While Drilling

Presented by: Paul Emerson
Director
MSc, DIC, CGeol, FGS
Introduction

- What is MWD?
- Where did it come from?
- How does it work
- What are its applications?
- Limitations
- Case Studies
- Future uses
MWD is not....

- Accelerometers
- Magnetometers
- Inclinometers
- Other down-hole parameters
- Geophysics

Pictures courtesy of Halliburton
What is MWD?

Measurement and recording of drilling parameters in real time:

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Tel: 0044(0)1225 855002 Web: www.emerson-moore.co.uk
History

- Originated from mining sector
- First systems were developed in 1980's, including:
  - Detection of weak water bearing zones.
  - Determine bedrock depth for piling (probing).
  - Fracture location and lithology definition.
- EMD have been operating the Envi system since 2005
- Other manufacturers include Jean Lutz (France) and Geotech (Sweden)
What is MWD?

**Aims:**

- Obtain data during drilling to increase the information available rock material and rock mass characteristics including, material type, fracture location / zones;
- Efficiency of operations;
- Improve reliability and accuracy of data;

It can be used with both rotary coring and open-hole drilling techniques.
How does it work?

- This Driller is not holding a stopwatch and has no chalk in his hand.

Rotary coring supplemented by MWD for geotechnical investigations for potential nuclear waste depository sites, Sweden. Photograph courtesy of Environmental Mechanics, SE

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Depth Registration Unit: Wire goes from the unit to the top of drill head, the wire follows the drill head up and down.

Revolution Gauge: Records the revolutions of drill head.

Flow and Pressure Unit: Measures flow when drilling with mud/water / air.

Control Box: Consists of electronic transducers connected to rig hydraulics.

Feed force – bit load: Is measured directly from the rigs hydraulic system and is calibrated using a load cell.

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What is Displayed

- Depth;
- Rate Of Penetration
  - Very important this is influenced by several factors, including,
    - Strength, type and frequency of mass and materials
    - Type of rig and bit used
    - Flushing media and pressures
    - Drill personnel.
- ROP is function of depth, correlate logs at same scale from different holes
- Width of penetration rate peaks/ troughs are important
What is Displayed

- **Bit Load** – Directly influenced by ROP,
  - Check against variations in ROP;
- **Torque** – Heavily influenced by drill method.
- **Revolutions Per Minute**.
- **Flush pressure** – Directly influenced by rock mass characteristics;
## How is it Recorded

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- Initially recorded as text file or STD file
- Floppy disk or USB
Specific Energy?

Combination of all recorded parameters Specific Energy:

• Excellent method of clarifying plots and identifying voids.
• There have been attempts to correlate this to ground strength – so far without success.
• Manual interpretation of plots.

Specific Energy:

\[ E_s = \frac{F}{A} + 2\pi\frac{NT}{AV} \]

- \( F(\text{kN}) = \) Bit load
- \( A (\text{m}^2) = \) Area of Bit
- \( N = \) RPM
- \( T (\text{kN} \times \text{m}) = \) Torque
- \( V (\text{m/sec}) = \) ROP

Underground coring rig, complete with MWD, allows remote operation from surface. Photograph courtesy of Atlas Copco

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What are its uses and advantages (1)

- Voids identification, dissolution or man made cavities.
- Identification of fracture zones including where zones of core loss encountered.
- Probe drilling.
- Combined with coring reduce the number of cored holes required.
- Detecting contrasts between materials e.g. flint bands, mineral exploration, coal.
What are its uses and advantages (2)

- Depth control - Very accurate depth readings.
- Near continuous data profile of ground.
- More efficient coring operations.
- Assists drillers in gaining a feel for the ground – beneficial for training.
- Scandinavian drillers are now able to determine rock type from sounding plots.

- Consistent between drilling techniques.
- Quality control & monitoring.
Limitations

- Set-up cost.
- Driller influence.
- Requires experienced and trained drillers and those that are interested in development and training.
- Requires sensors for each rig.

Rotary coring supplemented by MWD for geotechnical investigations for potential nuclear waste depository sites, Sweden. Photograph courtesy of Environmental Mechanics, SE

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Case Study 1 – Identification of mines workings beneath railway

Techniques included:
- Overburden casing system;
- Rotary open-hole follow on;
- Voids identified

- 7.75m to 8.65m - VOID, rapid drop in flush pressure large increase in ROP.

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Case Study 2 – Identification of material boundaries and zones of core loss

- Change of drill parameters clearly defines material boundary;
- Good core recovery, high RQD
- You would not expect bad recovery in this material – quality control

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Case Study 3 - Probing for voids

Ground conditions, made ground over ground identified as containing voids.

- 0m to 16m - Variable weak materials. Note rapid variations ROP, fractured zones
  - 16m to 26m – Material boundary, bit load increases ROP decreases
- 26m to 29m - VOID between 26m and 27m.
- 29m to 33m - VOID, rapid drop in flush pressure with slow increase as void fills.

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The Future

• Potential future inclusion in Eurocode Standards, it is already proposed as a Work Item.

• MWD plots become common-place in ground investigations.

• Improved

• Automated Drill systems.

• These are already in operation in mining sector, underground and blast hole.

• Determination of classical rock properties such as strength???

Mine control room, Zinkgruvan, Sweden, including automated drill rigs. Photograph courtesy of Atlas Copco

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Thank you for listening