Case Histories
Building and Using 3D Models to Plan and Execute Site Characterizations

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Case Histories will show:

1. Existing projects can be totally recharacterized with existing information.
2. Creation of 3D models allows us to do a much better job of designing geotechnical investigations so that we are answering the right questions.
3. Creation of 3D model leads to project discovery
Our Approach to Site Characterization

• Start with Construction History
  - Review more than the typical plan view, section, profile, and geology descriptions

• View ALL available data in one space
  - Spend more resources upfront (time and money) to understanding the story
  - Data is displayed, limit interpretations
  - Sources are well documented

• Communication
  - Design Team, Owners, Stakeholders all on the same page from the beginning
  - Easily shared, user-friendly, visualization enhancing 3D PDF Models

The result is a significantly higher likelihood of confidence in our geotechnical investigations, risk analyses, instrumentation, and remedial designs.
Case History #1

Somewhere West of the Mississippi

350’ High Double Curvature Thin Arch
Underground powerhouse
Online in late-1960s
Massive 500-million-year-old limestone and dolomite, cliffs 500+ ft high
Case History #1 – Where we started...
Case History #1 – Where we started...
3D Model?! Where do we even begin?

- Let the data tell the story
- Dive into construction records and compile ALL existing geotechnical data
  - Construction photos
  - Construction drawings
  - Boring logs
  - Water test results
  - Geologic maps
  - **Point cloud**
    - Site coverage
Laser Scanning to Measure Discontinuities
Mapping Discontinuities – Planes

1) Identify Flat Plane
2) Outline the Plane
3) Compute Average Plane and Orient
4) Check for Fit
Mapping Discontinuities – Traces

- Left Abutment Trace Feature
- Orient and Check

- There are many traces with no planes
- There are many planes with no traces
- Traces and planes both saved for
Stratigraphic Analysis

North Forebay Wall

South Forebay Wall

Left Abutment

Right Abutment
South Forebay Wall

Ash Layer ("Rhyolite")

Rhyolite concreted up
North Forebay Wall
Left Spillway

Disposal Channel
Right Abutment
Case History #1 – Lessons Learned

- Site totally recharacterized based on existing data
- Complex stratigraphy and fracturing BUT the site is one contiguous block!
- “Possible Major Faults” appear to be through-going joint sets with little displacement
  - Form large potentially removable blocks
- Re-understanding of original geologic map stratigraphy
  - collapse breccia
Case History #1 – Lessons Learned

Understanding of Site Geology Changed Completely

- Resulted in analyses of potentially removable blocks on the abutments
- Emergency stabilization of bridge pier supported by a rock block with low Factor of Safety

3D Model was Used for a Variety of Tasks

- Rock block stabilization support
- Risk – address PFMs in PFMA and SQRA
  - Reclassification of PFMs
  - Increased confidence
- Targeted ground-truthing
- Reevaluation of instrumentation program
Case History #2

Down in a Valley

Embankments on either side of a central powerhouse
Maximum embankment height of about 160 ft
Output of ~800 MW
Built in late-1960s
Glaciofluvial deposits on a major river
Periodic Risk Assessment performed, and conclusion was that there is a lot of uncertainty regarding project risk.

3D Modeling Objectives:

• Inform filter compatibility analysis
• Support planning of a geotechnical investigation to inform:
  • seismic stability
  • internal erosion, and
  • other risk-driving PFMs.
Case History #2 – Using the 3D Model as our Guide

- Does the current site understanding make sense based on available data?
- Where are our existing borings? In-situ testing?
- What is missing?
- Where is the data we need? What are the best ways to get it?
- Is there liquefiable material in the foundation? Where are those materials?
1. Internal Erosion
   a) Material properties
   a) Characterize geometry of zone contacts
   b) Changes over time
   c) Gradients

No Erosion  

Some Erosion

Excessive Erosion

Continuing Erosion
2. Seismic Stability
   a) penetration resistance data
   b) material properties

What do you do when your materials are gravel or larger?
Targeted Investigation with Multiple Techniques

Drilling
- Sonic – samples for gradation testing (8-inch diameter in certain zones)
- Becker Drilling – penetration resistance
- Mud Rotary – SPT values and site-specific correlations
  - Blows per-inch
  - Shear wave velocity in embankment
- Diamond Rotary Coring – foundation shear wave velocities

Geophysics
- Suspension logging – shear wave velocity
Understanding construction methods is critical

Past performance is key

Data Quality Must be Assessed

Keep the end goal in mind
CONCLUSIONS

The process of building 3D models leads to a more holistic understanding of projects.

Existing records are critical for site characterization.

Good models result in higher likelihood of success.