Michigan Ditch Landslide & Tunnel Design and Construction

Amara Meier
Geological Engineer
Lithos Engineering
GLE Alumni - 2013
Outline

- The Site/The Problem
- Geotechnical Investigation
- Tunnel Design/TBM
- Tunnel Construction
- Take-Aways
The Site

• Elevation of 10,300 ft
• No power, phone, or internet
• Two-track road access
• Six-mile-long water supply ditch
• Water valued at $180 million

The Problem

• Large Landslide Complex
• 2,340 feet long
• 800 feet wide
• 730 feet of relief
• 90 feet deep
• Typical movement
  • 0-4 feet per year
• Spring 2015
  • 21 feet of movement
• Pipe destroyed
The Geotechnical Investigation

- Geologic mapping of the landslide and outcrops
- 10 Seismic refraction lines
- Eight vertical borings for design alternatives
- Three horizontal cores for tunnel alternative

Geology:
- Highly variable
- Highly fractured
- Highly faulted
- Average RQD = 10%
Tunnel Design

• Initial support
  • Ribs & Lagging
    • 4-foot set lengths

• Carrier Pipe
  • Hobas 60-inch diameter
    • 10-foot lengths

• Carrier Pipe Blocking
  • Steel straps
  • All-thread rebar on every rib

• Backfill Grout
  • Ports in Hobas
  • Five lifts
  • 500-psi strength
The Tunnel Boring Machine

- Akkerman TBM
  - 98-inch O.D.
  - 27 feet long

- Custom cutterhead
  - Open face
  - 13 Sets of disc cutters
  - 4 sets of scrapers

- Italian disc cutter manufacturer
Site Layout
Site Layout

- Muck Pile
- Launch Pit
- Ditch Road
- TBM Generator
- Initial Support Staging Area
- Landslide
Variable Geology
Gauge Disc Cutters
Daily Tunneling Progress

Michigan Ditch Tunneling Progress

Advance per Shift (feet)

Distance per Shift

Average Shift Production

6.9 ft/day
Final line and grade within 1 inch horizontally and 0.01 inch vertically.
Tunnel Carrier Pipe
Take-Aways:

• Value of horizontal coring
  • Avoided intersecting landslide

• Comprehensive Risk Register
  • Anticipated worst-case scenarios ahead of time and had solutions in place

• Pitfalls of too much geologic information
  • Smaller factor of safety for TBM capacity

• Cutterhead design
  • Should have conducted an external review

• Availability of replacement disc cutters
  • Italian holidays

• Redundant Surveys

• Continual site maintenance
  • Safety and efficiency

• More aggressive schedule to start
Placeholder for Construction Video