Mt. Washington Landslide, Emergency Response, and Wall Design

Trey Walker, PE
Overview

► Introduction
► Landslide Review
► Emergency Response Activities
► Site Investigation & Assessment
► Retaining Wall Design
► Retaining Wall Construction
► Survey Monitoring
► Summary & Lessons Learned
Site Location & Information

- Landslide Occurred on April 8, 2014 ≈ 3:00am
- Affected Parties
  - Norfolk Southern Railway
  - City of Pittsburgh
  - Duquesne Incline
  - LeMont Restaurant
  - Other Residents
Introductory Videos
Introductory Videos
Landslide Statistics/Impacts

 ► Total Slide
   ► 350-feet by 600-feet Slide Mass
   ► Estimated 450,000 CY
   ► Initiated ≈ 500-feet upslope of track

 ► Norfolk Southern
   ► Double Mainline Tracks Covered in Debris
     ► 75’ stretch of Main Track #1
     ► 230’ stretch of Main Track #2
     ► Up to 15’ deep

(Darrell Sapp – Pittsburgh Post-Gazette)
Emergency Response Activities

► Objective: Safely Restore Freight Operations
► Remove Debris & Restore Traffic on Main Track #1
► Remove Debris & Restore Traffic on Main Track #2
► Total of 3,000 CY Removed from Track
► Continue Observation of Slide Mass
► Begin Site Assessment & Investigation

(Darrell Sapp – Pittsburgh Post-Gazette)
Site Investigation & Assessment

Site Investigation:
► Walk accessible sections of slope and slide mass.
► Geotechnical Borings
  ► 4 total
    ► 3 at track Level, 1 on slide mass.
► Survey of lower slope

Assessment:
► Colluvial soils
► Wet Conditions
  ► Fluctuating groundwater conditions
  ► Abnormally cold winter
► Slide toe located at track level
► Embankment supporting track is not moving
Retaining Wall Design

► Objectives:
  ► Protect track operations
  ► Provide a system with advanced warning of additional movement

► Multi-phase approach
  ► Provide design for immediate protection (Phase 1)
  ► Continue to monitor slope conditions
  ► Provide design for alternate reinforcement (Phase 2)

► Design timeline
  ► Conceptual design in 5 days
  ► Preliminary design in 10 days
    ► Owner & Contractor review
  ► Final documents/begin construction in 20 days
  ► Phase 2 design in 6 weeks
Retaining Wall Design (continued)

Design Concept Phase 1
- Soldier Pile Wall
  - 12’ typical design height
  - 6’ stickup above stone backfill
  - 355’ wall length
- HP14x117 Soldier Pile (60’ Length)
  - 24” diameter socket
  - Backfilled with concrete
- HP12x53 Continuous Waler
- Precast Concrete Lagging

Design Concept Phase 2
- 225-kip Anchors
- 2 anchors every other bay
- Double HP waler connected to wall face

Benefits of design
- Meets objectives
- Small footprint
- Easily altered alignment
- Short construction timeline
- Phase 1 easily adapted to incorporate phase 2
Retaining Wall Design (continued)

Wall Alignment
Retaining Wall Design (continued)

Phase 1 Typical Section
Retaining Wall Design (continued)

Phase 2 Typical Section

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Retaining Wall Construction

► Construction Notes
  ► Wall Alignment changed to expedite construction and accommodate utilities
  ► Some lagging sections were cast-in-place
  ► Grading upslope of wall to assist drainage
  ► Construction completed within one month.
Construction Photos
Survey Monitoring

- **Monitoring Program**
  - Movement monitored for 12 weeks after completion.
  - Final readings August 2014
  - 27 monitoring points along top of wall
  - Max movement \( \leq 0.25" \)
  - As result Phase 2 was not constructed
Summary and Lessons Learned

► Revisit Objectives
  ► Protect track operations
  ► Provide a system with advanced warning of additional movement

► Design and Construction complete within two months

► Wall Monitored for Movement
  ► Minimal movement observed over three months

► Phase 2 Not Constructed
  ► Saved approximately $400,000 in construction costs.

► Lessons Learned
  ► Comfortable with limited information & changing conditions
  ► Provide flexible designs
Questions?

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