Geotechnical Design and Construction of the Pittsburgh Mills Interchange: Ancient Landslides, Rock Bolts, Soil Nails, and Geogrids, Oh My!

Presented by

Paul A. Hale, P.G., L.R.S.
Pittsburgh Mills Interchange

Introduction

Project Location

Pittsburgh
Pittsburgh Mills Interchange

Introduction

- S.R. 0028
- Mills Blvd.
- Relocated Tawney Run Rd.
- Ramp A
- Ramp B
- Ramp C
- Ramp D

November 5, 2004
Pittsburgh Mills Interchange

Introduction

Project History

• Originally Zamias / Frazer Heights Galleria

• Work Started in the Early 1990’s

• Cash Flow Issues, Advanced to Pre-pay Status with GF

• Mills Corporation Took Over the Project

• Design Resumed in 2002
Pittsburgh Mills Interchange

Presentation Summary

- Construction Phasing
- Design Challenges
- Late Addition Scope Items
- Construction Services
- Lessons Learned
Pittsburgh Mills Interchange  

Construction Phasing

Design Packages

• A1 – Roadway West of S.R. 0028, Ramp C / D (Grading & Drainage)

• A2 - Roadway West of S.R. 0028, Ramp C /D (Complete Roadway)

• B – Demolition, Waste Mitigation & Culvert Construction

• C – Bridge Over S.R. 0028

• D – Roadway East of S.R. 0028, Ramp A, Ramp B & Tawney Run Road Relocation

Packages Were Structured to Dovetail With Mall Site Construction and Funding Sources
Pittsburgh Mills Interchange

*Construction Phasing*

- Packages A through C Were Constructed Under HOP’s
- Package D Used PennDOT’s Traditional PS&E Package

![Funding Percentage Graph](chart.png)

- **40%** Federal
- **50%** Mills, Inc.
- **10%** State
Pittsburgh Mills Interchange

Design Challenges

- Ancient Landslide Delineation
- Tawney Run Culvert Extension
- Ramp A Facing Wall
Pittsburgh Mills Interchange

**Design Challenges**

**Ancient Landslide Delineation**

- USGS Landslide mapping indicated presence of ancient landslide
- Review of Aerial Photos (1938 & 1973)
- Tawney Run Displaced
- W – NW Failure Direction
- Area Lacking Vegetation
- Established Initial Limits
Pittsburgh Mills Interchange

Design Challenges

Ancient Landslide Delineation

• Existing Boring Data (Phase I; 1990)
• Pittsburgh Redbeds
• Marker Bed (Ames Limestone)
• Typical Elevation Across Site
  Elevation 1020’ MSL
• Borings Within Landslide
  Elevation 1009’ – 1013’ MSL
Pittsburgh Mills Interchange

Ancient Landslide Delineation
Borings Added to Delineate Landslide

Northwest Boundary Defined by Tawney Run Offset

North - Marker Bed Was Less Than 1113’ In All Borings

Field Reconnaissance Delineated Southern Boundary
Ancient Landslide Delineation

Recommendations

- **Ramps (3V:1H)** buttress slide
- **Restricted excavation within the slide limits**
- **Rock blanket (R-4)** vs. overexcavation in unsuitable areas
- **Limited width (20’)** excavations within slide limits
Ancient Landslide Delineation

Design Challenges
Pittsburgh Mills Interchange  

**Tawney Run Box Culvert**

- Existing culvert beneath S.R. 0028 was undersized for the additional fill for Mills Boulevard and Ramps

- Required to maintain traffic flow on S.R. 0028

- GF opted not to design a shoring measure, but instead include a shoring provision with conservative shoring parameters
Pittsburgh Mills Interchange

Design Challenges

Ramp A Facing Wall

• Existing 1:1 cut in shale
• Proposed vertical
• Required to maintain existing catchment zone
• Approximately 800 feet long
Conducted detailed line survey of discontinuities

Failed Markland’s test for wedge failure propagation

Therefore reinforcement required
Pittsburgh Mills Interchange

Ramp A Wall

• Cut exposes Birmingham Shale, Duquesne Coal, and Duquesne Claystone

• Southern end is vegetated, and < 1:1

• Borings found that southern end is comprised of soil and rock.
Pittsburgh Mills Interchange

Ramp A Wall-Southern 150 Feet

Soldier Pile and Concrete Lagging Wall

- Rock Bolts Couldn’t be Used Due Lack of rock
- Increased Ka vs. Rock
- Redesign Using Light Weight Structure Backfill

Design Challenges

Soil Ka = 0.62

Rock Ka = 0.027

2.54Kips

0.05Kips
Pittsburgh Mills Interchange

**Design Challenges**

**Last Minute Designs**
- Dominion Peoples Gas Line Crossing
- Ramp B
- Tawney Run Road
- Tawney Run Road Reinforced Soil Slope
Pittsburgh Mills Interchange

Design Challenges

Last Minute Designs

• 20” & 30” Gas Line Traverse Project

• Ramp B & Tawney Run Road Relocation Encroach on Uncased Line Sections

• Ramp B uses Anchored Soldier Pile & Lagging Wall

• Tawney Run Road Utilizes Drilled Caisson and Concrete Cap Wall
Design Challenges

Last Minute Designs
Ramp B  Soldier Pile and Lagging Wall

• Up to 3 rows of continuous strand anchors

• 78 Ton Capacity Per Anchor

• Minimum bond length of 23 feet

• Final condition is partly buried, designed for temporary condition of exposed pipeline
Pittsburgh Mills Interchange

**Design Challenges**

*Last Minute Designs*

**Soldier Pile and Lagging Wall**

- 2 to 3 rows of anchors
- Designed for excavation in the future by utility company
Pittsburgh Mills Interchange

Design Challenges

Last Minute Designs

Tawney Run Road Concrete Caisson Wall

Gannett Fleming
Pittsburgh Mills Interchange

**Design Challenges**

**Last Minute Designs**

Tawney Run Road Concrete Caisson Wall

- Four foot diameter caissons embedded in rock a minimum of five feet
- Designed to utilize soil arching
- Slots provided in caissons for lagging (to prevent sloughing)
Pittsburgh Mills Interchange

Design Challenges

Last Minute Designs
Reinforced Soil Slope

• Prevent encroachment on gas lines, and adjoining private property
• Geogrid Reinforcement
• Additional boring and analysis
Pittsburgh Mills Interchange

Design Challenges

Last Minute Designs

[Diagram showing details of the interchange design, including slope, guide rail, erosion control blanket, geosynthetic reinforcement, and reinforced fill.]
Compaction requirements necessitated the use of baskets and AASHTO No. 57 stone beyond the wrapped face.
Pittsburgh Mills Interchange

Construction Services

• GF reviewed shop drawings and other submissions on behalf of PennDOT
• GF invoiced Mills Corp for these services
• GF was stuck in the middle at times
• Services Included;
  • Caisson Confirmatory Boring Inspection
  • Shop Drawing Review
  • Soil Nail East
  • Soil Nail West
  • Temporary Bridge
  • Inspection of Ramp A rock fall occurrences
Pittsburgh Mills Interchange

Construction Services

Caisson Confirmatory Boring Inspection

Gannett Fleming
Pittsburgh Mills Interchange

Soil Nail Wall - West

Construction Services
Pittsburgh Mills Interchange

Soil Nail Wall - East

Construction Services
Pittsburgh Mills Interchange

Construction Services

Temporary Bridge

Gannett Fleming
Pittsburgh Mills Interchange

Temporary Bridge

Construction Services
Pittsburgh Mills Interchange

Excavated early in construction to yield embankment material

Included a ditch for drainage from coal horizon

Ditch held water against the underlying claystone

Ramp A Wall Rockfall Inspections

11/18/2004
Pittsburgh Mills Interchange

Construction Services

Ramp A Wall Rockfall Inspections

- Claystone slaked due to water and exposure, creating overhangs
- Rockfall defined by the joint sets occurred at overhang locations
GF advised contractor to cover the slope with embankment material above the coal elevation until wall construction was undertaken.
Lessons Learned

Pittsburgh Mills Interchange

Pertaining to Ramp A Rockfall

• PennDOT Construction Standards require contractor to provide temporary support for all excavations

• However, the contractor left the Ramp A wall location unsupported for approximately 6 months

• An item in the specifications limiting the time between excavation and wall construction would have prevented much of the rockfall problem at this location
Pittsburgh Mills Interchange

QUESTIONS?