Geohazards Impacting Design of the The Ohio River Bridges, East End Crossing, Section 4 Northbound and Southbound Tunnels

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August 7, 2014
Presentation Outline

- Project overview
- Site geology
- Potential geologic hazards
- Construction methodology
- Support schemes
- Project status
Project Overview – Location

LOCATION MAP

VICINITY MAP
Project Overview – Location
Project Overview – X-Section at Portal

20' RESIN BONDED TENSIONED ROCK BOLTS

12' LONG SWELLEX TYPE ROCK BOLTS

SOUTH PORTAL SUPPORT ELEVATION
Project Overview - X-Section at Portal
Site Geology – Field Techniques

- Surficial geologic mapping
- Surface-based geophysical
- Borings (horizontal, vertical, inclined)
  - Observation wells (some nested)
  - Down-hole geophysics
  - In-situ packer tests
Potential Geologic Hazards

- Karst features
- Geologic discontinuities
- Groundwater inflow
- Swelling/slaking shale
- High horizontal rock stresses
Potential Hazards - Karst

- Louisville Limestone and Laurel Dolomite
- Sinkholes and sinking springs
  - Enlarged joints and bedding planes
  - Cavities (air/water/soil/rock)
- Resistivity and refraction surveys
  - “Ground truthing” vs. borings and sinkholes
  - “Hot spot” analogy
- Contingency Plans
Potential Hazards - Discontinuities

- Sub-horizontal (bedding)
  - Televiewer data
  - Few minor low angle joints (35 to 60 deg)
- Sub-vertical
  - Borings and road cuts
  - Within a few degrees of vertical
- Rock Mass Classification
Potential Hazards - Groundwater

- Permeability of intact rock (pores) is low
- Groundwater moves through solution joints and channels (transient loads)
- Sinking stream
- Soil/rock interface, LL, LL/WS interface, LD
  - Some perched water at interfaces
  - Regional table probably in LD (or lower)
Potential Hazards - Swelling/Slaking

- Requires unloading and access to water
- Huder-Amberg Testing
  - 3.3% strain vertical borings (average)
  - Pre-loading = more volume change
- Some of the shale cores slaked severely, majority did not
- Generally, high dolomite content and low clay content; except locally
Known region where $s_h > s_v$ (typically)

Close to the Ohio River

Valley features (tunnel is within a ridge)

Stress reduction at shallow depths likely

Modeling at $K_o = 0.5$ more conservative than $K_o = 1$
Construction Methodology

"A" LINE

"B" LINE,S" OVERBREAK

① HEADING

③

②

BENCH

ELEVATION

21'-2"

19'-2"

17'-5"

19'-1"

12'-8"
Construction Methodology

MINIMUM DRIFT SEPARATION
1.5 TUNNEL DIAMETERS (64"

CENTER DRIFT

BENCH MAY FOLLOW AS REQUIRED
MINIMUM BENCH LENGTH 50'

PLAN

DIRECTION OF MINING
Support Schemes – Class A

Tunnel excavation is expected to be a minimum of line "A" with no rock protruding inside line "A". "B" line defines outer extent of expected overbreak.

ROCK BOLT

UPPER BUSHING DIA.

PROFILE DIA.

WATER INFLATION HOLE

INFLATION BUSHING DIA.

LENGTH AS SPECIFIED

12'-0" LONG SWELLEX TYPE ROCK BOLTS, MIN. 11'-6" EMBEDMENT

"A" LINE

"B" LINE, 9" OVERBREAK

PGL

CLASS A SUPPORT
Support Schemes - ‘SEM’ Toolbox

- Mine straps
- Rolled “U” channels
- Welded wire fabric
- Additional Shotcrete
- Resin bonded rock bolts
- Split set rock dowels
- Polymer fiber shotcrete
- Grouted rock bolts
- Lattice girders
Support Schemes – ‘SEM’ Toolbox

RESIN GROUTED ROCK BOLT

LENGTH AS REQUIRED
TAPERED END
SLOTTED STEEL TUBE
BEARING PLATE
WELDED RING FLANGE

"FAST-SET" RESIN GROUT

#8 ALL-THREAD BAR, SUPPLIED IN 30'-0" LENGTHS AND CUT TO SIZE AS REQUIRED

"SLOW-SET" RESIN GROUT

SPHERICAL SEAT HEX NUT

SPLIT SET DOWEL
Support Schemes - ‘SEM’ Toolbox

20’ Long x 1” Dia. Rebar Spiles, Fully Resin Bonded

Lattice Girder

12’

Excavation Line

10° to 15° Inclination

Spiling Section

Spiling Elevation

"B" Line, 9" Overbreak

"A" Line 120° Min.

Fully Resin Bonded Rebar Spiles, Spacing 18"

Springline
Support Schemes – ‘SEM’ Toolbox

LATTICE GIRDER CROSS-SECTION

"B" LINE, 9" OVERBREAK

"A" LINE

DETAIL - LATTICE GIRDER
Project Status - Geologic Hazards

- **Karst features**
  - Portal cuts: limestone solutioned near surface
  - Tunnel depth: no significant features

- **Geologic discontinuities**
  - Sub-vertical joints observed (dolomite), widely spaced
  - Discontinuous at shale
Project Status - Geologic Hazards

- Groundwater inflow
  - Few instances < 0.5 gpm, very dry tunnel

- Swelling/slaking shale
  - Effectively mitigated by flashcrete (contract requirement)

- High horizontal rock stresses
  - No observed evidence
Project Status

- Northbound Tunnel: X,XXX ft / 1,680 ft
- Southbound Tunnel: X,XXX ft / 1,680 ft
- Bench removal and hole through at North Portal (i.e., the tie-in) remaining
Project Status
Project Status
Questions