Geotechnical Challenges on the Manchester Bridge Design-Build Project

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KC Geotechnical Seminar
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  - MoDOT
- John Szturo, PG
  - PM and Chief Engineering Geologist, HNTB
Project Description

- Planned improvements to I-70/US 40 Highway
- Address both existing and future traffic needs
- Project involves construction of 3 new bridges
- I-70 will be widened at 2 bridges
- Design included bridge foundations, retaining walls, embankment evaluations (slope stability and settlement)
Project Location
Proposed Highway Improvements

- I-70 EB over Blue River
- I-70 WB over Blue River
- US 40 Highway over Blue River
- I-70 EB and WB Widening over US 40 Highway
Highway Improvements continued

- I-70 EB and WB over Blue River
  - 18 Bents, 16 interior and 2 abutments
- Anticipated pile foundations at abutments
- Anticipated pile foundations at 14 bents with drilled shafts at bents on either side of Blue River
General Project Geology

- Residual clay overlying shale
- Most of Site
  - Pleasanton Shale
- East End of Site, Bents 16-18
  - Middle Creek Formation
  - Sniabar Limestone
  - Pleasanton Shale
Anticipated Design Challenges

- Railroad Crossings
- Areas of Environmental Concern
- Blue River
- Limited Right-of-Way and Headroom
- Known Utilities
Railroads

- I-70 crosses over 6 rail lines
- Rail lines are owned by 4 entities
  - Chicago Rock Island and Pacific
  - Kansas City Terminal
  - Kansas City Southern
  - Union Pacific
Railroads
Environmental History

- Early 1920’s - National Lumber and Creosote Company begins wood treating operations.
  - Railroad ties, posts, and telephone poles.
- 1937 – Koppers Company, Inc. purchases site.
  - Continued creosote wood treating operations.
- Late 1950’s / Early 1960’s – Koppers begins using Pentachlorophenol (PCP) in treatment operations.
- Late 1960’s PCP use in treatment is stopped.
- Late 1987 / Early 1988 Koppers closes the facility.
- Late 1988 Beazer Materials and Services purchases site.
  - 1990 – Beazer changed name to Beazer East, Inc.
Environmental History, Continued

- September 1990—Demo of site began and was completed February 1991.
- From closure until the present various interim measures have been implemented to cleanup the site.
Environmental Concerns on Site

**Creosote**
- EPA Classified as Group B1 Probable Human Carcinogen
- Polycyclic Aromatic Hydrocarbons (PAHs)
  - Phenol
  - Cresols
- Harmful effects to
  - Skin
  - Eyes
  - Nervous System
  - Lungs
  - Kidneys

**Pentachlorophenol (PCP)**
- EPA classified as Group B2 Probable Human Carcinogen
  - Hodgkin's Disease
  - Soft Tissue Sarcoma
  - Acute Leukemia
- Chronic Effects
  - Inflamed respiratory tract and bronchitis
  - Kidney and Liver
  - Blood effects like aplastic anemia
  - Immunological effects
  - Irritation of eyes, nose, and skin
Blue River
Right-of-Way
Site and Subsurface Investigation

- Site reconnaissance
- Boring information
  - MoDOT borings in 1950’s
  - As-Built foundation information
  - MoDOT proposal phase borings
  - Project phase borings (30)
- Laboratory testing
Site Reconnaissance – I-70 EB and WB
Existing Subsurface Information
Rock Core Photos & Logging
Rock Core Photos & Logging
Laboratory Testing

**Rock Strength (All Tests)**

<table>
<thead>
<tr>
<th>Elevation, ft</th>
<th>Qu, psi</th>
<th>q, (psi)</th>
<th>q, (ksf)</th>
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<tbody>
<tr>
<td>Mean, x-bar</td>
<td>1066.0</td>
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<td>153.51044</td>
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<tr>
<td>Std, s</td>
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<tr>
<td>COV s/(x-bar)</td>
<td>139%</td>
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<td></td>
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</tbody>
</table>

**Sta 276+14**

- N2 (A-12-25)
- S2 (A-12-26)
- N4 (A-12-24)
- S4 (A-12-23)
- N5 (A-12-27)
- S5 (A-12-28)
- S6 (O-12-53)
- S7 (A-12-30)
- S15 (O-12-54)
- S17 (A-12-29)
- B-1
- B-2
- B-3
- B-4
- B-11
- B-12
- B-13
- B-14
- B-15
- B-16
- B-17
- B-18
- B-19
- B-20
- B-21
- B-28
- B-29
- B-30
- B-31
- B-32
- B-33
- B-34
- B-35
- B-36
- B-37
- B-38
Laboratory Testing

Rock Strength (Bents 5-8)

Stratum 1 (Elevation 700-665 excluding locations where q_u > 100 between el 672 and 665)

<table>
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<tr>
<th></th>
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<th>q_u (psi)</th>
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<td>Std. s</td>
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Stratum 2 (Elevation 672-652)

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<th>q_u (psi)</th>
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<td>1237</td>
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<td>Std. s</td>
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Laboratory Testing

Rock Strength (Bents 15-18)

- S15 (O-12-54)
- S17 (A-12-29)
- B-11
- B-12
- B-13
- B-14
- B-15
- B-16
- B-28
- B-29
- B-30
- B-31
- B-32
- B-33
- B-34
Site & Subsurface Conditions
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Site & Subsurface Conditions
Foundation Type Evaluation

- Drilled Shafts
- Driven Piles
- Shallow Foundations
Design Factors – I-70 Viaduct

- Bents 1-4
  - Piles at West Abutment
  - Piles at Interior Bents 2-4
  - Hydraulics indicate deeper scour than anticipated at Bents 2-4.
  - Pile foundations still viable since scour is above the top of the pile foundation - no need to switch to drilled shafts
  - \( Q_u \) results indicate piles will drive deeper than anticipated
Design Factors – I-70 Viaduct

- **Bents 5**
  - Original planned for pile foundation
  - Changed to drilled shafts due to scour

- **Bents 6 and 7**
  - Drilled shafts at bents on either side of Blue River due to scour

- **Bent 8**
  - Originally planned for pile foundation
  - Drilled shafts at bent due to proximity to sewer line and 54” water line

- **Bents 5, 6, 7, 8**
  - Hydraulics indicate deeper scour than anticipated
  - Laboratory Data of Rock $Q_u$ Results Required Longer Shafts than anticipated
Design Factors – I-70 Viaduct

- Bents 9-14
  - MDNR worried that piles and shafts will provide a medium for contamination to be introduced into the water table
  - Ground “improvement” to prevent migration of contamination
  - A soil mixing operation was selected to allow piles to be driven through ground prior to set-up

- Bent 15
  - Piles proposed
  - Rapidly dropping top of rock
Design Factors

- Bents 16 through 18
  - Shallow foundations proposed
  - Shallow foundations no longer viable based on voids in rock seen in rock cores
  - Utilities at Bents 16 and 17 prohibit use of pile foundations
  - Drilled shafts designed for Bents 16 and 17
  - Pile supported abutment designed at Bent 18
Construction – Pile Driving
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Construction – Drilled Shafts
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Construction Challenges
Construction Challenges

- Additional Utility Protection at Bent 8
  - Construction Delay to Sleeve Water Line
- Delays with equipment within Beazer area
- Unknown Utility Found at Bent 14
  - Design Change from Piles to Drilled Shafts
  - Get buy-in from MDNR
  - Delays with removing temporary casing
Construction - Soil Mixing
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Construction-Bent 14
Construction-Bent 14
Construction-Bent 14
Construction Status

- **I-70 EB over Blue River**
  - Opened to Traffic March 2015

- **I-70 WB over Blue River**
  - Foundation Construction Completed
  - Estimated Opening Date – Spring 2015

- **US 40 Highway over Blue River**
  - Opened to Traffic April 2015

- **I-70 EB and WB Widening over US 40 Highway**
  - Completed in December 2014
Summary and Conclusions

- Quantity of piles within 11% of anticipated
- Drilled shafts constructed to design depths. Permanent casing within 8% of design.
- Construction of drilled shafts at Bent 14 only significant delay for foundation construction
- Design-Build allowed for quick decisions
Texting & Driving
QUESTIONS