Roadway and Bridge Design and Construction Practices Used to Mitigate the Presence of Mine Voids

G. A. Chappell, Sr., A. L. Wentz, & J. R. Barclay
WVDOT-DOH
Overview

• How to recognize previous mining activity
• Potential issues with deep mine works
• Mine voids under bridge support structures (Guyandotte R. Bridge)
• Mine voids under fills (Coalfields Expressway)
• Mine voids under roads (Fairmont Conn.)
Figure 2. Overview of Abandoned Underground Mine Lands in Western Maryland and the Surrounding Region.
MODES OF SUBSIDENCE

Trough Subsidence From Coal Pillars Punching Into Underclay
Trough Subsidence From Crushing Of Remaining Pillars
Sinkhole Subsidence From Mine Roof Collapse

Modified From Bruhn, Et Al, 1978
STRATA MOVEMENT

Subsidence Trough

Tension

Compression Zone

Tension

Surface

Rock Strata

Coal Seam

Mined Out

Modified after Mining Subsidence Engineering, 1983
GUYANDOTTE RIVER BRIDGE
LOGAN COUNTY, WV
Background

• Design started in the 1990’s. The geotech report noted an “ancient” landslide where the proposed abutment 1 was located. The abutment was moved back thereby lengthening the bridge.

• The geotech report did not perform a coal mining related background study of the area of the project.

• The project was shelved due to funding related issues until 2012. A review was performed in 2012 and the design was brought up to recent code. No additional investigation relative to mining was performed.

• The project was advertized and the contract awarded. As part of a Value Engineering proposal the contractor wanted to shorten the bridge and evaluate the past mining.
Background (cont.)

• The contractor’s consultant identified past mining in the Eagle coal seam below Pier No. 1 and Abutment 1. The elevation of the coal seam was thought to be at approximately 610’; however, borings advanced to that elevation only revealed thin seams that could not be the Eagle. The mine mapping for this particular mine did not have any elevations associated with it; only seam thickness which indicated that the coal was between 3 to 4 feet thick.

• Mines to the east and west of the subject mine were identified in the Eagle seam. The associated mine maps did have elevations noted within the adjacent mines. The WVDOH geotech unit constructed a structural contour map for each of these adjacent mines and then interpolated to determine the elevation of the subject mine.
Background (cont.)

• Based on this structural contouring we hypothesized that the seam was at an elevation of 565’ + 15’.
• Additional borings intersected the mine between 555’ to 575’. Out of 5 borings, 4 intersected mine voids and 1 intersected coal between 42 inches thick.
Approximate Bridge Location
Additional Coal Probe Test Boring

Note: Abutment 1 Coal Probe Borings should be located 85' behind Abutment 1 with one on CL and the others 30' left and right of CL. The Pier 1 Coal Probe Borings should be spaced 65' behind the Pier with a boring 30' left and right of CL.
<table>
<thead>
<tr>
<th>ELEV. (ft)</th>
<th>DEPTH (ft)</th>
<th>DESCRIPTION OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Untidy SAND ORNITE, medium to coarse grained, with some interbedded carbonaceous bands. Hard LAYER. CONTINUED DESCRIPTION. REPEATED</td>
</tr>
<tr>
<td>165.0</td>
<td>175.0</td>
<td>Void:</td>
</tr>
<tr>
<td>165.0</td>
<td>175.0</td>
<td>Untidy SHALE WITH METAMORPHIC FEATURES, soft to average</td>
</tr>
<tr>
<td>167.0</td>
<td>175.0</td>
<td></td>
</tr>
<tr>
<td>167.0</td>
<td>175.0</td>
<td></td>
</tr>
</tbody>
</table>

**Sampling Method**: Shelby Tube, Auger, Split Spoon, Bag, Rock Core, Troshes

**Water Level Observations**: Immediate: NW, After: 15.0 ft, After 24 Hrs: 15.0 ft, After 48 Hrs: 15.0 ft
<table>
<thead>
<tr>
<th>ELEV (ft)</th>
<th>DEPTH (ft)</th>
<th>DESCRIPTION OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>145.5</td>
<td>155.5</td>
<td>Grey SANDSTONE; medium to coarse grained, with few interbedded carbonaceous inclusions, moderately hard (LAYER CONTINUES)</td>
</tr>
<tr>
<td>145.5</td>
<td>155.5</td>
<td>Grey SLAGSTONE; medium to coarse grained, with few interbedded carbonaceous inclusions, moderately hard (LAYER CONTINUES)</td>
</tr>
<tr>
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<td>155.5</td>
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</tr>
</tbody>
</table>

**Driller:** TEAM 11

**Sampling Method:** | 
| | Shelby Tube |
| | Anger |
| | Agge |
| | Walkway |
| | Core |

**Water Level Observations:**

<table>
<thead>
<tr>
<th>Method</th>
<th>深度 (ft)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### Final Log

#### BORING

**CP-3**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH</th>
<th>DESCRIPTION OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>140.0</td>
<td>5.0 ft</td>
<td>Gray Siltstone, medium to coarse grained, with few interbedded carbonaceous lenticles, micaceous, hard</td>
</tr>
<tr>
<td>144.5</td>
<td>5.0 ft</td>
<td>Gray Shale, weathered, with interbedded carbonaceous lenticles, soft to average</td>
</tr>
<tr>
<td>150.0</td>
<td>5.0 ft</td>
<td>Gray Shale with some carbonaceous lenticles, average to hard</td>
</tr>
</tbody>
</table>

**Sampling Method**
- Shelby Tube

**Water Level Observations**
- At Completion: 140.0 ft
- After 24 hrs: 120.0 ft
- Water used in drilling: NA
- No water

**Driver**
- TRIAD
### Final Log BORING CP-4

**Project Name:** Opequona Bridge Additional Drilling  
**Boring Location:** Station 063+65  
**Offset 30° 0' 0" CL:** Drilled on Land  
**Date Started:** 05/01/2013  
**District:** D-2  
**Date Completed:** 06/26/2013  
**County:** Logan  
**Elevation (ft):** 660.745  
**Horn Installed:**  
**Lat. and Long.:**  
**Engr. by:** HCP

#### DESCRIPTION OF MATERIALS

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH</th>
<th>TYPE</th>
<th>INT. DEPTH</th>
<th>RLN. DEPTH</th>
<th>SPN. OF</th>
<th>TORS.</th>
<th>SAMP.</th>
<th>SAMPLE</th>
<th>ADDITIONAL NOTES</th>
<th>W %</th>
<th>L %</th>
<th>R %</th>
</tr>
</thead>
<tbody>
<tr>
<td>104.2</td>
<td>114.3</td>
<td>Gray SANDSTONE, medium to coarse grained, with interbedded carbonaceous inclusions, micaceous, hard (LAYER CONTINUED DESCRIPTION REPEATED)</td>
<td>10.0 ft</td>
<td>10.0 ft</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>115.1</td>
<td>116.5</td>
<td>Voids:</td>
<td>114.5</td>
<td>114.5</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120.0</td>
<td>122.6</td>
<td>Gray SANDSTONE, medium to coarse grained, with interbedded carbonaceous inclusions, siltoidic and carbonaceous inclusions, average</td>
<td>10.0 ft</td>
<td>10.0 ft</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125.0</td>
<td>126.6</td>
<td>Gray SLATE:</td>
<td>102.3</td>
<td>102.3</td>
<td>60%</td>
<td>60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>130.0</td>
<td>136.0</td>
<td>Gray SANDSTONE, medium to coarse grained, with interbedded carbonaceous inclusions, micaceous, hard</td>
<td>10.0 ft</td>
<td>10.0 ft</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>135.0</td>
<td>136.0</td>
<td>BORING COMPLETED AT 136.0 ft</td>
<td>10.0 ft</td>
<td>10.0 ft</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sampling Method:**  
- Shelby Tube  
- Split Spoon  
- Bag  
- Rock Core  
- Tricone

**Water Level Observations:**  
- Immediate: 25.0 ft  
- After 34 Hrs: 50.0 ft  
- Water used in drilling: NA ft
<table>
<thead>
<tr>
<th>ELEV. (ft)</th>
<th>DEPTH (ft)</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>SAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>100.0</td>
<td>broken and weathered (70.5 - 70.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grey SANDSTONE, medium to coarse grained, with some interbedded carbonate nodules, micaceous</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80.0</td>
<td>80.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60.0</td>
<td>60.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.0</td>
<td>40.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SAMPLING METHOD**
- Shelby Tube
- Auger
- Split Spoon
- Bag
- Rock Core
- Incision

**WATER LEVEL OBSERVATIONS**
- Immediate: 10 ft
- At Completion: 4.2 ft
- After: 24 Hrs: 6 ft
- Water used in drilling: N/A
- DF = DRAINED: N/A = NO WATER
Mine Grouting Plan
COALFIELDS EXPRESSWAY
WYOMING COUNTY, WV
Beckley Coal

Approximate Mainline Alignment

Approximate Connector Alignment

Beckley Seam Underground Mining

Beckley Seam Surface Mining
Approximate Mainline Alignment

Approximate Connector Alignment

Pocahontas No. 9 Structural Contour (1880')

Pocahontas No. 9 Coal
Approximate Mainline Alignment

Approximate Connector Alignment

Pocahontas No. 6 Upper Split 1 Structural Contour (1760')

Pocahontas No. 6 Upper Split 1 Coal
Pocahontas No. 3 Seam
Underground Mining

Approximate Mainline Alignment

Visible Open Mine Portals

Approximate Connector Alignment

Pocahontas No. 3 Structural Contour (1560’)

Pocahontas No. 3 Coal
Multiple Mine Entries In the Pocahontas No. 6
Collapsed Mine Entry Into the Pocahontas No. 6
Collapsed Mine Entry Into the Pocahontas No. 6
Collapsed Mine Entry Into the Pocahontas No. 6
Open Entry Into the Pocahontas No. 3

11/18/2010
Collapsed Entry Into the Pocahontas No. 7
Close Up of Entry Into the Pocahontas No. 7

Mr. Wentz Investigates ...... Again
Another Collapsed Entry Into the Pocahontas No. 7

And Again ......
Another Collapsed Entry Into the Pocahontas No. 7

..... And Yet Again
DEP Installed Wet Seal and Animal Guard into the Pocahontas No. 7

Mr. Wentz Posing For GQ Magazine ..... Geologists Quarterly
12" Ø PVC PIPE ANIMAL GUARD CROSS SECTION, TYP.

SCALE: 1" = 1 FT.

8" Ø PVC PIPE ANIMAL GUARD CROSS SECTION, TYP.

SCALE: 1" = 1 FT.

NOTE:
1. Animal Guards shall be installed the same day as the pipe is installed.
EXTENDED WET MINE SEAL

(W IEP)

PROFILE VIEW, TYP.

SCALE: 1" = 6 ft

PORTAL DRAINAGE BENEATH EMBANKMENT
FAIRMONT CONNECTOR INTERCHANGE WITH I-79 MARION COUNTY, WV
Aerial View (2003)
Property Prior to Construction Of The Fairmont Connector
Property Prior to Construction Of The Fairmont Connector
Pittsburgh Coal Seam Exposed
During construction, old rooms were exposed and the pillars removed.
**Typical Section - Coal Below Subgrade**

**Details For Treatment Of Coal Below Subgrade**

Notes:
1. Maximum Depth for Excavation is 2 Feet Below Subgrade
2. Backfill with Select Embankment
3. Top 6' Shell Be Granular Material
4. Outlet Drainage As Directed By The Engineer (Use Pipe Underdrain if Needed)
Details For Treatment Of Voids Below Grade

Note:

Exploratory drilling may be required by the Contractor to locate void areas. The Engineer shall determine the area to be drilled and the type of drilling required. Normal exploratory depth is 10 feet below subgrade. The recommended treatment is undercut to the bottom of the void and backfill the void area with Select Embankment (S.E.) to the top of the void and from the top of the void to the subgrade with Random Fill material. Excavation shall be paid as per item 207-01, Unclassified Excavation. Exploratory drilling shall be paid for per linear foot of drilling, Item 628004-00, Exploratory Drilling and Sampling.
Details For Treatment Of Mine Void Above Grade

1. Slopes and bench widths above and below mine voids as per cross section.
UNDERDRAIN PIPE LONGITUDINAL VIEW, TYP.

SCALE: 1" = 1 FT.

UNDERDRAIN PIPE CROSS SECTION, TYP.

SCALE: 1" = 1 FT.

DETAIL XX
UNDERDRAIN PIPE DETAILS, TYP.

SCALE: AS NOTED

DO NOT PLACE FABRIC ON SLEEP SIDE OF SUBSURFACE DRAIN

DIRECTION OF SEEP

DIRECTION OF SEEP

DIRECTION OF SEEP

PIPE LEVELING 1" TO 6" NON-CALCAREOUS STONE

4.0 FT.
MIN.

4.0 FT.
MAX.

4.0 FT.
MIN.

4.0 FT.
MAX.

1" MIN.

12" # SCHEDULE PVC REINFORCED PIPE

1" SCHEDULE PVC TYP.

STANDARD ADJACENT ROWS

1.0 FT.
MIN.

1.0 FT.
MAX.

NON-WOVEN FABRIC AS SPECIFIED IN SECTION 715.10.4 OF THE IWSH STANDARD SPECIFICATIONS FOR "ROADS AND BRIDGES" ADOPTED 2000

NOTES:
1. THE FABRIC SHALL BE OVERLAPPED 1.0 FOOT, MINIMUM, AT ALL JOINTS.
**Detail XX**

**Seep Collector Pipe Details, Typ.**

Scale: AS NOTED

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**Notes:**

1. Size No. 2 (AASHTO No. 1) non-calcareous stone shall meet the gradation requirements in Table 203.4 of the AASHTO specifications for roads and bridges.

2. The filter fabric shall be overlapped 1.0 foot, minimum, at all joints.

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**Scale:** 1" = 1 FT.
QUESTIONS????
Thank You from the In-house Geotechnical Unit