EVALUATION AND REMEDIATION OF AN ABANDONED MINING SITE

by: Richard E. Mabry, P.E.
Yongli Min, P.E.
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LEGEND:

- **Test Boring Location**
- **Test Boring Location Drilled During the Preliminary Investigation in July 2002**
- **Geophysics Survey Line**

NOTE: BASE DRAWING PROVIDED BY R.F. BIELINSKI, AS; P.E., OF SCRANTON, PENNSYLVANIA

SCALE IN FEET

0 100' 200' 300'
EVALUATION AND REMEDIATION OF AN ABANDONED MINING SITE

Typical Cross-section of Electrical Resistivity Survey
Table 1  Summary of Deep Mining Conditions

<table>
<thead>
<tr>
<th>Vein No.</th>
<th>Lowest Mining Elevation, ft.</th>
<th>Unmined Width, ft.</th>
<th>Vein Thickness, ft.</th>
<th>Mining Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>732 (223 m)</td>
<td>110 – 150 (33.5–45.7 m)</td>
<td>5.0 – 9.0 (1.5–2.7 m)</td>
<td>First mined with extraction ratio of 0.65; north flank partially robbed, south flank mostly robbed</td>
</tr>
<tr>
<td>10 ½</td>
<td>533 (162.5 m)</td>
<td>130 – 180 (39.6–4.9 m)</td>
<td>5.0 – 6.0 (1.5–1.8 m)</td>
<td>First mined with extraction ratio of 0.65 - 0.70, North flank robbed, South flank robbed below El. 780 +/- ft</td>
</tr>
<tr>
<td>9 ½</td>
<td>530 (161.6 m)</td>
<td>650 +/- (198 m)</td>
<td>3.0 – 5.0 (0.9–1.5 m)</td>
<td>First mined with extraction ratio of 0.65; North flank robbed, south flank partially robbed</td>
</tr>
<tr>
<td>9</td>
<td>330 (100.6 m)</td>
<td>700 – 900 (213–274 m)</td>
<td>5.0 – 6.0 (1.5–1.8 m)</td>
<td>First mined with extraction ratio of 0.65; North flank mostly robbed, south flank partially robbed</td>
</tr>
<tr>
<td>8</td>
<td>530 (161.6 m)</td>
<td>900+ (274 m)</td>
<td>5.0 – 7.0 (1.5–2.1 m)</td>
<td>First mined with extraction ratio of 0.65, partially robbed</td>
</tr>
</tbody>
</table>
EVALUATION AND REMEDIATION OF AN ABANDONED MINING SITE

Engineering Considerations

- Mine Subsidence
- Site Development
- Foundation System
Mine Subsidence Evaluation

- Credible Mechanisms
- Critical Conditions
- Ground Response
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From Bruhn, et al. (1978)
Pillar Crushing

\[ P_p = \frac{P_u - \mu}{C(1-R)} \]

- After Mining
- Present Condition
- Post Construction
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Pillar Strength

\[ P_p = P_c \left[ 0.64 + 0.36 \left( \frac{w}{h} \right) \right] \]

\[ P_c = \frac{k}{(H_c)^{\frac{1}{2}}} \]
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Table 2. Summary of Vein No. 11 Pillar Analyses

<table>
<thead>
<tr>
<th>Location</th>
<th>Est. Vein Elevation</th>
<th>Pillar Width (ft)</th>
<th>Vein Height (ft)</th>
<th>After Mining</th>
<th>Present Condition</th>
<th>Post Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northwest Addition</strong></td>
<td>915 (279)</td>
<td>7 (2.1)</td>
<td>6.5 (2.0)</td>
<td>2.5</td>
<td>2.6</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>915 (279)</td>
<td>5 (1.5)</td>
<td>6.5 (2.0)</td>
<td>2.2</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>822 (251)</td>
<td>7 (2.1)</td>
<td>6.5 (2.0)</td>
<td>1.54</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>North Central Building Addition</strong></td>
<td>904 (276)</td>
<td>5 (1.5)</td>
<td>6.5 (2.0)</td>
<td>2.3</td>
<td>2.4</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>813 (248)</td>
<td>5 (1.5)</td>
<td>9 (2.7)</td>
<td>1.33</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>982 (299)</td>
<td>10 (3.0)</td>
<td>7 (2.1)</td>
<td>5.9</td>
<td>5.9</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>910 (277)</td>
<td>10 (3.0)</td>
<td>7 (2.1)</td>
<td>3.0</td>
<td>3.1</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Northeast Addition - East Half</strong></td>
<td>978 (298)</td>
<td>14 (4.3)</td>
<td>6 (1.8)</td>
<td>7.2</td>
<td>7.2</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>836 (255)</td>
<td>10 (3.0)</td>
<td>6 (1.8)</td>
<td>2.3</td>
<td>2.6</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>978 (298)</td>
<td>12 (3.6)</td>
<td>6 (1.8)</td>
<td>6.7</td>
<td>6.7</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>838 (255)</td>
<td>12 (3.6)</td>
<td>6 (1.8)</td>
<td>2.5</td>
<td>2.9</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>820 (250)</td>
<td>7 (2.1)</td>
<td>6 (1.8)</td>
<td>1.7</td>
<td>2.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Other Mechanisms

- Pillar Punching
- Roof Collapse
- Mine Caving
- Pot Holes
- Time Effects
Cap Rock Index

\[ I_c = \sum L_i (1 + RQD_i) \]
Other Mechanisms

- Pillar Punching
- Roof Collapse
- Mine Caving
- Pot Holes
- Time Effects
Mine Subsidence Potential
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Fig. 2.1 Subsidence at various width/depth ratios of extraction.
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Figure 9 Subsidence Contour
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Figure 3: Prediction of the maximum subsidence factor (longwall case studies)
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Design and Construction

Design Considerations

• Refrigeration plant and office wing over “bootleg” mining area

• Deep loose fill in the Vein No. 12 area within the building
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Recommendations:
1. Continuous footings/Mats designed to span potential loss of support, or
2. Move the structures 30 feet north
No. 12 Vein Area:

Loose fill up to 50 feet in thickness presented a risk of differential settlement under the slabs and columns.
Recommendations:

1. Compact the existing fill using DDC.
2. Create transition zones under the slab at soil/rock interfaces
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U.S. Standard Sieve Size

Zone 1

Zone 2

Zone 3

Grouping of Soils for Dynamic Compaction
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1. Soil Type

2. Acceptance Criteria
   - Minimum energy
   - Minimum SPT improvement based on settlement analysis: N > 20 bpf within 25 feet of the subgrade

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**SPT N-Value (bpf)**

- Elevation (ft)
  - Finished Floor El: 1,032 ft

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*Graph showing SPT N-Value (bpf) vs. Elevation (ft) before Deep Dynamic Compaction treatment.*
DDC Criteria:

- $N > 20$ bpf within 25 feet of below the slab
- To be confirmed by test borings at every 7,500 SF per test boring
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DDC Construction:

- 16 to 20-ton tampers dropping 65 to 80 ft on 13 by 13 feet grid points
- Two passes
- Ironing passes using 11 to 17-ton tampers dropping 25 ft
SPT Values Before and After DDC Treatment
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Project Statistics

- Total Earthwork Duration: Over 4 months
- Total Volume of Earthwork: 1 Million CY
- Max. Cut: 60 feet
- Max. Fill: 50 feet
- DDC Area: 140,000 SF
- Total Duration of DDC: 5 weeks
- Building Construction: April 2005
- 500 jobs for the local area