Stabilisation/Solidification of Manufactured Gas Plant Wastes: Selected Case Histories – Part 3

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Williams Environmental Services, Inc.
A Compass Environmental, Inc. Company
Deep Soil Mixing (DSM) has been practiced for many years, primarily in the geotechnical and deep foundations arenas.

In the late 1980s and early 1990s, DSM crossed over into the environmental arena.

Since that time, DSM has gained wide acceptance in the environmental remediation market, and in particular, the MGP sector.

To date, approximately 46 sites have been remediated via DSM, of which Williams has completed 9.
Remediation Phases:

- Bench-scale treatability testing
- Pilot-scale (field) testing
- Full-scale implementation
Following the treatability study and a successful pilot study, full-scale implementation of DSM may commence.

- DSM is becoming a remediation technology of choice because:
  - It reduces the amount of soils hauled off-site, which saves disposal fees and backfill costs.
  - It reduces odours.
  - Remediation costs are typically lower than other specialty technologies, including thermal desorption and in situ chemical oxidation.
DSM is typically accomplished by single auger mixing techniques. As the auger proceeds to the desired depth, a grout mixture is injected through the blades on the auger to create a solidified column.
Technology Description (continued)

- Crane-Mounted Turn Table or Top Drive Drill Rig
- Reagent Batch Plant
- 4-foot to 12-foot Diameter Auger
Case I

Augusta MGP Site

• The Augusta MGP site operated from 1852 until 1955

• Processed coal, coke, and oil to produce gas for the City of Augusta

• Cooling and purification processes resulted in process residuals (tars, liquors, sludge, and other chemical compounds) that were steadily released into the soil and groundwater
Case I
Augusta MGP Site

- Plant closed in 1955
- Demolition debris buried on site and covered with one foot of fill material
- Until 1984, site used to park vehicles, store equipment, and provide maintenance

Augusta MGP Site - circa 1959
Treatability study performed to determine dosage of additives, including Type I Portland cement, bentonite, lignosulfonate (thinner), and water

Test mixes evaluated for Unconfined Compressive Strength (UCS), permeability (k), durability, and the presence of free liquids

Mix designs developed for each type of soil present at the site: sand, peat, and clay
### Augusta MGP Site Treatability Study

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Sand</th>
<th>Peat</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Density</td>
<td>kg/m³</td>
<td>2000</td>
<td>1525</td>
<td>1926</td>
</tr>
<tr>
<td>Water Content</td>
<td>%</td>
<td>16.7 – 21.4</td>
<td>20.0 – 28.8</td>
<td>18.9 – 30.8</td>
</tr>
<tr>
<td>Portland Cement</td>
<td>%</td>
<td>6.5</td>
<td>15</td>
<td>10.5</td>
</tr>
<tr>
<td>Bentonite</td>
<td>%</td>
<td>0.50</td>
<td>0.25</td>
<td>0.0</td>
</tr>
<tr>
<td>Thinner</td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>Grout Density</td>
<td>kg/m³</td>
<td>1200 - 1240</td>
<td>1410</td>
<td>1260</td>
</tr>
<tr>
<td>Grout Density</td>
<td>sg</td>
<td>1.19 – 1.24</td>
<td>1.41</td>
<td>1.26</td>
</tr>
</tbody>
</table>
Augusta MGP Site
Pilot Study

- Upon completion of the bench-scale testing, the selected mix ratios were verified in the field
- A total of 23 test columns were installed
- Pilot study results indicated that DSM of all types of soils at the site was both technically and economically feasible
Augusta MGP Site
Pilot Study

Example of solidified columns from pilot test
Augusta MGP Site Pilot Study

- Pilot study indicated compliance with the following performance criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS</td>
<td>$\geq 345$ kPa</td>
</tr>
<tr>
<td>Permeability</td>
<td>$\leq 10^{-5}$ cm/s</td>
</tr>
<tr>
<td>Mass Loss</td>
<td>$&lt; 10%$ after 12 cycles of wetting/drying for 24-hour period</td>
</tr>
<tr>
<td>Free Liquids</td>
<td>No free liquids</td>
</tr>
</tbody>
</table>
Augusta MGP Site
Full-Scale

- Full-scale operations performed in two steps
- Unsaturated soils initially excavated to top of the low water table
- DSM proceeded from the top of the low water table to a minimum depth of 1-metre into the underlying saprolite confining layer
## Key Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additives &amp; Dosage</td>
<td>Portland cement, bentonite, and thinner at previously discussed rates</td>
</tr>
<tr>
<td>Curing Time</td>
<td>28 days</td>
</tr>
<tr>
<td>Penetration Rate</td>
<td>0.6 – 1.2 metres per minute during penetration &amp; withdrawal</td>
</tr>
<tr>
<td>Volume Increase</td>
<td>20% (on average)</td>
</tr>
</tbody>
</table>
Augusta MGP Site Results

- Stabilized approximately 42,360 m³ of soils using 1,209 DSM columns 3.7 metres in diameter
- Achieved the following:
  - Average UCS: 857 kPa
  - Average Permeability: $2.1 \times 10^{-7}$ cm/s
  - Average Wet/Dry Durability: < 0.14% mass loss when subjected to 12 cycles of 24-hour saturation and 24-hour drying
Case II
Macon MGP Site

- Former MGP operations conducted on a 1.8-hectare parcel located in a light industrial area of the city
- Maps from 1884 indicated a retort house, coal house, tar tank, tar well, purifier, and two gasometers present on site
Case II
Macon MGP Site

- Additional wells, tanks, and other equipment added up until the height of operations in 1930
- Preliminary site investigations conducted in 1986-87
- Geophysical exploration & test pit excavation used to collect information for further studies
• Treatability study performed to determine dosage of additives, including Type I Portland cement, bentonite, ground granulated blast furnace slag (GGBFS), and water

• Test mixes evaluated for Unconfined Compressive Strength (UCS), permeability (k), durability, and the presence of free liquids

• Based on the results, design mixes specified for demonstration by means of a field pilot study
• Upon completion of the bench-scale testing, the selected mix ratios were verified in the field

• A total of 9 test columns were installed

• Pilot study results indicated that DSM was both technically and economically feasible

• Verified proper design mix → 6.5% of dry weight stabilization reagents to wet weight of material
  - 2.6% Portland cement, 3.9% GGBFS
  - Additional 0.5% bentonite added for sandy soils
### Macon MGP Site Pilot Study

- Pilot study indicated compliance with the following performance criteria

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</thead>
<tbody>
<tr>
<td>UCS</td>
<td>≥ 345 kPa</td>
</tr>
<tr>
<td>Permeability</td>
<td>≤ $10^{-5}$ cm/s</td>
</tr>
<tr>
<td>Mass Loss</td>
<td>&lt; 10% after 12 cycles of wetting/drying for 24-hour period</td>
</tr>
<tr>
<td>Free Liquids</td>
<td>No free liquids</td>
</tr>
</tbody>
</table>
Macon MGP Site Full-Scale

- Full-scale operations performed in two steps
- Unsaturated soils initially excavated to top of the low water table
- DSM proceeded from the top of the low water table to a minimum depth of 0.6 m below the impacted soils and no more than 1.5 m into the underlying saprolite confining layer
## Key Parameters

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Additives &amp; Dosage</td>
<td>Portland cement, bentonite, and GGBFS at previously discussed rates</td>
</tr>
<tr>
<td>Curing Time</td>
<td>28 days</td>
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<tr>
<td>Penetration Rate</td>
<td>0.6 – 1.2 metres per minute during penetration &amp; withdrawal</td>
</tr>
<tr>
<td>Volume Increase</td>
<td>20% (on average)</td>
</tr>
</tbody>
</table>
Macon MGP Site Results

- Stabilized approximately 26,800 m³ of soils using 1,108 DSM columns 3.7 metres in diameter
- Achieved the following:
  - Average UCS: 673 kPa
  - Average Permeability: 3.0 x 10⁻⁷ cm/s
  - Average Wet/Dry Durability: 0.88% average mass loss when subjected to 12 cycles of 24-hour saturation and 24-hour drying
Case III

Columbus MGP Site

- The Columbus MGP site is located in the central business district of Columbus along the Chattahoochee River.
- The 1.6-hectare site operated from the 1850s until 1931.
- Site subsequently demolished and backfilled.
• Treatability study performed to determine dosage of additives, primarily Type I Portland cement

• Test mixes evaluated for Unconfined Compressive Strength (UCS), permeability (k), and PAH content of TCLP extract

• Based on the results, design mixes specified for full-scale implementation
  – 10% by weight addition of Portland cement for stabilization of soils
  – 25% by weight addition of Portland cement for western soil-cement wall
Results of the treatability study were designed to achieve the following DSM performance criteria:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>General Stabilization</th>
<th>Soil/Cement Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS</td>
<td>413 kPa</td>
<td>413 kPa</td>
</tr>
<tr>
<td>Permeability</td>
<td>$10^{-5}$ cm/s</td>
<td>$10^{-6}$ cm/s</td>
</tr>
<tr>
<td>PAH Content</td>
<td>10 mg/L</td>
<td>10 mg/L</td>
</tr>
</tbody>
</table>
Columbus MGP Site
Full-Scale

Full-scale operations performed with 2.4-metre diameter auger

Average water:cement ratio of 1½:1 used across the site
## Key Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additives &amp; Dosage</td>
<td>Portland Type I cement</td>
</tr>
<tr>
<td></td>
<td>10% w/w for monolith</td>
</tr>
<tr>
<td></td>
<td>25% w/w for wall</td>
</tr>
<tr>
<td>Curing Time</td>
<td>28 days</td>
</tr>
<tr>
<td>Penetration Rate</td>
<td>0.3 – 1.2 metres per minute during penetration &amp; withdrawal</td>
</tr>
<tr>
<td>Volume Increase</td>
<td>20% (on average)</td>
</tr>
</tbody>
</table>
Columbus MGP Site
Results

• Stabilized approximately 62,700 m³ of soils using an 2.4-metre diameter auger in less than 20 weeks

• Achieved the following:
  – Average UCS: 575 – 1150 kPa
  – Average Permeability: 10⁻⁷ cm/s
  – Total PAH content: < 10 mg/L TCLP
Georgia Power Company implemented post remediation monitoring to confirm and document the effectiveness of the remedial action.

No statistically significant levels of MGP-related compounds were recorded during a five-year period.
Additionally, in 2003, EPRI in association with Southern Company, Georgia Power, and LSU published a 10-year assessment study of the site\(^{(1)}\)

Results demonstrated “that the present integrity of the solidified mass is in excellent condition” and that there is “no evidence to suggest that the integrity of the stabilized mass would diminish over time”

To date the groundwater “continues to remain clean at the site”

Thank You

Questions