Soil Mixing Design Methods and Construction Techniques for Use in High Organic Soils

GRIP 2013
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Problem Statement

- Organic soils are problematic for roadway construction; typically, the material is replaced, modified, or bridged.

- Insitu soil mixing is one method that can be used to stabilize the material but the low pH necessitates high binder content and promotes unwanted variability in the resulting strength.
Project Overview

- Existing Soil Mixing Methods
- Case Histories with Long-Term Performance
- Various Binder Materials
- Techniques for New and Existing Roadways
- Lab / Field Tests to Evaluate Long Term Performance
- Cost Evaluation
- Guidelines for Soil Mixing
Research Approach

- Task 1 Literature Review
- Task 2 Laboratory Testing
- Task 3 Field Testing and Exploration
- Task 4 Cost Evaluation / Guidelines and Recommendations
- Task 5 Reporting
Research Approach

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1. Reduce fill height
2. Provide waiting period to allow for majority of consolidation to occur
3. Increase surcharge height
4. Use a lightweight fill
5. Install wick drains within the compressible material to be surcharged
6. Excavate soft compressible material and backfill with granular soil
7. Ground modification such as stone columns, dynamic compaction, etc.
8. Deep soil mixing
9. Combinations of some of the above
Wet Soil Mixing
Dry Soil Mixing

Garbin and Mann, 2010
Research Approach

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Organic Laboratory Samples
Organic Laboratory Samples
Laboratory Testing
Organic Soil Properties

- Organic Content = 50-65% (ASTM D 2947-00)
- Moisture Content = 260-300% (ASTM D 2974-00)
- pH = 5.5-7 (ASTM D 4972)
- Resistivity = 5 kΩ-cm (FM 5-551)
- Chloride Content = 590 ppm (FM 5-552)
- Sulfate Content = 35 ppm (FM 5-553)
Soil Mixing Considerations

- Soil Type
- Organic Content
- Moisture Content
  - Dry or Wet Mixing
- Binder Type
  - Cement, Slag, Fly Ash, Etc.
- Binder Content
- pH of the Soil
  - Low pH detrimental to reactivity of cement
- pH Modifiers
  - Soda Ash, pot ash, lye, lime, pearl ash, etc.
- pH Modifier Content
- Mixer Type
- Mixing Energy
Initial Soil Mixing

- 100 – 300 pcy Cement
- Dry & Wet Mixing
- Starting Soil pH Range from 6 to 9
  - Soda Ash
- Moisture Content (265 to 450%)
- 4x8 inch Cylinders
Soil Mixing
Unconfined Compression Testing
Soil Mixing Results

- 350% Moisture Content
- 300 pcy Cement
- 7 day Strength

Dry Mixing Method

Wet Mixing Method
Soil Mixing Results

300 pcy Cement
350% M.C.
7 day Strength

Dry Mixing Method

Wet Mixing Method

300 pcy Cement
350% M.C.
7 day Strength

UC Strength (psi)

Soda Ash (lb/cy)
Dry Mixing - No pH Modification
7 Day Strength – 400% Moisture Content

Graph showing stress (psi) vs. strain (με) for different cement contents: 100 lb/cy of Cement (blue), 200 lb/cy of Cement (red), and 300 lb/cy of Cement (green).
Dry Mixing - pH Modification - Soda Ash 17.2 lb/cy
7 Day Strength - 400% Moisture Content

Strain (µε)

Stress (psi)

- 100 lb/cy of Cement
- 200 lb/cy of Cement
- 300 lb/cy of Cement
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Case Histories

- District 1: SR 33 North of Polk City
- District 2: SR 100 in Putnam County
- District 5: SR 46 in Sanford
- District 6: US-1 Jewfish Creek
- Turnpike: Milepost 284.7 in Lake County
US-1 Jewfish Creek

- Florida Keys 2005
- 18 miles, 40ft Widening, Northbound
- 10-15 ft of Organic Silts
- 40-60% Organic, 85 – 650% m.c.
- Dry Soil Mixing
  - 200-300 pcy (75% slag / 25% cement)
<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Interval, ft</th>
<th>Samples N-COUNT</th>
<th>Sample Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>0.0’ - 0.3’ Asphalt (3.25”)</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>0.3’ - 2.0’ DENSE brown silty fine SAND with some limerock (fill), A-1-b</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>2.0’ - 4.0’ DENSE brown silty fine SAND with some limerock and reclaimed asphalt (RAP) (fill), A-1-b</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>4.0’ - 6.0’ VERY DENSE brown silty fine SAND with some limerock (fill), A-1-b</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>6.0’ - 7.5’ MEDIUM DENSE brown silty fine SAND with some limerock (fill), A-1-b</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>7.5’ - 8.0’ Concrete with silt</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>8.0’ - 9.0’ LOOSE brown silty fine SAND with traces of limerock (fill), A-2-4</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>9.0’ - 10.0’ VERY SOFT brown to dark gray calcareous sandy organic SILT, A-7-5/A-8.</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>10.0’ - 12.0’ VERY SOFT brown to dark gray calcareous sandy organic SILT, A-7-5/A-8.</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>10.0’ - 12.0’ : org=12.0%; fines=93.0%; w=74.0 to 103.0%; LL=53, PI=17</td>
</tr>
<tr>
<td>11</td>
<td>WH/18”</td>
<td></td>
<td>12.0’ - 14.0’ VERY SOFT brown to dark gray calcareous sandy organic SILT, A-7-5/A-8.</td>
</tr>
<tr>
<td>12</td>
<td>WH/24”</td>
<td></td>
<td>12.0’ - 14.0’ : org=7.0%; w=42.0%.</td>
</tr>
<tr>
<td>13</td>
<td>WH/24”</td>
<td></td>
<td>14.0’ - 16.0’ VERY SOFT brown to dark gray calcareous sandy organic SILT, A-7-5/A-8.</td>
</tr>
<tr>
<td>14</td>
<td>WH/24”</td>
<td></td>
<td>14.0’ - 16.0’ : org=7.0%; fines=77.0%; w=60.0 to 65.0%.</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>17’ limestone</td>
</tr>
<tr>
<td>16-18</td>
<td></td>
<td></td>
<td>14.5’ - 16.0’ Tan to brown porous sandy LIMESTONE and calcareous fine SAND</td>
</tr>
</tbody>
</table>
US-1 Jewfish Creek 2009 Borings

CB-1 STA 1302+00

CB-2 STA 1335+00

CB-3A STA 1445+85

CB-3 STA 1446+01

Soil Mix
US 1 Jewfish Creek Survey

- Station 1325 to 1350
- 2009 & 2010 Surveys
  - Parsons Brinckerhoff
  - Southbound Shoulder
- May 2013
  - USF
  - Northbound Shoulder
- July 2013
  - North & Southbound Shoulders
State Road 33 Polk City

- 1000ft roadway through Green Swamp
- 70 years of Settlement
- 2006 Boring at the Lowest Section
  - 43 inches of asphalt
  - 5 – 6ft of Sand & 72ft of organic material (competent bottom not found)
2011 Project
Dry Soil Mixing
- 400pcy cement
Silty-Organics
Survey Taxiway
- January 2013
- March 2013
Macro Island Airport Dry Soil Mixing
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Guidelines for Soil Mixing

- Soil Type?
- Organic Content?
- Soil Strength?
- pH?
- Moisture Content?
- Δ Stress?
- Depth of Formation?
- ???

Acceptable Methods!
Future Work

- Soil Mixing
  - Vary Mixing Energy / Type
  - Vary Binder Type (Fly Ash, Slag, etc.)
  - Lower pH Soil
  - pH Modifiers
  - Time Dependency
  - Larger Scale Mixing

- Guidelines
- Long-term Performance Monitoring
- Cost Evaluations