Soil Modification Mix Design

An Overview of Sample Acquisition and Laboratory Testing

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Alt & Witzig Engineering
Soil Modification Mix Design

- Typical questions:
  - Who does this work?
  - What about sampling?
  - What laboratory tests will be conducted?
  - What will the design tell me?

- How long will it take?
Most often the specialty contractor would include the mix design portion of the project in their costs. Most times they will contact the consultant.

<table>
<thead>
<tr>
<th>Soil Modification Mix Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who does the mix design?</td>
</tr>
<tr>
<td>- An INDOT approved Geotechnical Laboratory</td>
</tr>
<tr>
<td>- Ask INDOT Geotechnical or visit their website</td>
</tr>
<tr>
<td>- Ask the specialty contractor</td>
</tr>
</tbody>
</table>
Typically 2-3 samples are collected. Larger jobs may have many samples over the length of the project. Collect 50-75 pounds per sample. Label with contract number, station & offset. Close or cover sample so that “as received” moisture content can be determined.
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Soil Modification Mix Design

- What laboratory tests will be conducted?
  - Grain size Analysis
    - Hydrometers and Sieves
  - Atterberg Limits
  - pH, Soluble Sulfates, Moisture Content
  - Moisture-Density Relationship (Proctor)
  - In some cases: LOI, Marl, Eades & Grim
<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Total Qualification</th>
<th>HI</th>
<th>PI</th>
<th>PI1</th>
<th>LU</th>
<th>I</th>
<th>U</th>
<th>O1</th>
<th>O2</th>
<th>Occasional Joints</th>
<th>Anomalous Joints</th>
<th>%</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300</td>
<td>A+ (O) SILT LOAM</td>
<td>88.6</td>
<td>82.4</td>
<td>59.2</td>
<td>11.2</td>
<td>36.6</td>
<td>86.0</td>
<td>2.3</td>
<td>5.8</td>
<td>23</td>
<td>22</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>1310</td>
<td>A+ (O) SILT LOAM</td>
<td>100.0</td>
<td>98.0</td>
<td>72.0</td>
<td>0.0</td>
<td>24.8</td>
<td>72.4</td>
<td>2.9</td>
<td>9.9</td>
<td>26</td>
<td>20</td>
<td>6</td>
<td>2.4</td>
</tr>
<tr>
<td>134 Lime C</td>
<td>A+ (O) SILT LOAM</td>
<td>95.0</td>
<td>92.0</td>
<td>88.7</td>
<td>0.0</td>
<td>2.0</td>
<td>75.0</td>
<td>10.2</td>
<td>5.4</td>
<td>30</td>
<td>21</td>
<td>9</td>
<td>4.75</td>
</tr>
<tr>
<td>135 Lime C</td>
<td>A+ (O) SILT LOAM</td>
<td>94.0</td>
<td>92.0</td>
<td>78.9</td>
<td>0.2</td>
<td>15.0</td>
<td>71.6</td>
<td>3.3</td>
<td>4.6</td>
<td>27</td>
<td>20</td>
<td>7</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Chemical Modification Summary**

- Project Name: I-90
- Location: Indiana - Greene County
- NOTE: NT = Not Tested

DES #: INDOT Contract # I-90-32720

*All S. Willig Engineering, Inc.*

4105 West 60th St.
Carmel, IN 46032
Telephone: 317-875-7000
Fax: 317-876-3700
Soil Modification Mix Design

- Soil Classification Completed
  - Time to add the chemicals!
    - Lime product, Cement, or both?
  - Chemical selection depends on soil type
  - Moderately to Highly Plastic (A-7-6) (A-6)
    - Lime By-Product (LKD) or Quicklime (rare)
  - Low to Moderate Plasticity (A-6) (A-4)
    - Lime and/or Cement
  - Granular (A-4) (A-2-4) (A-1-a)
    - Cement
Comment on the shift in MDD and OMC
Soil Modification Mix Design

- Soil-Chemical MDD and OMC determined
  - Create strength specimens or “pills”
    - Compact mixture at ~95% MDD of T-99 effort
    - Mixture at OMC to +2%
  - Cure the specimens in plastic baggies in cure room at 100% humidity and ~73°F for 48 hrs
  - After cure, test in unconfined compression
  - Compare the average strength of two soil-chemical pills to an untreated soil pill to determine the “gain”

Mention that we also test “natural” pills
## Soil Modification Mix Design

<table>
<thead>
<tr>
<th>Specimen ID</th>
<th>PLID</th>
<th>Specimen Description</th>
<th>Strength Specimen Data</th>
<th>Minimum M.C. @ time of Composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LL</td>
<td>PL</td>
</tr>
<tr>
<td>S1061</td>
<td>1</td>
<td>Cement</td>
<td>104.0</td>
<td>17.6</td>
</tr>
<tr>
<td>S1064</td>
<td>1</td>
<td>Lime 1</td>
<td>98.2</td>
<td>17.6</td>
</tr>
<tr>
<td>S1064</td>
<td>1</td>
<td>Lime 2</td>
<td>98.6</td>
<td>17.7</td>
</tr>
<tr>
<td>S1064</td>
<td>1</td>
<td>Natural</td>
<td>98.0</td>
<td>17.9</td>
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<tr>
<td>S1120</td>
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<td>Cement</td>
<td>102.4</td>
<td>17.4</td>
</tr>
<tr>
<td>S1120</td>
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<td>Lime 1</td>
<td>97.7</td>
<td>17.8</td>
</tr>
<tr>
<td>S1120</td>
<td>1</td>
<td>Lime 2</td>
<td>98.6</td>
<td>17.9</td>
</tr>
<tr>
<td>S1120</td>
<td>1</td>
<td>Natural</td>
<td>104.8</td>
<td>17.4</td>
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Soil Modification Mix Design

- Current Strength Gain Requirements
  - Lime based chemicals
    - 50 psi
  - Cement
    - 100 psi
Soil Modification Mix Design

- **Report Recommendations**
  - If only one chemical meets the strength gain requirement, then that chemical is recommended.
  - If both chemicals are found to meet the requirements...
    - We generally lean toward lime (cost)
    - However, other non-laboratory parameters may dictate cement
  - If neither pass then it is likely that...
    - High plasticity, sugar sand, organics, waste materials
    - More testing would be required
Soil Modification Mix Design

- From the project we have been referencing:

  - "Recommendations
  - 
  - We recommend 4% Portland Cement by dry weight be used for the soils at these locations. Chemically treated soils must be at or above the OMC as determined by the soil-chemical mixture. The soils-cement mixture should be at a minimum optimum moisture content of 17%."
Soil Modification Mix Design

- **Moisture-Water-H₂O**
  - Minimum moisture content prior to compaction
    - OMC to +2%
    - We must not leave the soil-chemical mixture thirsty!
  - Compacting soil-chemical mixture below OMC
    - Higher air voids
    - Incomplete chemical reaction
    - Potential for catastrophic subgrade failures
Soil Modification Mix Design

- Other Considerations
  - The laboratory testing is limited to the laboratory!
  - Consider all aspects of the project
    - Foundation Soils - are they stable?
      - Largest majority of subgrade modification "failures" are due to weak foundation soils
      - Must be treated before attempting subgrade modification
    - When will the work take place?
    - What worked on the previous section?
Soil Modification Mix Design

- **How long will it take?**
  - Typical projects can be completed in 2-3 weeks
  - Larger projects with more samples or troublesome soils will take longer
  - Our lab completes over 100 studies a year
  - Get the samples as early as possible!
    - Technically, the results need to be in the hands of the INDOT Engineer 5 days prior to field operations
Soil Modification Mix Design

- In Summary
  - Steps to initiate the mix design
  - Sampling locations & number
  - Laboratory testing requirements
  - Recommendations of the report
  - Time frame for the study

- Thank you, hold the questions please!