Strengthening of Pavement Subgrade Soil Using Biofuel Co-products

Objectives

- To investigate the strength improvements of Iowa soils treated with two different biofuel co-products (BCPs) containing lignin for pavement geo-materials stabilization
- Two types of BCPs investigated in this study are
  - A liquid type with higher lignin content (co-product A)
  - A powder type with lower lignin content (co-product B)

Motivations

- Sulfur-free lignin has been more available as a co-product of the increasing biofuel or ethanol productions
- As a renewable and economic resource, lignin has been given more attention to use in highway geomaterials stabilization

Experimental Materials

- **Soil: Iowa loess**
  - **Classification**
    - AASHTO (group index) A-4(2)
    - USCS group symbol CL-ML
    - USCS group name Sandy Silty with clay
  - **Grain size distribution**
    - Gravel (> 4.75 mm), % 0.1
    - Sand (0.075–4.75 mm), % 37.2
    - Silt and clay (< 0.075mm), % 62.7
  - **Atterberg limits**
    - Plasticity index (PI), % 22.9
    - Plasticity index (PI), % 6.2
  - **Standard Proctor test**
    - Optimum moisture content (OMC), % 18.2
    - Maximum dry unit weight (Gd,max), kg/m^2/(pcf) 1,631 (101.8)
  - **Additives**

Experimental Plan

- **Sample categorization:** (1) untreated soil samples (control), (2) soil samples treated with the BCP A, (3) soil samples treated with the BCP B
- **Sample geometry:** 2 in. diameter by 2 in. height.
- **Additive content:** 12% by dry soil weight for treated sample and no additive for untreated sample
- **Moisture content:** OMC-4%, OMC and OMC+4%
- **Curing period:** 1-day, 7-day, 28-day air dry curing (wrap is required to avoid moisture loss)
- **Sample repetition:** three (in total 81 samples)

Unconfined Compressive Strength (UCS) Test Results

**Compressive strength results under OMC-4 (wc=14.2%):**

<table>
<thead>
<tr>
<th>Compressive Stress (psi)</th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses</td>
<td>30</td>
<td>21</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Losses+12% Co-Product A</td>
<td>44</td>
<td>38</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Losses+12% Co-Product B</td>
<td>59</td>
<td>50</td>
<td>84</td>
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</tr>
</tbody>
</table>

**Compressive strength results under OMC (wc=18.2%):**

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<th>80</th>
<th>100</th>
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</thead>
<tbody>
<tr>
<td>Losses</td>
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<td>16</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Losses+12% Co-Product A</td>
<td>44</td>
<td>38</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>50</td>
<td>40</td>
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</tbody>
</table>

**Compressive strength results under OMC+4 (wc=22.2%):**

<table>
<thead>
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<th>Compressive Stress (psi)</th>
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Preliminary Findings

- Both BCPs can improve soil strength of Iowa loess soil
- BCP A performs better under short term curing condition but BCP B performs better under long term curing condition
- Higher moisture content in soils reduces strength capacity of all sample tested