Turning Mud to Gravel
USE OF FIBER AND CHEMICAL STABILIZATION IN ALASKA
ACKNOWLEDGEMENTS

- **Funding**
  - US DOT RITA
  - Alaska DOT&PF
  - Peak Oil Industries

- **Materials Supplied by**
  - Dirt Glue
  - Midwest Industries
  - Soil Works

- **Students**
  - MS Student Rodney Collins
  - Undergraduates
    - James Collier

- **Previous PI:**
  - Kenan Harzirbaba

- **Current PI:**
  - Billy Connor
The Problem: Gravel is scarce in Western Alaska. Import Costs: $200 -$600/CY
The cost of a 4,000 foot gravel runway: More than $30 million
Our goal: Reduce that cost by $5 million
The Solution: Find a way to use local materials
Current Construction Method

- Embank the best available material and let drain for 2 to 3 years
- Cap with 6 inches of imported crushed gravel.
Types of Soils Encountered in Western Alaska

- Sands
- Silts
- Clays
- Organic Clays
Borrowing From the Past, We Tried Straw in Bricks.
Along with Synthetic Fluids

- Earth Armour Limited – Arctic
- Severely Hydrotreated Paraffinic Liquid
- Designed to allow soil compaction to \(-10^\circ C\)
Background-Cape Simpson

After improvement
Soil Tested

- Sieve Analysis of soil
- Bethel material has
  - more silt
  - finer grains of sand
First Step: Optimum Fiber Content

Optimum Fiber Content

CBR value vs. Percent Fiber for each depth of penetration at 11% MC

- 0.100
- 0.200
- 0.300
- 0.400
- 0.500

CBR value [% fiber]

Fiber Content [% of dry soil unit weight]
Step 2: Effect of Synthetic Fluid

CBR values vs. Depth of Penetration for soil at 11% total liquid content
Geofiber + Synthetic Fluid

CBR values vs. Depth of Penetration for soil at 11% total liquid content with and without 0.5% fiber content

- 0 / 11 / 0
- 0 / 11 / 0.500
- 5 / 6 / 0.500

CBR values vs. Depth of Penetration [in.]

Depth of Penetration [in.]: 0.100, 0.200, 0.300, 0.400, 0.500

CBR values: 0, 20, 40, 60, 80, 100, 120
Aging Effect

CBR vs. Depth of Penetration for aged samples with fiber

- 0/11/0 - not aged
- 0/11/0.500 - aged
- 5/6/0.500 - aged

Depth of Penetration [in.]

CBR value
UU Triaxial Test

- Results from 0/11/0 combination (Soil at OMC)

\[ \phi = 41.8^\circ \]
\[ c = 2.9 \text{ psi} \]
UU Triaxial Test

- Results from 5/6/0.5 combination

![Graph showing strain vs. stress with different curves for σ3=2.6psi, σ3=10.0psi, and σ3=5.0psi.](image)

- $\phi = 53.6^\circ$
- $c = 11.2 \text{ psi}$
## UU Triaxial Results

<table>
<thead>
<tr>
<th>Synthetic Fluid Content, %</th>
<th>Water Content, %</th>
<th>Geofiber Content, %</th>
<th>Friction Angle, degrees</th>
<th>Cohesion, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>11</td>
<td>-</td>
<td>41.8</td>
<td>2.9</td>
</tr>
<tr>
<td>-</td>
<td>11</td>
<td>0.5</td>
<td>43.7</td>
<td>23.5</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>0.5</td>
<td>48.5</td>
<td>13.9</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>0.5</td>
<td>53.6</td>
<td>11.2</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>0.5</td>
<td>55.6</td>
<td>4.9</td>
</tr>
</tbody>
</table>
UU Triaxial Failure Modes

Distinct failure plane

Compacted/unimproved sample

No distinct failure plane—bulging out

Compacted/geofiber-reinforced sample
Conclusions for Bethel Sand

- Optimum Geofiber Content = 0.5%

- Adding 0.5% geofiber to soil at OMC increased CBR from 31 to 62 (by this 100% improvement, the soil is now like well graded gravel or sandy gravel!!)

- Synthetic fluid requires some original soil moisture; hard to work with pure synthetic fluid and no water. In-situ water content may be sufficient (~6% for Bethel silty sand)
Conclusions

- Optimum combination = 5/6/0.5 (total liquid content = 11%)
- Compaction effort is significant. Increasing compaction effort from non-standard low (> Standard Proctor) to Modified Proctor yielded 50% higher CBR values.
- Aging samples by ~10 days appeared to result in significant improvement in CBR values as much as 340% (CBR went from 36 to 124 for the 5/6/0.5 combination)
- UU Triaxial tests confirmed the results obtained from CBR testing and provided further understanding of the soil behavior (i.e., strength components, failure mode)
From the Lab to the Field

- Designed a Road Near Wasilla using 6 and 12 inches of 5% fiber stabilized with 4% Soil
Horseshoe Lake Construction Sequence
Lessons Learned

- Probably Not Necessary to use Fluid in Bottom Layer
- Need Rubber Tire Compaction Equipment
- Best to Seal Surface Against Tire Abrasion

After one Year
DOT Asks to Stabilize Kwigillingok

- Material: Organic Silts and Clays @ 50% moisture
- Fiber didn’t stabilize.
- Traditional cement stabilizers failed.
- We found ourselves looking for something totally new.
We Knew About Dirtglue and PolyCure but Would Polycure Work with Anything Else?
First Attempts With Chemical Stabilizers
Test Specimen Preparation

- Optimum Moisture
- 4% liquid chemical added
- 7 day cure at room temperature
- 4 inch diameter, 6 inch height
- Modified Proctor
Typical Unconfined Compression Test Results
The Question is No Longer How Strong Can We Make the Soil, but How Strong to We Need to Make it.
Next Steps

- Complete tests on additional soils types
  - Silts (underway)
  - Clays (waiting for samples)
- Additional Testing
  - Vary Liquid Content
  - Resilient Modulus
  - Indirect Tension Testing
- Maximize Benefit/Cost
- Field Tests
  - Looking for partner willing to build a test section
Cost is about $300/ton

Still determining the most cost effective formula.
Chemical And Fiber Stabilizers do Have a Future. The Challenge is Reducing Costs Down to $100/ton.
Contact Billy Connor
bgconnor@alaska.edu
907-474-5552