High Density Polyurethane for Soil Stabilization and Pavement Preservation

Mark Hurley
Project Manager
Why is it important?

Pavement Preservation is Cost Effective

- Spending $1 on pavement preservation before this point...
  - ...eliminates or delays spending $6 to $14 on rehabilitation or reconstruction here.

<table>
<thead>
<tr>
<th>Pavement Condition</th>
<th>Time (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>0</td>
</tr>
<tr>
<td>Good</td>
<td>5</td>
</tr>
<tr>
<td>Fair</td>
<td>75% of Life</td>
</tr>
<tr>
<td>Poor</td>
<td>12% of Life</td>
</tr>
<tr>
<td>Very Poor</td>
<td>20</td>
</tr>
</tbody>
</table>

40% Drop In Quality

75% of Life

12% of Life
How is Soil Stabilization Part of Pavement Preservation?

Extend the Life of Pavements by increasing the Load Bearing Capacity of Foundation Soils.

A process for stabilizing weak and/or poorly compacted foundation soils **IN SITU** by injecting High Density Polyurethane directly into the foundation soils.
“Many concrete distresses are a result of poor support conditions.”

Source:
American Concrete Pavement Association, 1998
*Technical Information: Concrete Pavement Engineering and Research*,
*Page 1, paragraph 2*
“Pavement with a substantial subbase will not likely be problematic...weak underlying support (little to no subbase and soft subgrade that is often saturated) can produce marginal stability”

Source:
Chapter 3, Program Project 04-01 Processing Pavement Stability, Airfield Asphalt Pavement Technology, by Mark Buncher, PhD, PE, Asphalt Inst.
History of High Density Polyurethane Grouting

1975: Invented in Finland to stabilize buildings.

1979: High Density Polyurethane grouting was introduced from Finland

2001: Soil Stabilization for Roadways was established
High Density Polymer for Pavement Stabilization
Deep Injection Process

- Method for increasing the load bearing capacity of soil using a two-part hydro-insensitive chemical grout

- Purpose
  - Strengthen Foundation Soils without Digging
  - Utilized on Ridged, Flexible, and Composite Roadways and Runways.
  - Strengthening Weakened Infrastructure and Buildings
## Polyurethane - Composition

<table>
<thead>
<tr>
<th>Composition</th>
<th>Resin &amp; Hardener</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing Ratio</td>
<td>1 : 1</td>
</tr>
<tr>
<td>Chemical Reaction</td>
<td>Exothermic chemical reaction generates $CO_2$ gas and heat</td>
</tr>
<tr>
<td>Polyurethane interacting with INSITU soils creates a stronger matrix.</td>
<td></td>
</tr>
<tr>
<td>Reaction</td>
<td>Fast</td>
</tr>
<tr>
<td>Adjustable – varying formulations and injection methods</td>
<td></td>
</tr>
<tr>
<td>Controlled Reaction</td>
<td></td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>Environmentally benign material</td>
</tr>
</tbody>
</table>
### 486 STAR Polymer - Characteristics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rapid Cure</strong></td>
<td>Reaches <strong>90% of strength in 30 minutes</strong>; full strength after 24 hours</td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>Rigid Structural Polyurethane created as material hardens</td>
</tr>
<tr>
<td></td>
<td><strong>Compressive Strength, Tensile Strength directly proportional to Density</strong></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>Spread is limited due to speed of reaction</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td><strong>Lightweight</strong>: 4 to 10 lb/pcf (installed density)</td>
</tr>
<tr>
<td><strong>Water Resistance</strong></td>
<td><strong>Hydro-Insensitive</strong></td>
</tr>
<tr>
<td></td>
<td>Contains water insoluble diluents - can be injected into very wet soils</td>
</tr>
<tr>
<td></td>
<td>Resists water intrusion into the chemical reaction that forms polyurethane</td>
</tr>
</tbody>
</table>
Polymer Characteristics

Soil Box Polymer Stabilization Demonstration

Injection Phase
Polymer Characteristics

One Hour after Injection

Ad-Hoc Geo-Material/Polymer Matrix Compression Test
To pass the NYSDOT Hydro insensitivity test, the Polymer must Maintain 90% Compressive Strength while injecting into water.
Panel Test Results

Hydro-Insensitivity of High Density Polyurethane Grout - Panel Test Data Sheet

Polymer Type & Manufacturer: URETEK 02-40R-V3
Lot # & Date on Component Containers:
  Resin: URETEK 4R (Lot #1309LK) / 10-01-2013
  Component A Isocyanate (Batch# PB9300674) / 09-20-2013

INJECTION PROCEDURE - DRY

- ☑️ 5 lbs. of Material Injected into Box
- ☑️ After 10 minutes, Remove Top Cover
- ☑️ After 30 minutes, Sample the HDP Material

INJECTION PROCEDURE - Wet

- ☑️ Add 15 lbs. of Water into Box
- ☑️ 5 lbs. of Material Injected into Box
- ☑️ After 10 minutes, Remove Top Cover
- ☑️ After 30 minutes, Sample the HDP Material

MATERIAL ANALYSIS

<table>
<thead>
<tr>
<th>Dry Injection Shots</th>
<th>Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (pcf)</td>
<td>5.31</td>
</tr>
<tr>
<td>Sample 1</td>
<td>59</td>
</tr>
<tr>
<td>Sample 2</td>
<td>67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wet Injection Shots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (pcf)</td>
</tr>
<tr>
<td>5.24</td>
</tr>
<tr>
<td>5.03</td>
</tr>
</tbody>
</table>

% Retention of Density

- Sample 1: 98.7%
- Sample 2: 96.0%

Technician: Richard L. Boudreau
Date: 2-Oct-13
Requirements for a Successful Project

• Having appropriate Polymer for Highway work.

• Gather Soils Reports, Construction Drawings, and Visit Site to compile information to create a repair plan.

• Have Experienced Technicians with Robust DCP unit to test subgrade soils to minus 30 feet, so they can adjust injection plan when on site if necessary.
Working a Project

- Examine the conditions on site
  - Presence of water
  - Has the problem worsened
  - DCP tests

- Quality Control
  - Pre-injection Elevation Readings
  - Monitoring for “bump” with Laser Levels
  - Post-injection Elevation Readings

It is very important to have experienced technicians on the injection guns.
Common Uses for High Density Polyurethane
Fault Joint Repair

Faulted Joints

Realigned Joints

Before

After
Mainline Concrete pavement: I-78 Easton, PA 2013

- 3000 joints
- $625 per joint
- Included stabilization of sub-grade
- Included 24-month unconditional warranty
- Saved considerable amount of time and money vs. full depth repair/patching
Will Increase Load Transfer Efficiency & decrease deflections

- Penn Dot I-80 Composite

<table>
<thead>
<tr>
<th>Joint#</th>
<th>Pre-LTE</th>
<th>Post LTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80.08</td>
<td>83.01</td>
</tr>
<tr>
<td>2</td>
<td>78.01</td>
<td>79.10</td>
</tr>
<tr>
<td>3</td>
<td>69.99</td>
<td>79.09</td>
</tr>
<tr>
<td>4</td>
<td>12.12</td>
<td>61.10</td>
</tr>
<tr>
<td>5</td>
<td>04.04</td>
<td>63.33</td>
</tr>
<tr>
<td>6</td>
<td>05.05</td>
<td>48.40</td>
</tr>
<tr>
<td>7</td>
<td>06.05</td>
<td>75.55</td>
</tr>
</tbody>
</table>
Stabilizing & Lifting Roadways to Grade

Base Dip

Lifted and Void Stabilized

Before - 1993

After - 2008
Faulted Joints – with drainable base

Realigned Joints
Asphalt Roadways

Rutting

Settlement at storm drains
Subsidence and Sinkholes
Culvert Repair

Before

Water flow is underneat h'culvert

After

Water flow is through culvert

Upstream

Culvert Repair
Culvert Repair

Water flow is underneath culvert before.

Water flow is through culvert after.

Downstream
Asphalt Bridge Approaches
Injecting to Increase the Load Bearing Capacity of Foundation Soils
Airfield Pavement Stabilization
Significant 2” dip caused by a disjointed storm drain

**TRADITIONAL REPAIR METHODS**
- **Cost:** $250,000
- **Repair Time:** 30 Days

**URETEK USA REPAIR METHODS**
- **Cost:** $125,000
- **Repair Time:** 10 Days

**Cost Savings:** $125,000
**Time Savings:** 20 Days
Emergency Repair at Dulles Runway 1L/19R
Benefits of using High Density Polyurethane

✓ No excavation

✓ Fixes the underlying issue versus just the symptom

✓ Time/cost savings
Benefits of using High Density Polyurethane

- Small Energy Footprint
- Environmentally Friendly
- Eligible for Liquid Fuels Funds
- Increases the Compressive, Tensile, and Shear Strength of Foundation Soils Without Digging
Thank You!