Developing Affordable GTR Asphalt Mixes for Local Roadways

Munir D. Nazzal, Ph.D., P.E.
Sang Soo Kim, Ph.D., P.E.
Ala Abbas, Ph.D.

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Background

- Ground tire rubber (GTR) has been incorporated in asphalt mixtures to:
  - Enhance the pavement performance
  - Reduce environmental impact of pavements

GTR Mixtures Produced Using The Wet Process
Background

- ODOT has Supplement Specification 887 specifications for GTR asphalt binders and mixtures.

- Although the use of GTR may be beneficial for pavement quality and the environment, the GTR asphalt mixtures were not extensively used in Ohio.

- GTR has been used on approximately 33 local roads and 3 state highways since 2005.
Objectives

- Evaluate the long-term field performance of GTR
- Compare the life-cycle cost of GTR to traditional asphalt mixtures.
- Examine recent GTR technologies and assess their potential in reducing the initial cost of mixtures.
- Develop draft GTR mix design specifications to be used for local roads.
- Provide recommendations regarding QC/QA criteria for testing and acceptance of GTR mixtures.
All available information for GTR projects constructed in Ohio were collected. The collected information included:

- Pavement information (e.g. layers thickness & traffic)
- GTR asphalt mixtures information & properties
- Problems encountered during construction
- Pavement condition data
- Dates and costs of maintenance/repair activities

The collected data were analyzed.
Previous GTR Sections: Findings

- All GTR mixtures previously used in Ohio were produced using GTR binder from Seneca.
- After 10 years of service, GTR modified pavement sections had good performance.
- The use of GTR binder in place of a polymer modified PG 76-22M binder resulted in increasing the mixtures price by 10-15%:
  - Additional cost encountered by asphalt contractor when using a binder purchased from an asphalt supplier
  - Using GTR binders had resulted in increasing the required asphalt binder content by 0.2-0.5%.
GTR Technologies To Reduce Cost

A multi-stage procedure was pursued to select the GTR technologies that can reduce the cost and yet can be used to produce a PG 70-22 binder with similar performance to that of a polymer modified binder.

- Identify new GTR technologies
- Compare Prices of GTR technologies
- Evaluate Selected GTR Binders
- Evaluate Selected GTR Mixtures
- Select Cheapest two GTR
- Select Cheapest GTR binder meeting PG-70-22
# Price Comparison (Per Ton)

<table>
<thead>
<tr>
<th>Asphalt Product</th>
<th>PG 70-22</th>
<th>PG 76-22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seneca Petroleum-GTR asphalt</td>
<td>$660</td>
<td>$660</td>
</tr>
<tr>
<td>Wright-GTR asphalt</td>
<td>$675.00</td>
<td>$675.00</td>
</tr>
<tr>
<td>Quantum Polymer -GTR</td>
<td>$628.20</td>
<td>$642.70</td>
</tr>
<tr>
<td>Lehigh -GTR</td>
<td>$582.05</td>
<td>$582.05</td>
</tr>
<tr>
<td>Liberty –GTR</td>
<td>$561.6</td>
<td>$561.6</td>
</tr>
<tr>
<td>ODOT Price Index</td>
<td>$665.00</td>
<td>$695.80</td>
</tr>
<tr>
<td>SBS-Polymer modified Binder</td>
<td>$629.70</td>
<td>$652.00</td>
</tr>
</tbody>
</table>

*Price were estimated based on ODOT asphalt binder price index for Oct. 2014*
Continuous High Temperature Grade

PG 64-22 +10%Lehigh GTR  PG 64-22 +10%Liberty GTR
PG 64-22 +7%Lehigh GTR+ 0.5%Rheopave (Suspension aid additive)

![Bar chart showing temperature grading over 50 minutes and 24 hours for different asphalt types.](image)

- GTR Liberty
- GTR Lehigh
- GTR Lehigh+Rheopave

High Temperature Grading, °C

- 65
- 70
- 75
- 80
- 85

- 50 min
- 24 hours
Continuous Low Temperature Grade

50 min

24 hours

Low Temperature Grading, °C

GTR Liberty  GTR Lehigh  GTR Lehigh+Rheopave
Cigar Tube Test Results

<table>
<thead>
<tr>
<th></th>
<th>Softening Point °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOP</td>
</tr>
<tr>
<td>GTR Liberty</td>
<td></td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td></td>
</tr>
<tr>
<td>GTR Lehigh+Rheopave</td>
<td></td>
</tr>
</tbody>
</table>

- **TOP**
- **BOTTOM**
Mixture included:

- 47% limestone #8
- 16% natural sand
- 17% limestone sand
- 20% RAP
Mixtures Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>70-22M</th>
<th>GTR Liberty*</th>
<th>GTR Lehigh*</th>
<th>GTR Lehigh+ Rheopave*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design air Void (%)</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Total Asphalt Binder Content (%)</td>
<td>6.1</td>
<td>6.3</td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td>Virgin Asphalt Binder Content (%)</td>
<td>5.1</td>
<td>5.3</td>
<td>5.2</td>
<td>5.2</td>
</tr>
</tbody>
</table>

*PG 64-22 +10%Liberty GTR  
PG 64-22 +10%Lehigh GTR  
PG 64-22 +7%Lehigh GTR + 0.5%Rheopave
Lab Mixtures Testing

Conduct Laboratory Testing

- Low Temp Cracking: ACCD
- Fatigue Cracking: IDT
- Durability: AASHTO T283
- Rutting: APA
Low Temp. Cracking: ACCD Results

<table>
<thead>
<tr>
<th>Material</th>
<th>Cracking Temperature, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-22M</td>
<td></td>
</tr>
<tr>
<td>GTR Liberty</td>
<td>-20</td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td>-25</td>
</tr>
<tr>
<td>Lehigh+Rheopave</td>
<td>-30</td>
</tr>
</tbody>
</table>

STA | LTA
Fatigue Cracking: IDT Results

![Bar chart showing ITS (psi) results for different materials under dry and wet conditions.](chart.png)

- **PG 70-22M**
- **GTR Liberty**
- **GTR Lehigh**
- **GTR Lehigh+Rheopave**

### ITS (psi)
- DRY
- WET

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OHIO UNIVERSITY
Durability: AASHTO-T283 Results

- PG 70-22M
- GTR Liberty
- GTR Lehigh
- GTR Lehigh+Rheopave
Rutting: APA Results

- 70-22M
- GTR Liberty
- GTR Lehigh
- Lehigh+Rheopave

Rut Depth (mm)
Lab Study Findings

- The GTR binders prepared using 10% Liberty GTR, 10% Lehigh GTR, or 7% Lehigh GTR and 0.5% Rheopave were the least expensive.
- The binders prepared using Liberty GTR, and Lehigh GTR had a continuous high PG grade higher than 76 °C and a low temperature PG grade lower than -22 °C.
- Mixtures prepared with Lehigh and Liberty GTR modified binders had better resistance to low temperature cracking than those prepared using PG 70-22 polymer modified binder.
Lab Study Findings

- In terms of rutting, all GTR mixes had lower rutting in the APA test and are expected to have better rutting performance than PG 70-22 polymer mixes.

- GTR mixes had slightly higher indirect tensile strength values than those prepared using PG 70-22M polymer modified binder.

- The results of the modified Lottman test (AASHTO T283) indicate that GTR modified mixes had similar moisture damage resistance to those prepared using polymer modified binder meeting PG 70-22M.
Field Evaluation of GTR Mixes

Four test sections were constructed in Columbus:

- Section 1: SBS polymer modified PG 70-22M mix.
- Section 2: GTR modified binder-Liberty GTR (LI) mix
- Section 3: GTR modified binder-MicroDyne™-400 (LE) mix
- Section 4: GTR modified binder- MicroDyne™-400 GTR and Rheopave (LE-LH) mix

Two test sections were constructed in Akron:

- Section 1: SBS polymer modified PG 70-22M mix.
- Section 2: GTR modified binder- MicroDyne™-400 GTR and Rheopave (LE-LH) mix
Columbus Test Sections
<table>
<thead>
<tr>
<th>Section Name</th>
<th>Direction</th>
<th>Start Station</th>
<th>End Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (SBS Polymer)</td>
<td>West Bound</td>
<td>2+00</td>
<td>30+00</td>
</tr>
<tr>
<td>Lehigh GTR+ Rheopave</td>
<td>East Bound</td>
<td>2+00</td>
<td>30+00</td>
</tr>
</tbody>
</table>
Construction of Sections
COLUMBUS TEST SECTIONS RESULTS
Relative Compaction

![Bar chart showing relative compaction percentages for different treatments: Control (NB), Control (SB), LE-RH (NB), LE-RH (SB), LE (NB), LE (SB), LI (NB), LI (SB).](chart.png)
Three quart samples of the GTR modified asphalt were obtained from the production line at the asphalt plant.

- DSR: high temperature grade
- BBR&ABCD: Low temperature grade

Twelve 6-inch cores were obtained from each test section.
Core Samples Testing

- Low Temp Cracking
  - ACCD

- Fatigue Cracking
  - SCB

- Durability
  - AASHTO T283

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DSR Testing Results

Testing Temperature: 70 °C

Specification: $G^*/\sin \delta \geq 1.0$ kPa
BBR Testing Results

Low Temperature Grade (°C)

<table>
<thead>
<tr>
<th>Material</th>
<th>BBR</th>
<th>ABCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-22M</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GTR LIB</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GTR LEH</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GTR LEH+RH</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Create for Good.
AASHTO 283 Test Results

![Graph showing ITS test results for different samples](image-url)
AASHTO 283 Test Results

<table>
<thead>
<tr>
<th>TSR</th>
<th>70-22M</th>
<th>GTR LIB</th>
<th>GTR LEH</th>
<th>GTR LEH+RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>0.85</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>0.95</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>1</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

The red dashed line represents the standard threshold.
SCB Test Results

Fracture Energy (J/m²)

<table>
<thead>
<tr>
<th>Material</th>
<th>Fracture Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-22M</td>
<td>1900 ± 50</td>
</tr>
<tr>
<td>GTR LIB</td>
<td>2050 ± 70</td>
</tr>
<tr>
<td>GTR LEH</td>
<td>1850 ± 40</td>
</tr>
<tr>
<td>GTR LEH+RH</td>
<td>1950 ± 60</td>
</tr>
</tbody>
</table>
SCB Test Results

![Bar Chart]

- 70-22M
- GTR LIB
- GTR LEH
- GTR LEH+RH

FI

[Graph showing test results for different groups]
Eight Month Field Evaluations

Control

LEH

LEH-RH

LIB
Field Study Preliminary Findings

- All GTR mixtures were produced and compacted in the field without any problems.

- Binders obtained from the production line at the asphalt indicated that all GTR binders met PG70-22 specifications.

- The results of the laboratory tests showed that cores obtained from GTR sections had similar resistance to low-temperature and fatigue cracking as well as to moisture-induced damage as those obtained from the polymer modified PG 70-22M binder.
Thank you!!