Developing Affordable GTR Asphalt Mixes for Local Roadways

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Ala Abbas
Acknowledgement

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Background

- Ground tire rubber (GTR) has been incorporated in asphalt mixtures since the 1960s to
  - Enhance the performance and service life
  - Reduce noise and environmental impact of pavements

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

- Although the use of GTR may be beneficial for pavement quality and the environment, the GTR asphalt mixtures were not extensively used.
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.
Phase I: Overview

- Collect Information on Previously Constructed GTR Projects
- Analyze Data Collected from GTR Projects
- Perform Field Evaluation
- Conduct Life-Cycle Cost Analysis
- Identify and Evaluate New GTR technologies
Collect Information & Analyze Data

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.
Field Evaluation

- Field evaluation was performed on pavement sections in four selected GTR projects.
- Two of the evaluated projects included polymer and GTR modified sections that were constructed for comparison.

<table>
<thead>
<tr>
<th>Project</th>
<th>Constructed</th>
<th>ADTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>King Rd.</td>
<td>2005</td>
<td>142</td>
</tr>
<tr>
<td>Frank Rd.</td>
<td>2007</td>
<td>1241</td>
</tr>
<tr>
<td>US 6</td>
<td>2009</td>
<td>1420</td>
</tr>
<tr>
<td>Smithville Rd.</td>
<td>2012</td>
<td>167</td>
</tr>
</tbody>
</table>
Field Evaluation

- Field evaluation were performed on GTR and polymer modified sections and included
  - Conducting pavement conditioning rating according to ODOT procedure
  - Obtaining 4 inch & 6 inch cores from evaluated sections
Performance Data

<table>
<thead>
<tr>
<th>Years of Service</th>
<th>King Rd</th>
<th>Frank Rd</th>
<th>US 6</th>
<th>Smithville Rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCR</td>
<td>GTR</td>
<td>Polymer</td>
<td>GTR</td>
<td>Polymer</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>2.5</td>
</tr>
</tbody>
</table>

PCR: Percentage of Cure Rate
Life Cycle Cost Analyses

Net Present Value ($1000)

- GTR
- Polymer

King Rd.
US 6
Pervious GTR Sections: Findings

- All GTR asphalt mixtures used in previously constructed GTR sections in Ohio were produced using Seneca company GTR binder.
- In general, all GTR modified mixtures used in previous sections were dense graded surface mixes.
- The percentage of RAP used in the GTR mixtures ranged between 0% and 25%. At least half of the mixtures used in previous GTR sections had only 10% RAP.
Pervious GTR Sections: Findings

- The use of Seneca 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 a supplier
  - Using GTR binders had resulted in increasing the required asphalt binder content by 0.2-0.5% SBS polymer modified binder.
- GTR sections have performed well to date similar to sections with polymer modified mixtures.
Methods to Reduce Cost of GTR

Methods to Reduce Cost

- New GTR Products
- Increase RAP%
- Decrease Pavement Thickness
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 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 (Estimated Contactor cost)</td>
<td>$629.70</td>
<td>$652.00</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>50 min</th>
<th>24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTR Liberty</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>GTR Lehigh+Rheopave</td>
<td></td>
<td>88</td>
</tr>
</tbody>
</table>
Continuous Low Temperature Grade

Low Temperature Grading, °C

-35 -33 -31 -29 -27 -25 -23 -21 -19 -17 -15

50 min

24 hours

GTR Liberty
GTR Lehigh
GTR Lehigh+Rheopave
Cigar Tube Test- Softening Point

<table>
<thead>
<tr>
<th></th>
<th>TOP</th>
<th>BOTTOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTR Liberty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GTR Lehigh+Rheopave</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Softening Point °F

80 90 100 110 120 130 140 150 160
Selected Mixture Gradation

- 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>5.6</td>
<td>5.8</td>
<td>5.7</td>
<td>5.7</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
Mixtures Testing

Conduct Laboratory Testing

- Low Temp Cracking
  - ACCD

- Fatigue Cracking
  - IDT

- Durability
  - AASHTO T283

- Rutting
  - APA
Low Temp. Cracking: ACCD Results

Cracking Temperature, °C

<table>
<thead>
<tr>
<th>Material</th>
<th>70-22M</th>
<th>GTR Liberty</th>
<th>GTR Lehigh</th>
<th>GTR Lehigh+Rheopave</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-22M</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
</tr>
<tr>
<td>GTR Lehigh+Rheopave</td>
<td>-25</td>
<td>-25</td>
<td>-25</td>
<td>-25</td>
</tr>
<tr>
<td></td>
<td>-30</td>
<td>-30</td>
<td>-30</td>
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<tr>
<td></td>
<td>-35</td>
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<tr>
<td></td>
<td>-40</td>
<td>-40</td>
<td>-40</td>
<td>-40</td>
</tr>
</tbody>
</table>

- STA (Stable) - LTA (Low Temperature Ageing)
Fatigue Cracking: IDT Results

![Bar graph showing ITS (psi) for different materials under dry and wet conditions.](image)

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

**Dry:***
- PG 70-22M: Approx. 150 psi
- GTR Liberty: Approx. 160 psi
- GTR Lehigh: Approx. 155 psi
- GTR Lehigh+Rheopave: Approx. 162 psi

**Wet:***
- PG 70-22M: Approx. 120 psi
- GTR Liberty: Approx. 135 psi
- GTR Lehigh: Approx. 130 psi
- GTR Lehigh+Rheopave: Approx. 138 psi
Durability: AASHTO-T283 Results

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

TSR:
- PG 70-22M: 80%
- GTR Liberty: 80%
- GTR Lehigh: 80%
- GTR Lehigh+Rheopave: 100%
Rutting: APA Results

<table>
<thead>
<tr>
<th>Material</th>
<th>Rut Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-22M</td>
<td>5.5</td>
</tr>
<tr>
<td>GTR Liberty</td>
<td>4.2</td>
</tr>
<tr>
<td>GTR Lehigh</td>
<td>4.1</td>
</tr>
<tr>
<td>GTR Lehigh+Rheopave</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Preliminary 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.
Preliminary Findings

- In terms of rutting, all GTR mixes had lower rutting in APA test and is 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 (AASHTO T283) indicated that GTR modified mixes had similar moisture damage resistance to those prepared using polymer modified binder meeting PG 70-22M.
Phase II: Construction and Field Evaluation of the Draft Specification and QC/QA Criteria

- Develop Field Evaluation and Testing Methodology
  - Construction of GTR Pavement Test Section
    - Evaluation of GTR Pavement Test Section
      - Prepare and Submit Final Report
Thank you!!