MTO’s Experience Incorporating Fibres in Hot Mix Asphalt

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Outline

- Why Add Fibres to Hot Mix Asphalt?
- Our History with Fibres
- Current Reinforcing Fibre Trials
- Incorporating Reinforcing Fibres
- Challenges & Benefits
- Performance
- Conclusions
Why Add Fibres to Hot Mix Asphalt?

To control drain down of asphalt cement

To reinforce the pavement against cracking and rutting
Why Add Fibres to Hot Mix Asphalt?

Transportation agencies typically use fibres in Stone Mastic Asphalt (SMA) and open-graded mixes to control draindown.

Use of fibre for reinforcement is not common.

Research results and performance of fibre reinforced Hot Mix Asphalt (HMA) have mixed results.

Fibres have rarely been detrimental, but if they do not improve performance, they may not be cost-effective.

Source: NCHRP Synthesis 475
Our History: Mineral Fibres

- Naturally occurring or manufactured by melting minerals
- Absorptive, but not as much as cellulose fibres
- Use: prevent draindown

- Dosage: 0.4%
- Form: Loose or pellet
- MTO currently allows in SMA
## Our History: Cellulose Fibres

<table>
<thead>
<tr>
<th>Plant-based fibres</th>
<th>Absorbs asphalt cement</th>
<th>Use: prevent draindown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosage: 0.3%</td>
<td>Form: Loose or pellet</td>
<td>Low tensile strength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MTO currently allows in SMA</td>
</tr>
</tbody>
</table>
# Our History: Polyester Fibres

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic polymer fibre</td>
<td>Use: increase strength and stability of mix</td>
</tr>
<tr>
<td>High tensile strength</td>
<td>Dosage: 0.36%</td>
</tr>
<tr>
<td>Requires extra asphalt cement</td>
<td>Length: 6 mm</td>
</tr>
<tr>
<td>Melt Temperature: 250°C</td>
<td>Tensile Strength: 500 MPa</td>
</tr>
<tr>
<td>In 1980’s used on Highway 403 EB in Burlington</td>
<td></td>
</tr>
</tbody>
</table>
## Our History: Polypropylene Fibres

<table>
<thead>
<tr>
<th>Synthetic polymer fibre derived from petroleum</th>
<th>Disperses easily in asphalt cement</th>
<th>Begins to shorten at 150°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistant to acids and salts</td>
<td>Bonds strongly with asphalt cement</td>
<td>Lower melting point requires control of production temperatures</td>
</tr>
<tr>
<td></td>
<td>Requires extra asphalt cement</td>
<td>In 2000’s used polypropylene fibres on Highway 655</td>
</tr>
</tbody>
</table>
Our History: Polyethylene Terephthalate (PET) Fibres

- Synthetic polymer fibre from recycled pop bottles
- Use: increase mix strength
- Dosage: 0.3% (and extra asphalt cement)
- Length: 9.5 to 12.5 mm
- Melt Temperature: 200°C
- In 2000’s used on Highways 655, 427, and 417
# Our History: Aramid Fibres

<table>
<thead>
<tr>
<th>Synthetic polymer fibre</th>
<th>High tensile strength: 3,000 MPa</th>
<th>Use: increase mix strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form: Monofilament</td>
<td>Dosage: 0.0065 to 0.013%</td>
<td>Length: 19 mm</td>
</tr>
<tr>
<td>Melt Temperature: 400 to 450°C</td>
<td>Used on several trials since 2016</td>
<td></td>
</tr>
</tbody>
</table>
Current Reinforcing Fibre Trials

Aramid Fibres
Aramid Fibre Distribution Methods

Blend of polyolefin and aramid fibres

Sasobit coated aramid fibres
Incorporating Reinforcing Fibres

Pre-measured bags (1 bag/tonne)

Manual insertion directly into pugmill

Pneumatic tube

Conveyor
Incorporating Reinforcing Fibres

Loose Fibres

Manual weighing and pneumatic tube

Automated metering system
Challenges

The plant temperature may need to be increased in order to melt the bags or Sasobit wax.

No issues paving or rolling, but harder to rake.

May require some additional cleaning of equipment.
Past Challenges

Polyethylene Terephthalate (PET) fibres used in the 2000’s clumped

Solution was to add the PET fibres more slowly
Advantage or Disadvantage?

Fibres (and more asphalt cement) for more durable stronger mix?

 Increased cost of fibres (and additional asphalt cement to coat fibres)
Potential Benefits

Thus far, we cannot comment on the long term benefits or disadvantages of mixing aramid fibres with HMA.

The reported benefits include:

- Extends life of pavement
- Reduces rutting
- Higher resistance to all crack propagation and growth
Performance: Semi-Circular Bend (SCB)

According to AASHTO TP124

- Test Temperature: 25°C
- Specimen Thickness: 50 mm
- Notch Depth: 15 mm
- Monotonic load of: 50 mm/min

Outcome:
- Flexibility Index (FI)
- Fracture Energy (J/m²)

Testing limited to field cores from one contract

Fibre mixes had more variable results than control mix

Fatigue properties did not improve with addition of fibres
Performance: Disk-Shaped Compact Tension (DCT)

According to ASTM D7313

Test Temperature: 10° C higher than low PG grade

Crack Mouth Opening Displacement (CMOD) Rate: 1mm/min

Outcome:

Fracture Energy (J/m²)

Testing limited to field cores from one contract

DCT results less variable than SCB results for fibre mixes

Very minimal increase in fracture properties noted for fibre mixes
Performance: Hamburg Wheel Tracking

According to AASHTO T324

Samples submerged in water

Test Temperature: 50ºC

Number of cycles: 10,000 cycles

Outcome:

Rut depth vs. # of load cycles

Testing limited to loose mix from one contract

Rutting resistance of fibre mixes were better than the control mix
According to Tex-248-F

# of Cycles: 1000 cycles (1500 or 2000?)

Temperature: 25°C (15°C or 10°C?)

Outcome

# of cycles to failure

Resistance to reflective cracking did not improve with addition of fibres

Testing limited to loose mix from one contract

Lowered test temperature for softer asphalt grade and increased cycles in order to capture a fracture response
Many are performing similarly to the control.

Two started exhibiting reflective cracking within a few months of being placed.

Continued monitoring is required to determine long term benefits.
Performance: Summary

Preliminary Results
- Based on very limited testing, no significant difference in fracture properties found between fibre and control mixes
- Fibre mix test results more variable than control
- Rutting resistance increased with the addition of fibres

Next Steps
- Complete Texas Overlay testing
- Run SCB and DCT on loose mix from the same contract
- Run Cyclic Fatigue and Dynamic Modulus
- Evaluate fibre mix vs control from other contracts
- Monitor field performance vs test results over time
Conclusions

Mixed reviews on initial performance

A delay in propagation of working cracks through fibre reinforced mix is not assured

Review of non-working cracks is inconclusive at this stage

MTO is still in the exploratory phase regarding reinforced fibre mixes
Next Steps

Continue to monitor existing fibre reinforcing trials

Conduct more mix performance testing on fibre reinforced mix vs. control mix

Establish a method to check fibre dosage and distribution during construction
Questions?

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