MTO's Perspective
Positive Impacts & Challenges of Asphalt Cement Modification

Pamela Marks
Head, Bituminous Section

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Outline

- Background
- The Move to PGAC
- Modification and Additives
- Impacts and Challenges
- Future Development
- Conclusions

Background

- Prior to development of SuperPave through the Strategic Highway Research Program (SHRP), Ministry of Transportation, Ontario (MTO) specified that all asphalt cement used meet the Penetration grading system
- MTO's PEN graded system was relatively simple
- No incentive to improve asphalt cement properties with modifiers

Typical Pen Grade Issue - Rutting

Typical Pen Grade Issue - Transverse Cracking

The Move to PGAC

- Performance graded asphalt cement (PGAC) was a product of the Strategic Highway Research Program
- Developed to characterize the performance of asphalt cement (AC) for rutting and thermal cracking of asphalts manufactured at the time
- MTO fully implemented PGAC system in 1998 to replace Penetration graded system
- MTO's move to the PGAC system was consistent with other transportation agencies

PGAC Implementation

- PGAC system was successfully implemented in Ontario
- Some PEN graded AC met PG grading
- Most grades require modification
- It has not eliminated premature pavement cracking
- Many things can lead to premature cracking, but it is widely accepted that current PGAC specifications used across North America do not guarantee long term performance

Spec Requirements and Allowances

- PG system allows use of all technologies and modifiers to meet the grade
- Specification of single and double bump ups for traffic require use of modifiers
- System allows modification of any base binder
- Low bid environment encourages the use of lower cost materials
- Experts agree that while different base asphalts and modifiers can grade the same under PG system:
  - material properties are not necessarily equal
  - pavement performance may be different

Modification and Additives

- Currently used materials and processes include:
  - air blown, catalytically oxidized, or cracked residues
  - polyphosphoric acid (PPA), orthophosphoric acid, alkaline bases
  - ground tires, insoluble particulates or fibres
  - sulphur, salts of iron, copper, manganese and/or cobalt
  - silicates
  - synthetic waxes, vegetable oils
  - recycled engine oil bottoms (REOB), VTAE, tall oils, waste oils
  - rejuvenators, flux
  - polymers, e.g. styrene-butadiene (e.g., SB, SBS, SBR) or epoxy-type (e.g. reactive ethylene terpolymers)
  - warm mix additives, compaction aids

Recycled Engine Oil Bottoms (REOB)

- Produced during recycling of used lube engine oils for re-sale
- Contains olefin polymers, oil and metals
- Softens AC, lowering the low temperature grade
- Can be identified by elements not normally in AC
- Chemical analysis of AC has indicated REOB asphalt modifier in poor performing pavements
- May accelerate oxidation & aging of AC
- ΔTc ↑ for AC with REOB and recycled asphalt cement

Impacts and Challenges

- Knowledgeable Owner
  - What is in the AC?
  - Disclosure
  - MSDS
- Pavement Distresses
- Asphalt Cement Spec's
  - Modifiers
  - New or modified tests
  - Documents vary

Knowledgeable Owner: Impacts

- Disclosure issues; formulations considered proprietary
- AASHTO M320:
  - Asphalt binder shall be prepared by refining of crude petroleum by suitable methods, with or without the addition of modifiers.
  - Modifiers may be any organic material of suitable manufacture that is used in virgin or recycled condition and that is dissolved, dispersed, or reacted in asphalt binder to enhance its performance.
- All non-bituminous material must be identified.
- Texas DOT: Must disclose all additives or modifiers included in the asphalt binder as part of the facility quality plan. Reserve the right to prohibit the use of any asphalt additive or modifier.

Knowledgeable Owner: Impacts

- Most Suppliers providing generic MSDS sheets for all grades produced
- Some provide minimal disclosure: asphalt (bitumen) fume & sulphur
- Not reporting actual additives, say “no knowledge of them being classified as hazardous to health or environment”
- Others provide more comprehensive list, i.e. residues (petroleum), oxidized asphalt, sulphur, styrene-butadiene, copolymers, asphalt extender, warm mix additive, adhesion promoters

Knowledgeable Owner: Challenges

- Safety concerns
- Handling concerns
- Interactions with other products a concern
- Recycling and leaching concerns

Knowledgeable Owner: Challenges

- Asphalt Cement is pre-approved on the Ministry's Designated Sources of Materials list
- If a product changes, it is to be re-submitted for approval
- Asphalt cement supply changes day to day
- Products are seldom re-tested
- Suppliers never ask to have a product re-evaluated
- How much assurance do users of the list have that a product meets requirements?

Pavement Distresses: Impacts

- Asphalt pavements are cracking and deteriorating prematurely across the province, costing taxpayers millions of dollars.
- Link identified between different asphalt formulations (i.e. base asphalt and modifiers) as a primary cause.

Hwy 138 Cornwall to Monkland

Hwy 138 Monkland to Hwy 417

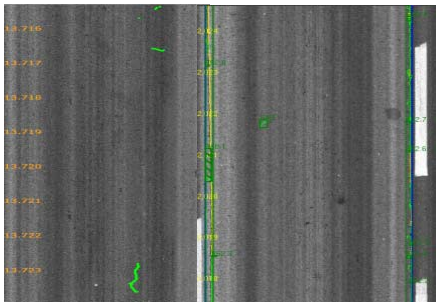
Highway 410 Extension (Ramps) – 6 years old

Highway 6, Stripping and Cracking – 4 years old

Highway 12, Orillia
- 5 years old

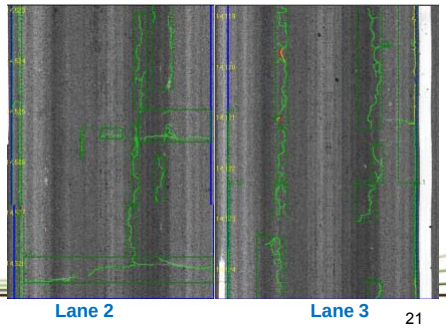
Highway 403, Mississauga
- 6 years old

MTO ARAN Laser Crack Measurement System (LCMS) Image - May 2013



MTO estimates that premature pavement cracking is 100's of millions of $ a yr. problem with overlays achieving only half the service life.

LCMS Image – Nov. 2014



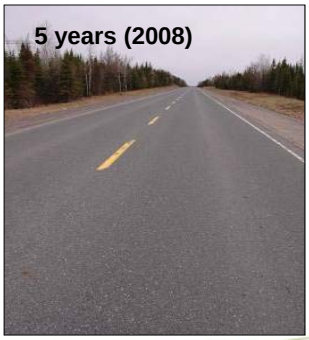
Lane 2 Lane 3

Pavement Distresses: Challenges

- Some pavements show distresses within the first year.
- Pavement performance impacts asset management – significantly reducing the expected life of the pavement.
- Not just cost of removing/replacing the surface course
  - cracks start at the surface and progress down through underlying layers;
  - also need to consider cost of traffic control.

Pavement Distresses: Challenges

- Two lifts over granular
- Performing with No REOB
  - 0% REOB based on XRF and FTIR testing
  - Performing well; largely free of cracking



Pavement Distresses: Challenges

- Two lifts over granular
- Cracking with 9 % REOB
  - 9% REOB based on XRF and FTIR testing
  - Severe alligator cracking since 5 years old

Asphalt Cement Specification: Impact

- Since 2007, MTO has limited modification using polyphosphoric acid:
  - PG 70-28, 70-34 and 64-34 shall not contain more than 0.5% PPA and shall only be used as a catalyst for the purpose of modification with polymers;
  - Other grades shall contain no more than 1.0% PPA; and
  - No orthophosphoric acid is permitted.

Asphalt Cement Specification: Impact

- Ontario limits use of REOB using the Ash Content Test
- Fast and inexpensive test
- Limits are set at:
  - 0.8% for all the -28 and -34 grades
  - - 40 grades remain at 1%
- MTQ's limit is 0.6%
- Asphalt cements with REOB have higher ash content:
  - 1.6% in modified vs.
  - 0 to 0.2% in neat binders
- Highest values in:
  - PG 64-28 and PG58-34

AC Specification: Impacts

- New test methods and approaches are needed in addition to PG testing
- MTO has developed lab tests to ensure that we receive better quality binder:
  - Double Edge Notched Tension Test (DENT, LS-299)
  - Extended Bending Beam Rheometer (Ex BBR, LS-308)
- MTO is also using:
  - Multiple Stress Creep Recovery test (MSCR) (AASHTO TP-70) to evaluate polymers used
- Several municipal specifications ban the use of REOB and some other modifiers

AC Specification: Challenges

- What tests to use?
  - Time consuming to adopt new tests and specifications that industry is resisting
  - Industry continues to be concerned with the duration of additional testing
- Banning modifiers
  - may impact innovation
- Proliferation of standards
  - Provincial continually changing and different versions
    - requirements
    - type (i.e. end result, performance)
  - Municipal:
    - no common standard

AC Specification: Challenges

- Enforcement issues:
  - Methods of identifying modifiers banned or limited
  - Testing variability
  - Acceptance criteria
- Samples:
  - Contamination
  - Impact of recycled materials
  - Impact of Warm Mix Additives
  - Overheating and
  - Silo storage

Future Development

- X-ray fluorescence (XRF) provides semi-quantitative results based on element content
- XRF has potential to reveal additional modifiers
- Modifiers including VTAE may not be quantifiable by element content analysis
- Fourier transform infrared spectroscopy (FTIR) used to identify different compounds (i.e. amine anti-stripping additive, butadiene)
  - MTO testing samples to estimate use of modifiers such as REOB:
    - XRF for Ca, Zn and Mo and
    - FTIR for the presence of peaks such as 1229 cm^{-1}.

Future Development

- Banning/limiting modifiers and processes
- Testing recovered AC
- Getting more AC in mixes
- Reducing recycled content
- Selecting PG grade based on 90-98% reliability with updated temperature database

Future Development

- Consider other tests to further characterize AC to better predict premature failure due to AC used in the mix:
  - Long term aging protocol
  - Δ Tc
- Reduce permeability of mixes
- Testing mix:
  - Disc -Shaped Compact Tension Test
  - Semi Circular Bend Test
  - Asphalt Mix Performance Test, etc

Conclusions

- Continue to monitor AC quality
- Pursue opportunities to improve AC quality
- Pursue opportunities to improve pavement performance including:
  - physical hardening in HMA
  - aging protocols and
  - mix tests
- Use material analysis to be more knowledgeable
- More horizontal partnerships

Questions

Pamela Marks
Head, Bituminous Section
145 Sir William Hearst Avenue, Room 238
Downsview, Ontario
M3M 0B6
Pamela.marks@ontario.ca