Addressing Asphalt Cement Quality Concerns

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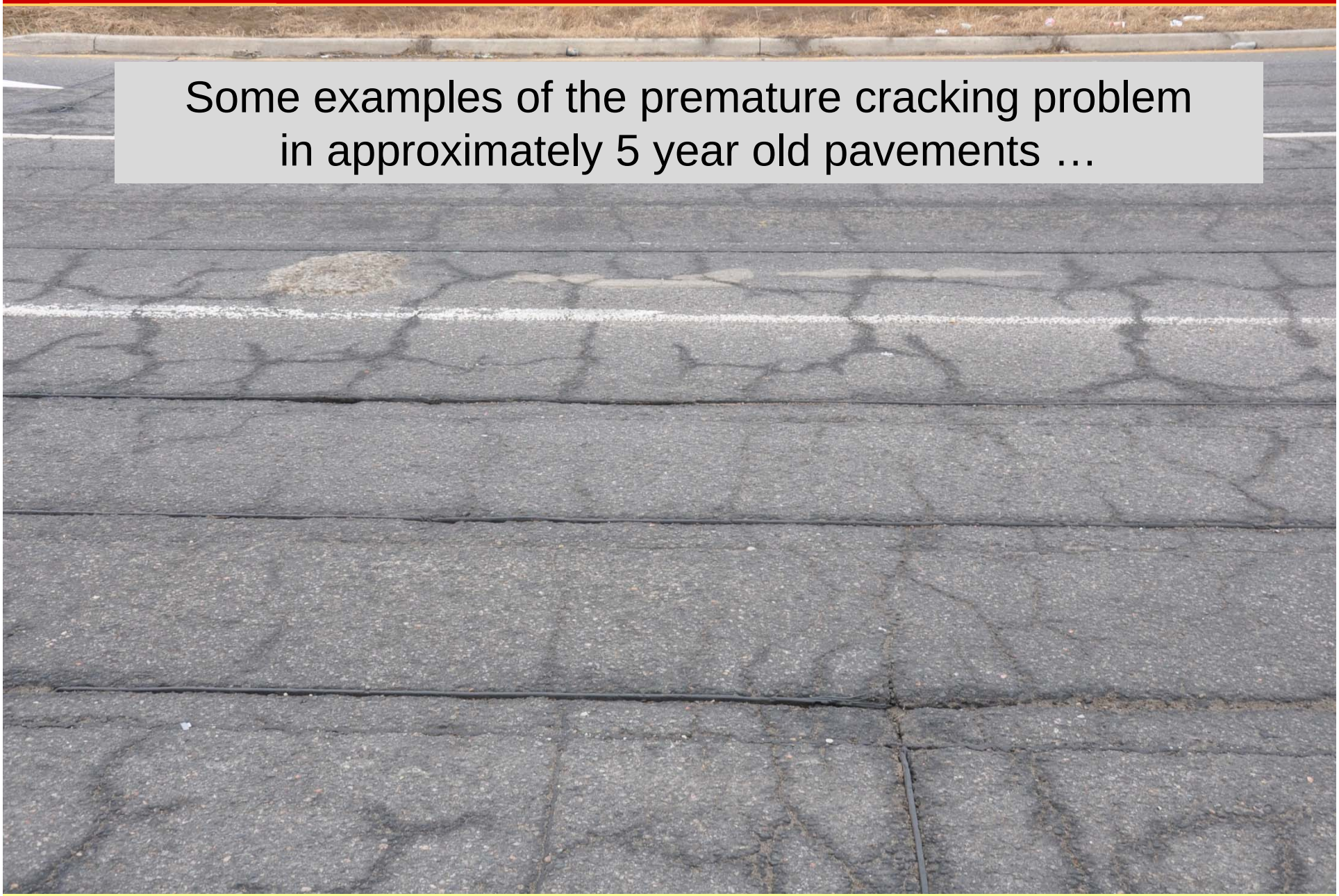
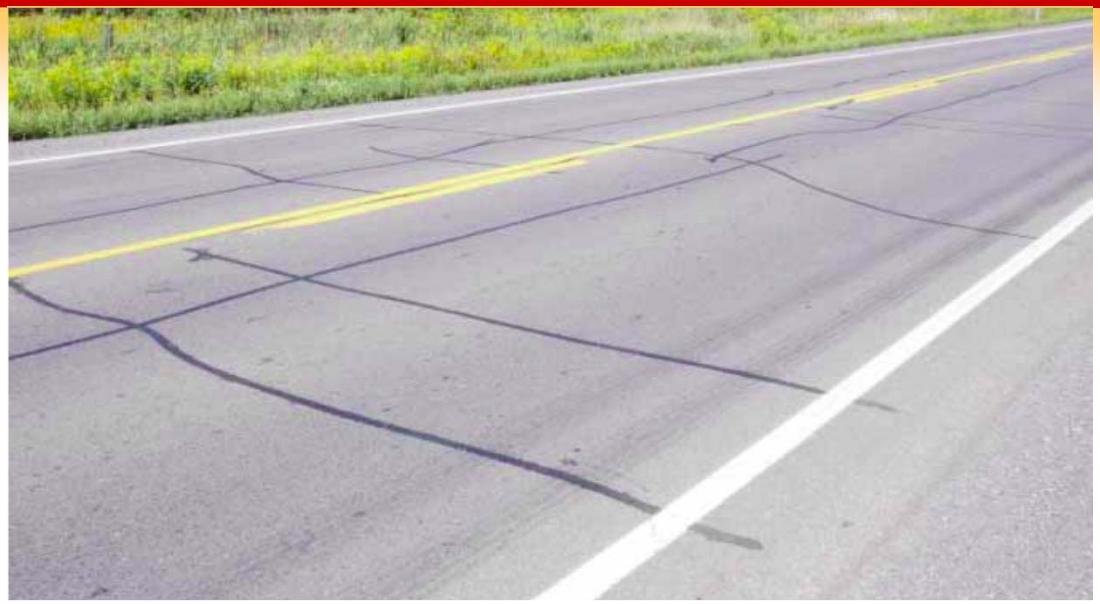
Background

- Across Ontario, some asphalt pavements are cracking and deteriorating prematurely, costing taxpayers millions of dollars, while other asphalt pavements are performing well.
- To understand this inconsistency, MTO initiated research projects with Queens University, to study the causes of premature and excessive cracking.
- Through numerous trial contracts and extensive research, MTO has identified poor quality asphalt cement (AC) as one of the primary causes for the premature pavement deterioration.

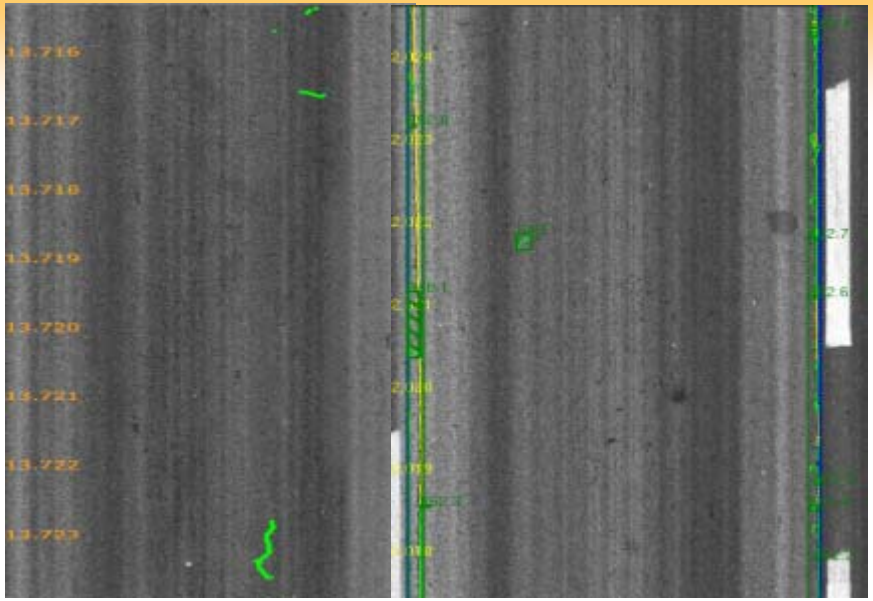
Some examples of the premature cracking problem in approximately 5 year old pavements …





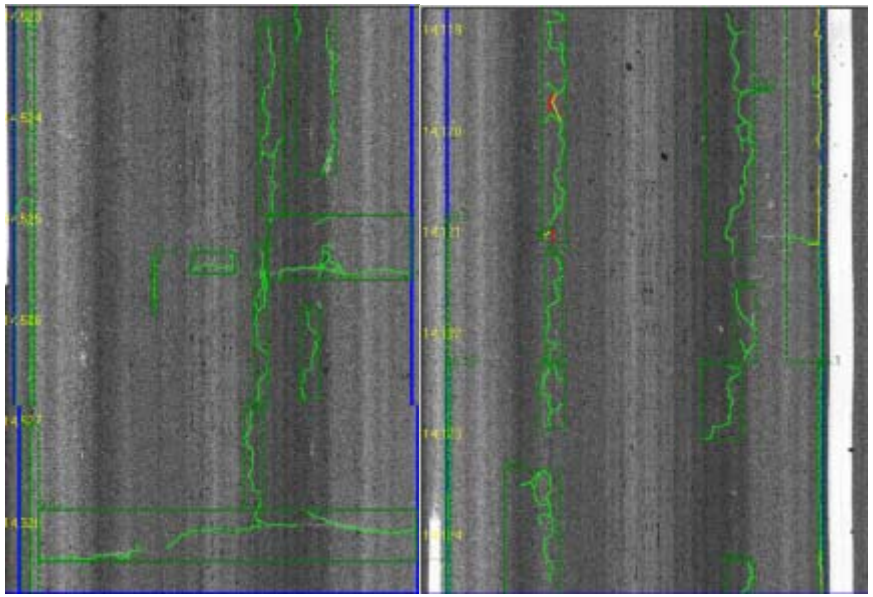

Highway 403, Mississauga

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



LCMS Image – Nov. 2014

- MTO estimates that premature pavement cracking is 100's of millions of $ / yr. problem
- Overlays achieving 1/2 service life.



Lane 2 Lane 3

What is Asphalt Cement?

- Asphalt pavement is made up of:
  - Coarse and fine aggregate
  - Asphalt Cement (glue holding mix together)

Performance Graded Asphalt Cement (PGAC)

The introduction of “SuperPave” in Ontario led to the introduction of Performance Graded Asphalt Cements (PGAC).

- Under the PGAC system, asphalt cements are modified to meet colder winter temperatures (PG 58-34); or modified on high volume roadways to resist rutting (PG 64-28).

What has changed?

- Since implementation of the PGAC specification, petroleum refining processes have changed considerably.
- Increased global demand for fuels and plastics has led refiners to develop improved refining techniques which allow them to extract increased amounts of the higher value light products from crude oil.
- Additionally, a wider variety of crude oil sources are on the market.

[Reference NCHRP 09-60 Addressing Impacts of Changes in Asphalt Binder Formulation and Manufacture on Pavement Performance through Changes in Asphalt Binder Specifications]

- An unintended consequence of the PGAC system is that it allows low cost asphalt cement modification (i.e. use of air blowing, recycled engine oil bottoms (REOB), paraffinic base oils, bio-binders, waxes, acids) to meet the AC grade.
- Extensive research suggests a link between these modifications and early pavement cracking.

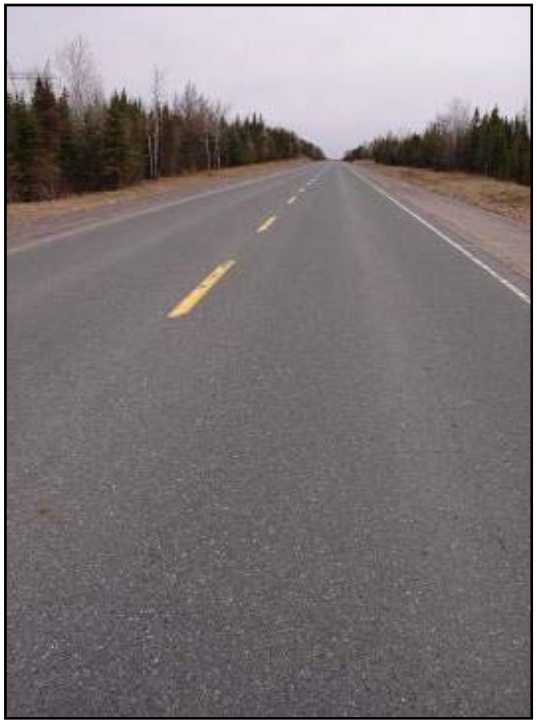
Industry Feedback

- In discussions with MTO, some asphalt cement suppliers agree that over-modification is detrimental to pavement performance.
- Some contractors have approached MTO to tell us that they also have concerns with some of the AC supplied.
  - They have noted differences in some ACs that are supplied (i.e. thinner, ages quickly, not sticky, bleached appearance/ pavement looks old).
- Industry emphasizes that asphalt cement quality is only one issue impacting quality – there are other issues (not enough AC in the mix, irresponsible use of RAP, etc.)

Hwy 655 Field Trials

- To investigate concerns with early cracking, MTO conducted field trials in 2003 on Hwy 655 in Northern Ontario, to evaluate the effects of asphalt cement on cracking performance.
- Seven (7) trial sections were built using the same contractor, location, climate, traffic and design (two lifts of hot mix over pulverized material).
- The only variable was the AC used in the mix.

MTO Hwy 655 Phase 1 Trials



Section 1 (5 years old)

- Largely free of distress
- Centerline joint and shoulders in almost perfect condition.

MTO Hwy 655 Phase I Trials

Section 4 (5 years old)

- Severe cracking in both lanes.
- Transverse cracks originating from wheel path and joint.
- Cracking is beyond repair.

Independent Review

- In 2008, an independent review of MTO and Queen's University findings (Gerry Huber Report funded by MTO and OHMPA), found that for Hwy 655 trials:
  - Design, construction, climate, traffic and other material variables could be eliminated as contributing factors
  - AC properties were responsible for the differences in performance
  - Superpave PG grading system did not identify poor performers (did not correlate with field performance)
  - Superpave PAV aging test was insufficient
  - ExBBR test developed by MTO in partnership with Queen's University was best able to predict the cracking.

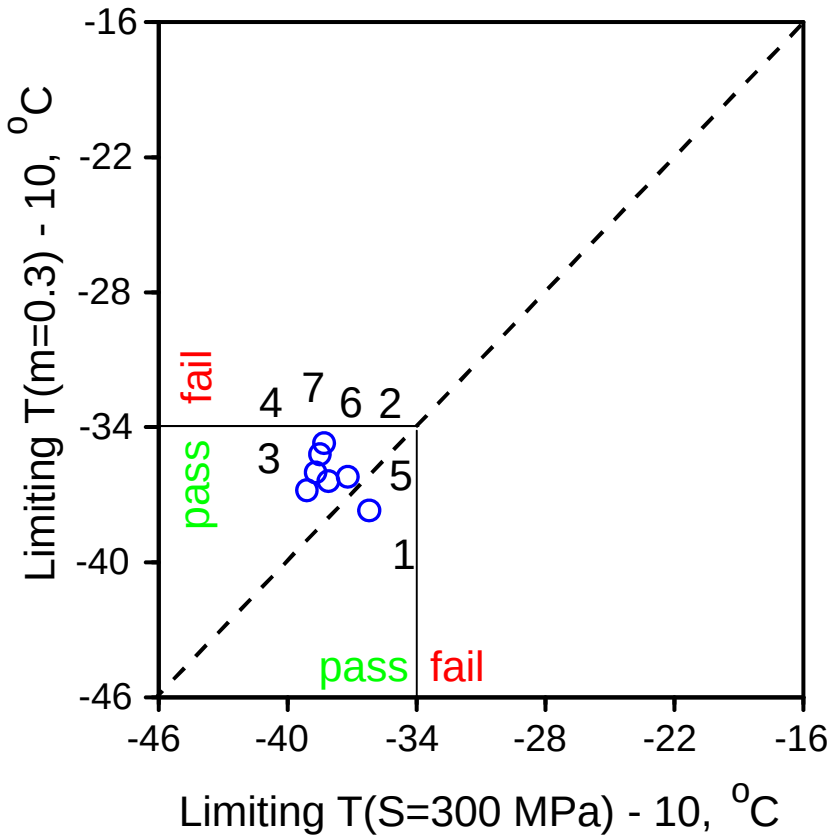
Extended Bending Beam Rheometer (ExBBR)

- MTO and Queen's University have determined that some modified asphalt cements physically harden more than others when cold.
- Some binders get more brittle than others at temperatures above the PGAC low temperature grade they are designed for, and are more susceptible to cracking the longer they are cold.
- Extending the conditioning time of the M320 BBR test, from 1 hour to 3 days, significantly improved the test's ability to predict cracking.
- The ExBBR has been used for acceptance on select MTO contracts since 2009.
- ExBBR is being implemented on MTO contracts in a phased approach to address early cracking problems.

Hwy 655 Trial Sections Meeting Same BBR versus Different ExBBR Grading

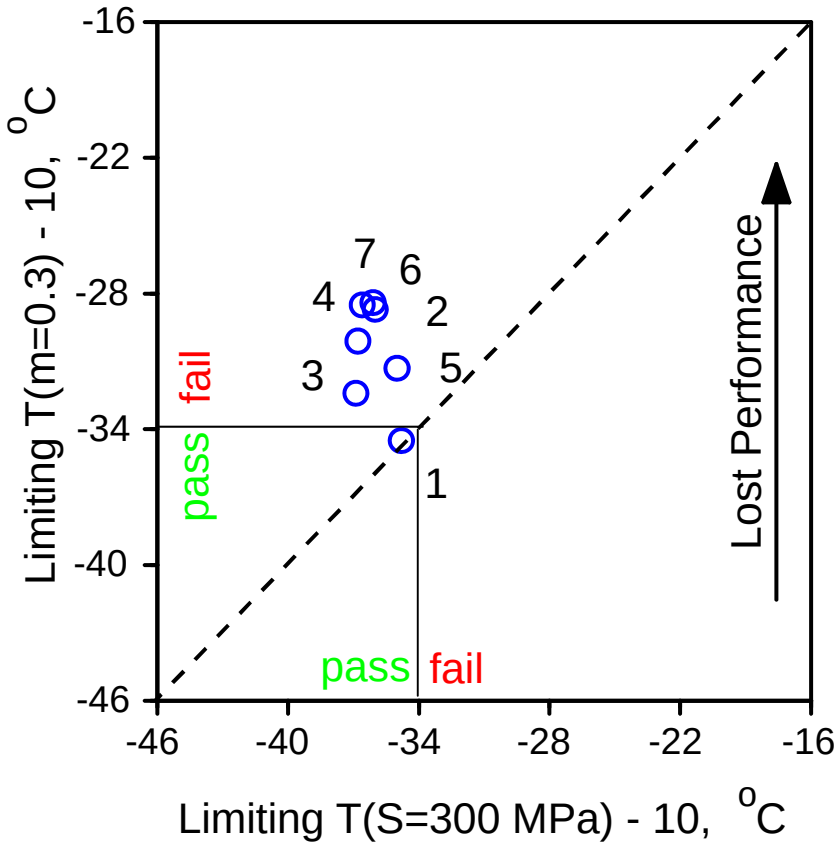
BBR Grading

14 % Overall Accuracy (1 out of 7)
0 % Accuracy in Predicting Failure (0 out of 6)



ExBBR Grading

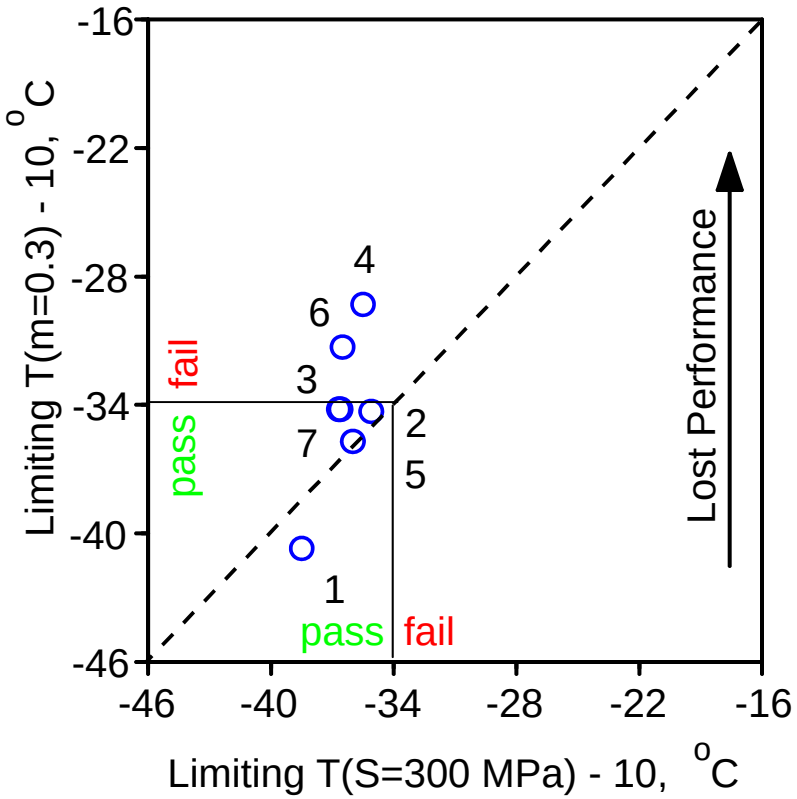
100 % Overall Accuracy (7 out of 7)
100 % Accuracy in Predicting Failure (6 of 7 times)



Recovered Asphalt Cements – Hwy 655

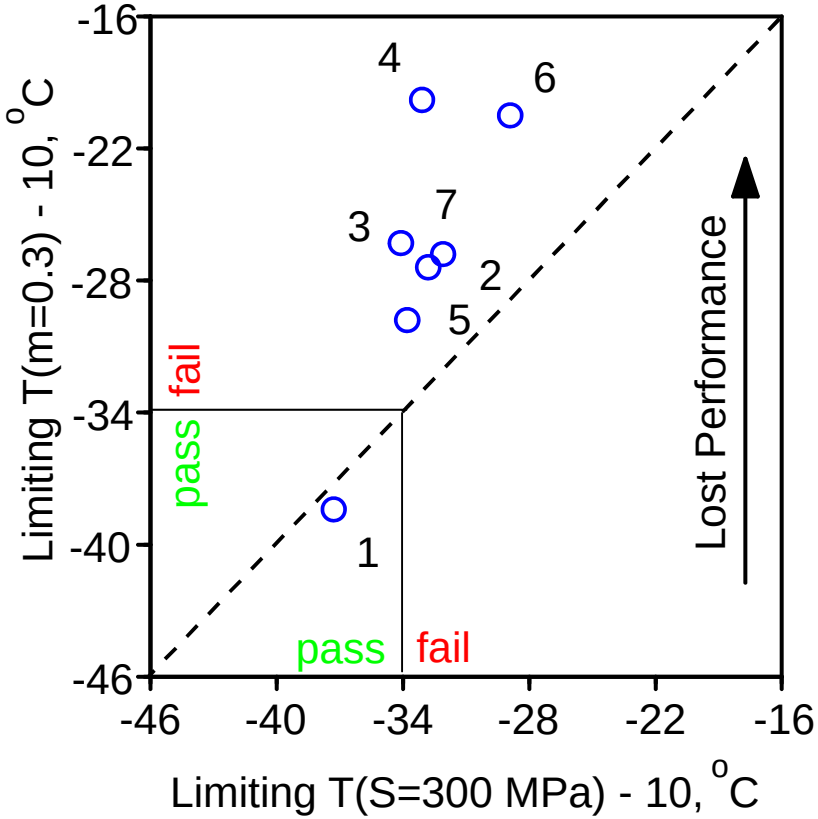
BBR Grading

43 % Overall Accuracy (3 out of 7)
33 % Accuracy in Predicting Failure (2 out of 6)

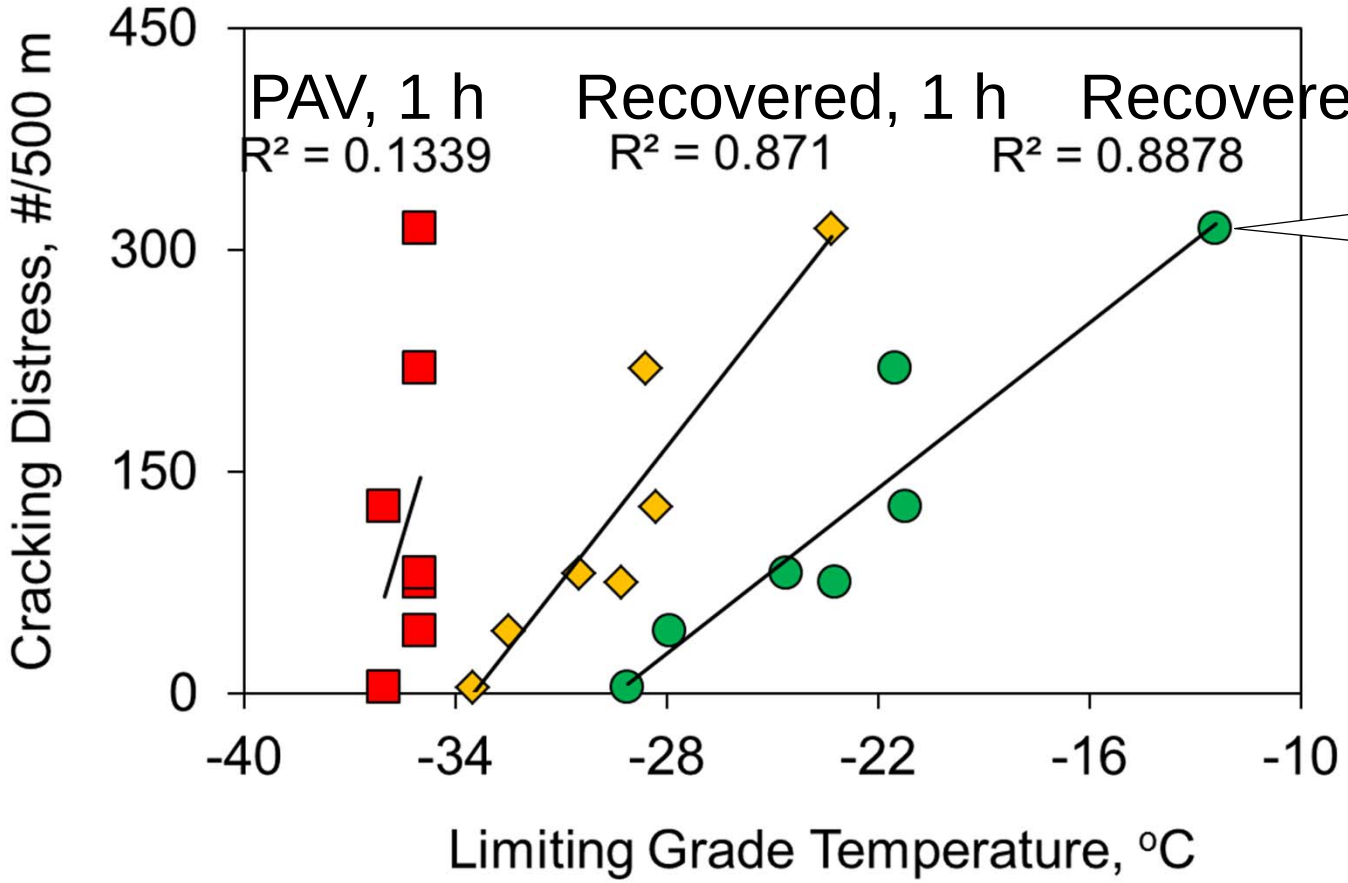


ExBBR Grading

100 % Overall Accuracy (7 out of 7)
100 % Accuracy in Predicting Failure (6 out of 7)



Various BBR Protocols – Hwy 655 Trials



10°C-20°C differences!

Paliukaite et al., 2015

List of Laboratory Tests to Address AC Quality

1. **Extended Bending Beam Rheometer (ExBBR) (LS-308)**
   - First published in 2006
   - Used for acceptance on selected contracts since 2009
   - Staged implementation to begin in 2016
2. **Double-Edge-Notched Tension (DENT) (LS-299)**
   - First published in 2006
   - Used for acceptance of all modified AC on MTO contracts since 2012
3. **Ash Content**
   - Used to reduce amount of REOB added
4. **Modified Pressure Aging Vessel (PAV) (LS-228)**
   - First published in 2012 and under development
5. **Multiple Stress Creep Recovery (MSCR) test**

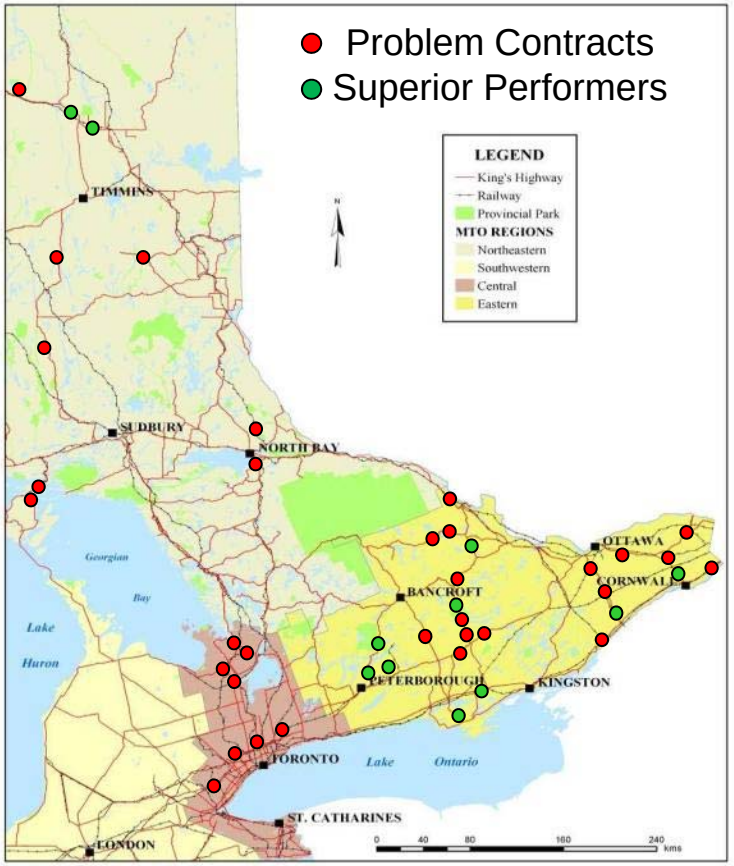
Field Validation of Laboratory Tests

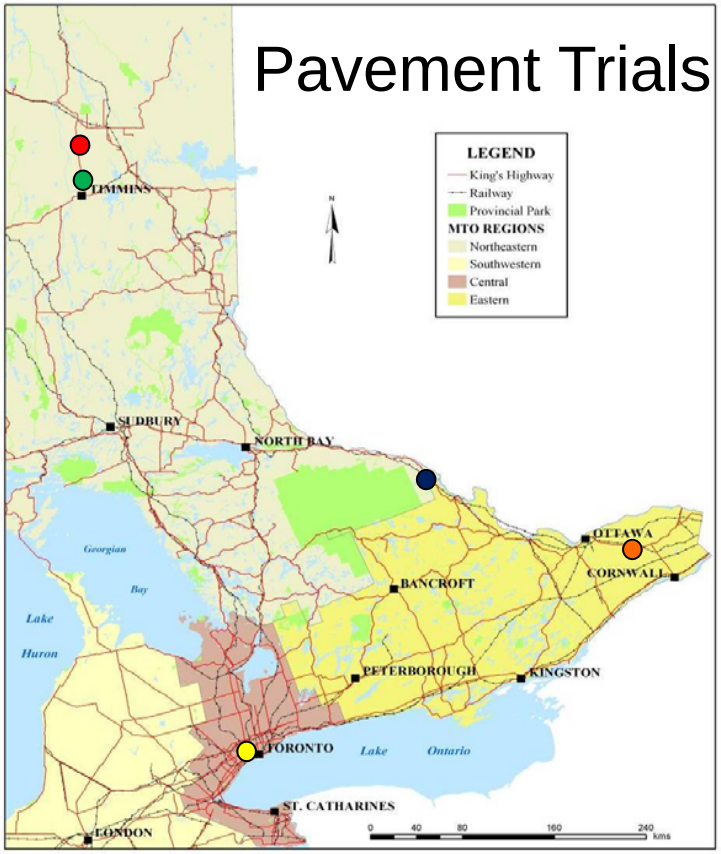
- Materials from various contracts have been evaluated:
  - Trial sections with the same PG M320 grading
  - Previously constructed pavements with the same PG (cracked and not cracked)

Hwy 41 North of Kaladar (1999)

Hwy 11 West of Cochrane (1999)

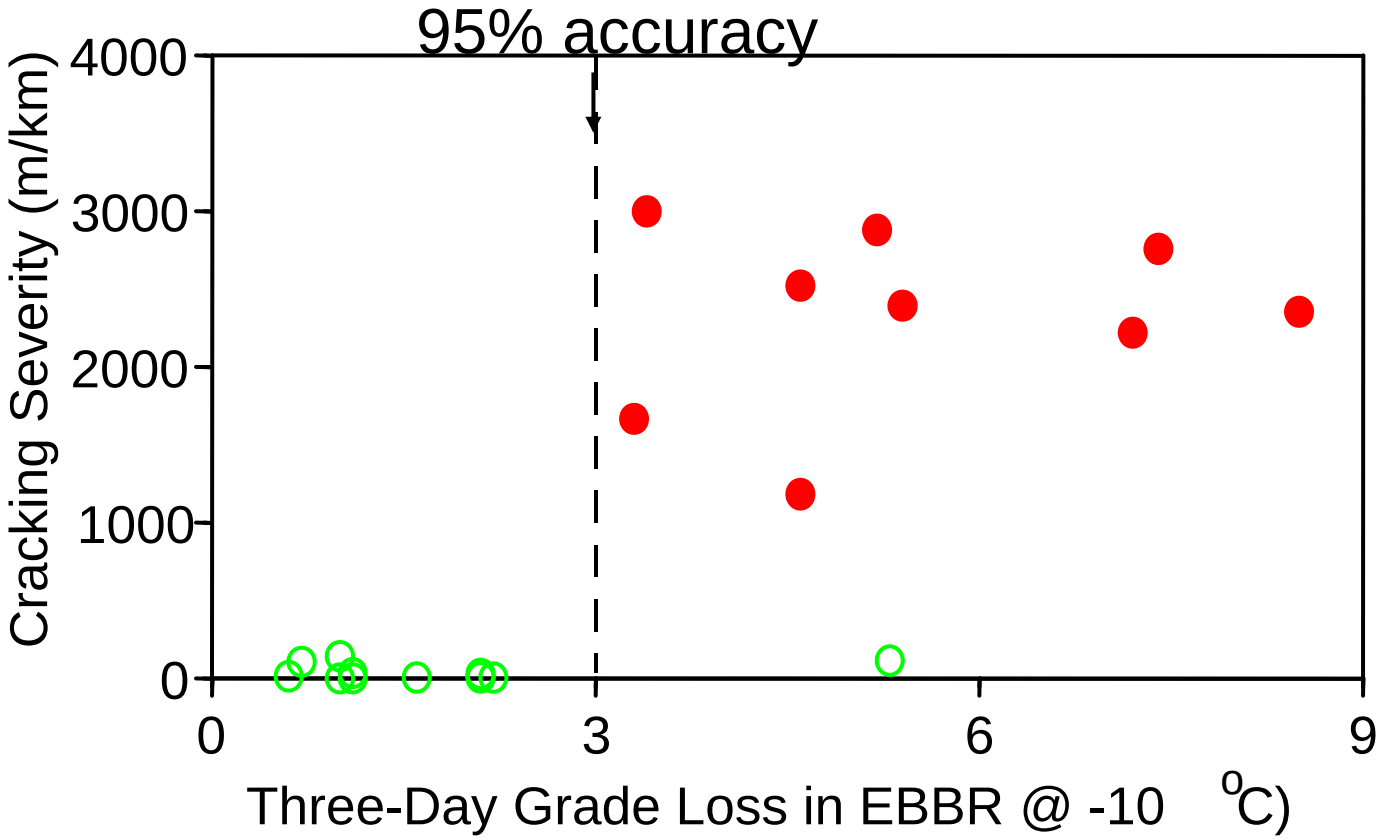
Pavement Performance Research





- 1996
- 2003
- 2006
- 2007
- 2008

Validation with Previously Paved Contracts (1993-2001): ExBBR

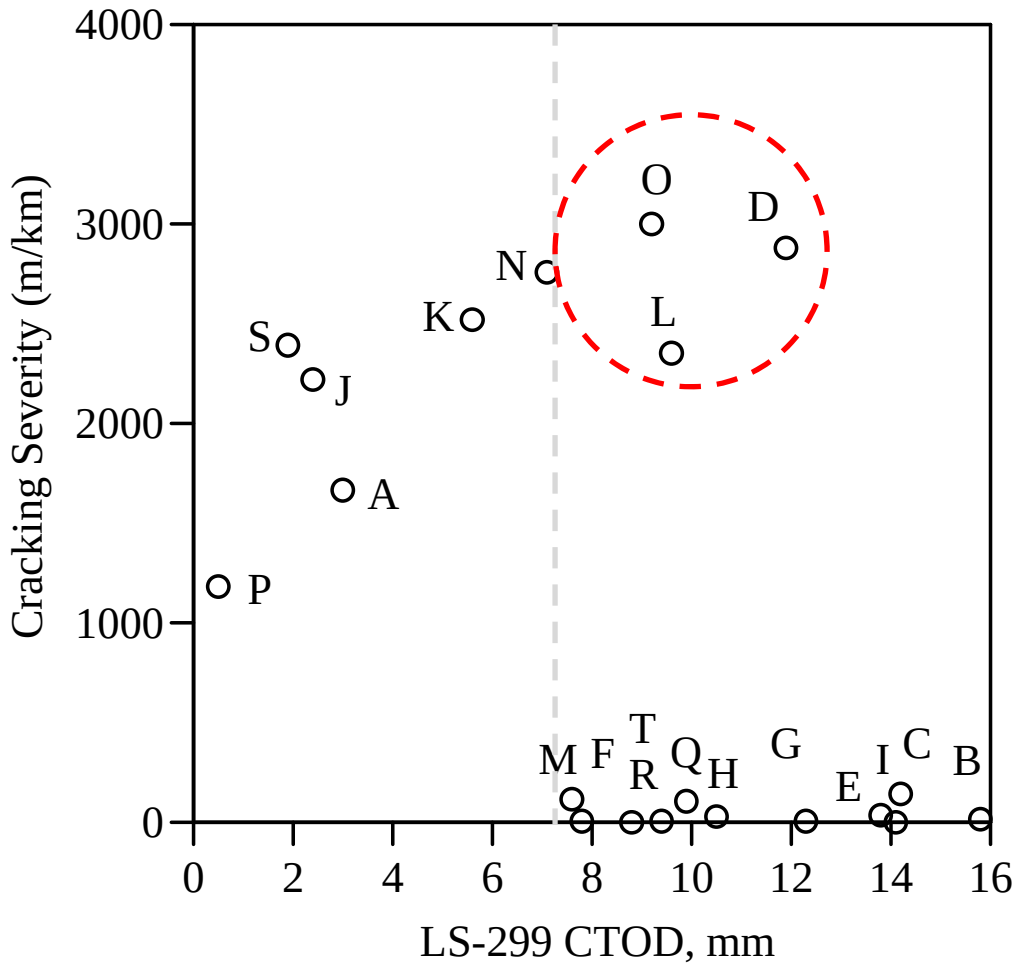


Hesp et al., *Int. J. Pavement Eng.*, 2009

Double Edge Notched Tension (DENT) Test

- The DENT test is used as a measure of asphalt cement's elasticity (ability to stretch and resist cracking).
- More ductile = less cracking (higher values are better)
- Used for acceptance of modified binder on select MTO contracts since 2009 and on all modified grades since 2012.
- Test passed AASHTO balloting.
- Published as AASHTO provisional standard in 2016.

Double Edge Notched Tension Test



- Tested asphalt cement recovered from previously paved contracts
- CTOD ~ 85% correct

Hesp *et al.*, IJPE 2009

Under Development - Modified PAV

- LS-228 Modified Pressure Aging Vessel (PAV)
  - Method B: 12.5 g per pan and 20 hrs,
  - Method C: 40 hrs
- Under Development
- Limited testing completed to date shows:
  - BBR Low Temperature grade was comparable between modified PAV methods B & C;
  - BBR grade loss with method B & C generally comparable (B sometimes harsher); and
  - Generally ExBBR with normal PAV harsher.

Conclusions

- MTO and many other jurisdictions are having problems with premature cracking of asphalt pavement, which is severely impacting the life of highway infrastructure.
- Research has shown that poor quality asphalt cements, additives such as REOB, and low cost modifications are linked to cracking.
- MTO is recommending lab tests to identify better quality asphalt cements to ensure durability, with the goal of reducing costs to the tax payer for infrastructure maintenance.
- MTO is willing to pay for better quality asphalt cement to ensure durability as it will result in overall reduced costs to the taxpayers for infrastructure maintenance.

Questions?

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