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Pavement performance compared with asphalt properties for five contracts in Ontario

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HIGHLIGHTS

- Pavement cracking compared to contract and recovered asphalt cement test results.
- Extended Bending Beam Rheometer test is best at predicting 5 year cracking.
- Double Edge-Notched Tension test identified all lower-performing pavements.
- Recovered asphalt cement testing showed good correlation with pavement cracking.

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ABSTRACT

This paper analyzes pavement performance of five Ontario Ministry of Transportation contracts paved in 2011 in relation to the properties of asphaltic materials used during construction. Pavement cracking data collected in 2016 was compared with characteristics of asphalt cement supplied for paving and recovered from pavement cores at year five. A major finding was that the Extended Bending Beam Rheometer test; part of enhanced testing currently carried out on asphalt cement in Ontario, was more reliable at predicting pavement performance than the standard Superpave™ Bending Beam Rheometer test for both asphalt supplied to the contract and recovered from in-service pavements.

1. Introduction

Shortly after fully adopting Superpave™ MTO[1] made several observations. First, rutting was all but eliminated and regular evenly spaced traverse cracking was greatly reduced. However, some pavements exhibited significant unexplained cracking within two to four years after placement. In the early 2000's, research projects were initiated to study the cause of this premature cracking. It was suspected at the time that the premature cracking was due to changes made to AC[2] to meet the newly adopted Superpave™ performance grading requirements. Field observations confirmed that AC's of the same grade resulted in vastly different pavement performance [1].

Through this research MTO developed additional acceptance criteria for AC, which includes: ash content, CTOD[3] obtained from the DENT[4] test, and LTLG[5] and grade loss from the ExBBR[6] test. In addition, while not discussed in this paper, MTO has started estimating the amount of REOB[7] using X-ray Fluorescence and Fourier Transform Infrared Spectroscopy [2].

In 2011, MTO tendered numerous contracts which included the enhanced acceptance criteria for AC supplied during construction

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[1] Ministry of Transportation of Ontario.
[2] Asphalt Cement.
[3] Crack Tip Opening Displacement.
[4] Double Edge Notched Tension.
[5] Low Temperature Limiting Grade.
[6] Extended Bending Beam Rheometer.
[7] Re-refined Engine Oil Bottoms.

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[3]. The goal was to evaluate how the properties of the AC material used in the mix affect cracking performance. This paper analyzes five of these contracts.

In this paper, the properties of the AC collected from the asphalt plant during construction for acceptance (hereafter referred to as contract AC), and the properties of the AC later recovered from the pavement by MTO (hereafter referred to as recovered AC) are compared to pavement performance of the selected roadways after five years. In the future, it is hoped that the information gained will assist contractors in selecting appropriate materials and processes to meet performance warranty requirements, thereby reducing risks for both the agency and the contractor. It is understood that the properties of the AC are not solely responsible for short and long term pavement performance, and that the properties of the other materials, the mix design attributes, production and placement processes, climate, and traffic loading all impact the pavement performance as well.

2. Pavements studied

Table 1 summarizes the five contracts constructed in 2011 that were selected for this investigation. In an effort to eliminate reflective cracking from underlying layers as a possible contributor to pavement distress, contracts with one or two lifts over FDR[8] or CIR[9] were selected. One contract with three lifts over a milled surface was included with the expectation that reflective cracking had not yet emerged.

In addition to pavement treatment and AC properties, the performance of the pavements studied in this paper may be influenced by variables such as mix design, recycled content, traffic level, and compaction.

3. Recovered grading

Currently agencies routinely characterize recovered AC properties to:

- Assist in the selection of pavement rehabilitation strategies;
- Research and develop new products and procedures; and
- Investigate premature pavement failures.

Use of recovered AC properties in place of contract AC properties could have significant benefits to both the agency and the contractor. These include:

- No need to maintain a Designated Source for Materials list for AC;
- Ability to add modifiers at the asphalt mix plant;
- Ability to innovate;
- Eliminate the need for traditional oversight of material condition before the mix is produced; and
- Capture true short term ageing effects so less laboratory ageing is required.

While the extraction and recovery process itself may affect the AC properties to a slight degree, the following factors may have a more significant impact:

- Contamination in the AC supply tank at the asphalt mix production plant;
- Storage length and temperature of the AC at the plant before use;
- Sample integrity;
- Use of recycled materials such as RAP and manufactured or waste roof shingles (waste roof shingles are not permitted in MTO mixes);
- Mix production temperature;
- Excessive storage and/or haul time of the asphalt mix; and
- Rate of oxidation of the AC on the road, exceeding Superpave™ PAV[10] predictions.

4. Methodologies

4.1. Testing program

Acceptance testing was carried out on the contract AC during construction of the contracts. AC recovered from the pavement after five years in service was subjected to the same testing. To correlate both contract and recovered test results to pavement performance after five years, pavement cracking data was collected by MTO's ARAN[11]; a vehicle that measures pavement distress for the entire provincial highway network.

Measures of low-temperature performance and ductility were determined using the ExBBR and DENT test, respectively. These test methods are used for acceptance of all Ontario paving contracts today. The contract AC was aged prior to testing by Rolling Thin-Film Oven and PAV, according to AASHTO T 240 and AASHTO R 28 respectively [4].

Contract AC was also tested for ash content, a measure of inorganic material that includes non-combustibles such as metals from REOB. REOB is commonly used as a softening agent in asphalt mixtures. Some research suggests that it can negatively impact pavement cracking performance. In an effort to limit the use of REOB, the ash content test is currently used for acceptance of all Ontario paving contracts. All of the test methods employed in this study are described below:

4.1.1. Bending Beam Rheometer and Extended Bending Beam Rheometer testing

AASHTO TP 122 for the ExBBR test determines the low temperature continuous performance grade of thermoreversibly hardened AC using different conditioning temperatures and times than those used in the AASHTO TP 313 test method for the regular BBR[12] [4]. The BBR method conditions samples for one hour and tests them at a temperature 10 °C warmer than the low temperature grade (T). The ExBBR method conditions samples for 1, 24, and 72 h at 10 °C warmer (T +10 °C) and 20 °C warmer (T +20 °C) to determine, by interpolation, the limiting temperature for each conditioning time and temperature.

In this paper, the one-hour ExBBR grade at the lower conditioning temperature (T +10 °C) is referred to as the BBR LTLG. The ExBBR LTLG is the warmest of the limiting grades from testing at three conditioning times and two conditioning temperatures. Grade loss is the difference between the ExBBR and BBR LTLG's.

4.1.2. Double Edge Notched Tension testing

The DENT test determines an AC's resistance to ductile failure and its ability to stretch and resist cracking at intermediate temperatures. It is conducted after intermediate thermal conditioning to determine the essential work of fracture, the plastic work of fracture, and an approximate critical CTOD; a measure of strain tolerance at a specified temperature and rate of loading. Testing was carried out per AASHTO TP 113 with the exception that conditioning and testing was carried out at 15 °C [4]. It is important to note

[8] Full-depth Reclamation.
[9] Cold In-Place Recycling.
[10] Pressure Aging Vessel.
[11] Automatic Road Analyzer.
[12] Bending Beam Rheometer.