ONTARIO ASPHALT PAVEMENT COUNCIL

Quality of asphalt

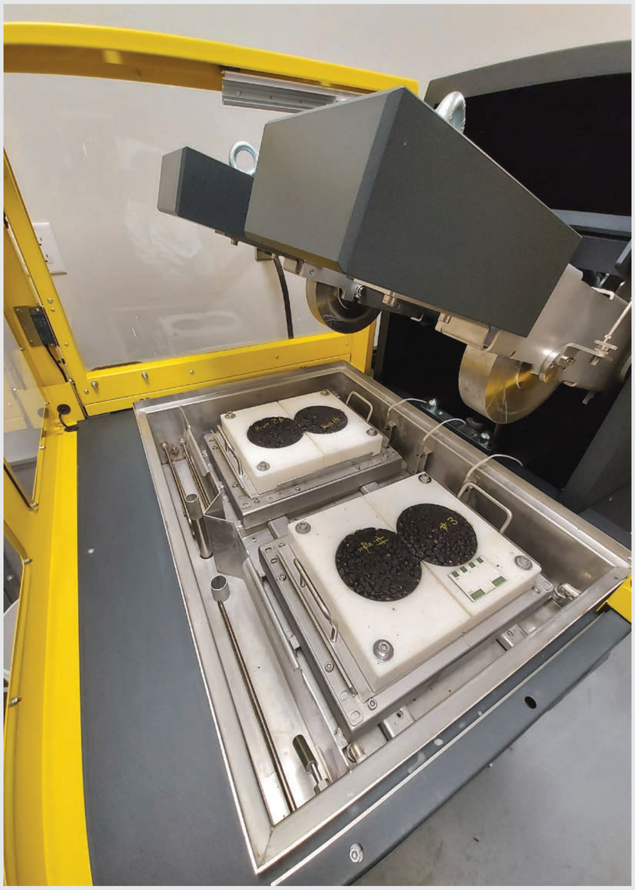
Asphalt Performance Testing

The motivation for performance testing of asphalt mixtures is primarily necessitated by an interest to provide more reliable ways for design, production, placement. It is important for understanding risks and establishing practical criteria for quality assurance (QA) acceptance. Performance tests are used to relate laboratory mix design to actual field performance. This is achieved through the evaluation of durability-related distresses and failures such as fatigue cracking, permanent deformation (rutting), and low-temperature (thermal) cracking. Performance testing involves mechanical characterization to determine fundamental engineering or empirical properties, and must be completed on appropriately conditioned specimens, taking into consideration, mix aging, traffic loading, climate and location within the pavement structure.

Read the following checklist to learn about some key facts pertained to the three-major distress-failure mechanisms, and recommended performance test(s) identified for adoption in Ontario, to ensure improved pavement performance.

PERMANENT DEFORMATION (RUTTING)

- Rutting results from the accumulation of small amounts of unrecoverable strain as a result of repeated loads applied to the pavement. This could be due to problems with the subgrade, unbound base course, or the asphalt layers. Rutting resulting from the asphalt mix is caused by consolidation and/or lateral movement (shear failure) under traffic. It is important that satisfactory materials are used, to prevent rutting occurrences beyond the top 100 mm of the pavement surface.
- In Ontario, the **Hamburg Wheel Tracking (HWT)** testing method - reflecting performance at high temperatures, has been identified as a promising approach to evaluate the combined effects of rutting, stripping potential and moisture susceptibility of compacted asphalt mixtures in accordance with AASHTO-T324.
  - The most commonly used test temperature for this test by many agencies is 50°C, selected due to its influence on aggregate quality, asphalt cement stiffness, aging, binder source, anti-stripping treatments and compaction.
  - Rut samples in Ontario are typically evaluated against **a maximum allowable rut-depth threshold of 12.5 mm after 20,000-wheel passes (10,000 cycles)**. Typical results for SP12.5FC2 mixes with 64-YY and 70-YY PGACs, have been observed in the range of ***4 mm - 8 mm*** after 20,000 passes.
  - A mixture that survives the HWT test should be rut resistant in the field. Results obtained from the HWT test device consists of rut depth, creep slope, stripping inflection point, and stripping slopes.



HWT Test Setup.

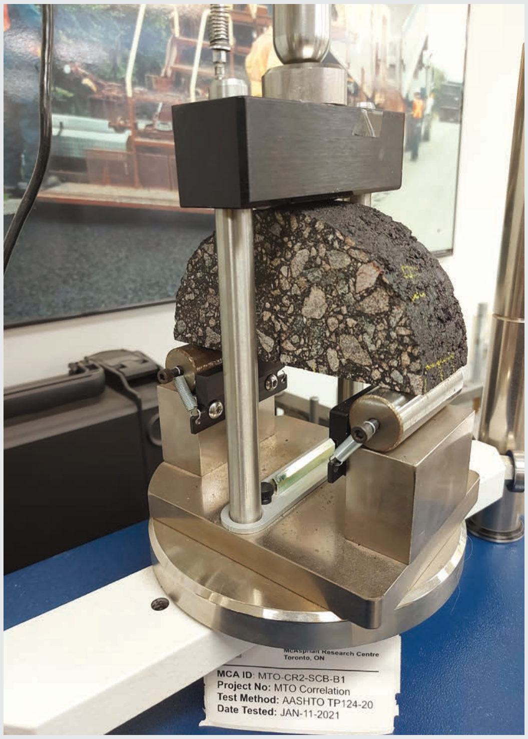
FATIGUE CRACKING

- Fatigue cracking is generally considered to be more of a structural problem than just a material problem, and is a pre-requisite to the development of potholes. Poor subgrade drainage, resulting in a soft, high deflection pavement, is a principal cause of fatigue cracking. Improperly designed and/or poorly constructed pavement layers that are prone to high deflections when loaded also contribute to fatigue cracking. The asphalt layers experience high strains when the underlying layers are weakened by excess moisture and eventually fail prematurely in fatigue.
- In Ontario, the **Illinois Flexibility Index Test (IFIT) using the "Semi-Circular Bend (SCB) test** - reflecting performance at intermediate temperatures, has been identified as a promising approach to address the fatigue distress-mechanism in asphalt pavements.
  - IFIT is a simple, practical test conducted at an intermediate temperature, and uses a semi-circular beam specimen with vertical notch along its symmetric axis.
  - The I-FIT establishes the load-versus-displacement curve for an asphalt mixture that is used to determine the relevant mixture fracture parameters of fracture energy (Gf) and the post-peak load-versus-displacement curve slope (m) of a mixture. These two parameters are used to calculate the flexibility index (FI). The FI is used to detect variations in the overall resistance of asphalt mixtures to crack propagation. The higher the fracture energy, the better the cracking resistance.

- An m-value dictates the rate of crack propagation. A lower m-value indicates slower crack propagation and a higher m-value indicates the mix is brittle, and more susceptible to cracking.
- Illinois DOT (IDOT) notes a minimum design FI of 8 as the current recommendation for asphalt surface mixes. FI value greater than, or equal to 8 have been found to be an adequate threshold for distinguishing good performing from poor performing mixtures.

LOW-TEMPERATURE (THERMAL) CRACKING

- Thermal cracking is purely a tensile failure of the material. It is characterized by intermittent transverse cracks that may occur at a surprisingly consistent spacing. The resistance of the asphalt mix to thermal cracking is mainly provided by the asphalt binder. Higher tensile strength has been generally associated with higher thermal cracking resistance.
- It can also be a fatigue phenomenon resulting from the cumulative effect of many cycles of cold weather shrinkage. The magnitude and frequency of low temperatures and stiffness of the asphalt mixture on the surface are major factors in the occurrence and intensity of low-temperature transverse cracking.
- In Ontario, the **Disk-shaped Compact Tension (DCT)** test - reflecting performance at low temperatures, has been identified as a promising approach to address this distress-mechanism in asphalt pavements.
  - In this test, a disk-shaped specimen is pulled apart until the post-peak level has reduced to 0.1 kN. The geometry of the specimen is a 150±10 mm diameter, 50±5 mm thick overall dimension with two 25±1 mm holes on either side of a 62±5 mm notch cut into a flattened portion of the circumference.
  - The DCT is often conducted at 10°C in a crack-mouth opening displacement (CMOD) controlled mode with an opening rate not more than 1.5 mm/min.
  - The fracture energy (Gf) is calculated by determining the area under the Load-CMOD curve normalized by the initial ligament length and thickness. The larger the Gf, the better the cracking resistance of the asphalt mixture. The typical coefficient of variation (COV) for the DCT test for virgin mixtures is around 10 percent.
  - The crack propagation is measured corresponding to the load applied by providing a value in fracture energy at a minimum acceptable value of 0.035 BTU/ft2 (400 J/m2). The Chicago Department of Transportation (Chicago DOT) minimum requirements for the mixtures tested in the DCT include: 0.035 BTU/ft2 (400 J/m2) for dense-graded asphalt mixtures; 0.031 (350 J/m2) for low ESAL (i.e., lower heavy vehicle volumes) asphalt mixtures; and, 0.017 (200 J/m2) for pervious asphalt mixtures.



IFIT-SCB Test Setup.

DCT Test Setup.

ONTARIO'S PATH FORWARD

- Ontario's path towards implementing performance testing for paving with asphalt mixtures are aimed at adopting a structured, simplified system that is flexible in approach, measurable and modifiable.
- Uniformity in practices is critical for industry buy-in. It is imperative that stakeholders continue to question and evaluate performance testing strategies to ensure that the approach for final implementation fits Ontario's unique challenges.
- Currently, efforts towards performance testing are being built based on the experiences of other jurisdictions. Many factors are being considered with particular emphasis on: test simplicity; technician training requirements; sample preparation protocols; sensitivity to mix design parameters; correlation to field performance; ease of data interpretation and analysis; and equipment availability.
- Central to this effort is the Ontario Asphalt Expert Task Group (OAETG) continued focus on recovered asphalt testing, and pathways towards mix performance testing in Ontario. These efforts will assist industry in better understanding the current knowledge gaps and providing any future research needs for ensuring long-term pavement performance.

RESOURCES

- Related presentations from the Asphalt Technical Symposium (ATS), Fall Asphalt Seminar (FAS), Partners-in-Quality (PIQ) and Asphaltopics Magazine articles are available on the "**Publications and Education**" section on the OAPC website.
- **Other Reference Materials:**
  - *NCHRP Synthesis 552: Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories.*
  - *NCHRP Project 9-57: Laboratory Tests to Assess Cracking Resistance of Asphalt Mixtures.*
  - *NCHRP Synthesis 492: Performance Specifications for Asphalt Mixtures*