Canadian Technical Asphalt Association | CTAA | Association technique canadienne du bitume

2022 Paper Abstracts in Tentative Presentation Order

Paper : **1**

A History of North American Heatwaves and Their Impact on Rutting in Flexible Pavements

Alyssa Bernier, Surya Swarna, Kamal Hossain, Yusuf Mehta

Human induced climate change has become a pressing phenomenon that will continue to change Canadian weather patterns in the coming years. Many aspects of daily life will be affected with the onset of these changes, the most widely felt of which will be an increase in daily average temperature. Although this particular effect of climate change will have consequences on many industries, it is of unique interest to flexible pavement designers. An abundance of previous studies have identified that increased temperatures will have impacts on asphalt pavements. However, there exists an additional phenomenon included within the trend of increasing temperatures. “Heat waves” are extended periods of extreme heat and humidity that follow unique daily temperature patterns, likely to affect pavements in different ways than traditional hot days. To fully understand the effects future climate change caused heat waves may trigger on asphalt pavement performance, this paper investigates the most notable of recent historical heat waves and their impacts on pavements within select North American cities. As several locations in Canada set new temperature records throughout the summer of 2021, the effects of this year are explored in great depth. The pavement performance is simulated in Pavement ME. Significant effects on the pavement performance are analyzed, with special attention on the asphaltic concrete rutting. The heat wave pavements are then compared with this control data to observe any significant differences between the two scenarios. The results of this study report that previous Canadian heat waves have not followed typical temperature trends, which should be accounted for in future heat wave simulation efforts. It was additionally identified that the heat waves exacerbated and expedited the development of rutting in the observed pavements.

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Paper : **2**

Laboratory Evaluation of a High-Strain Asphalt Crack Relief Interlayer Characteristics in Ontario

Vince Aurilio, P. Blankenship, Z. McKay & M. Simons

Reflective cracking of hot mix asphalt (HMA) pavements continues to be a major concern and complex problem for roadway agencies throughout Canada. This is particularly important on roadways or highways with composite pavements (i.e., asphalt over concrete) that continue to pose significant and costly repairs due to the movement of the underlying concrete and the resultant reflective cracks due to the mismatch of high-modulus (rigid) concrete and lower-modulus (flexible) asphalt.

In the US, high-strain, asphalt interlayers have been used since 1998 with success reported at delaying reflective cracking over 70% in the early life of the pavement. Today, several US states specify an asphalt interlayer to combat reflective cracking. In addition, the Federal Highway Administration (FHWA) encourages the use of the asphalt interlayer as one of its Targeted Overlay Pavement Solutions (TOPS) with a goal of "…integrating innovative overlay procedures into practices that can improve performance, lessen traffic impacts, and reduce the cost of pavement ownership."

In 2021, a laboratory study was undertaken to evaluate the properties of a 4.75 mm high-strain, asphalt interlayer designed using local Ontario aggregate, incorporating a PG 64-34 modified with a para-aramid fibre. The gradation is fine-graded and designed to hold more asphalt than typical asphalt mixtures. The mixture was designed with a total binder content of 8.5 % at 1.4 % air voids compacted to 50 gyrations. The natural concern of using this type of mixture is if we achieve the needed cracking resistance without having a rutting problem. This concern is resolved by the use of performance-based tests.

The performance-based testing included Hamburg Wheel Tracking (HWT), IDEAL-CT and SCB IFIT to evaluate the rutting and cracking performance of the interlayer mixture, respectively. The HWT and the Ideal-CT tests were both conducted at two temperatures to further evaluate and understand the influence of the PG 64-34 on the performance properties and potential climates. The cracking tests were also conducted at two air void levels. The laboratory results are very encouraging and essentially confirm the extreme crack-resistant characteristics of the high-strain asphalt crack relief interlayer using locally available materials for high-strain application.

This paper presents the results of the laboratory performance testing and recommendations for the design of the high-strain asphalt interlayer. Key requirements for a draft specification are also discussed as well as best practices for construction. In terms of the next steps, it is anticipated that trials will be constructed in 2022 to validate the field performance and the demonstrate the benefits of the high-strain asphalt crack relief interlayer under different flexible and composite pavement conditions.

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Paper : **3**

LOWERING DESIGN GYRATIONS AND IMPACT ON MIX DURABILITY

Doubra Ambaiowei, Taylor Lefebre, Yashar Alamdary, and Sina Varamini.

The main target of asphalt mix design is to determine the optimum asphalt content to balance the fatigue and rutting resistance of mixes. However, the design philosophy in the Superpave method has only focused on minimizing the rutting failure by increasing the compaction effort for higher traffic levels. This strategy can be translated into lower asphalt cement (AC) content for pavements with heavier traffic. Although this could effectively increase the mix's resistance to permanent deformation, it could compromise durability by reducing mixes' fatigue and cracking resistance. Many US Department of Transportation (DOT) agencies have adopted a lower laboratory compaction effort than recommended in the original AASHTO R35 "Standard Practice for Superpave Volumetric Design for Asphalt Mixtures".

In this collaborative study involving the Ontario Asphalt Pavement Council (OAPC – Council of Ontario Road Builders' Association, ORBA) and two participating industry partner laboratories, the impact of lowering laboratory compaction effort (from 125 to 100 design gyrations for category E, and from 100 to 75 design gyrations for category D) on design AC content and resulting performance-related properties was investigated. A round-robin mix design campaign was performed on a mix with traprock aggregates and PG70-28 AC using two different compaction effort levels. Flexibility Index using Semi-Circular Bend Geometry, Disk Shaped Compact Tension and Hamburg Wheel Tracking were further utilized to evaluate the impact of laboratory compaction effort on the performance of resulting mixes.

The laboratory study described in this paper supports continuing efforts to improve Ontario's Superpave asphalt mix durability. The paper discusses findings concerning optimum AC and Air Void (AV) contents, performance testing results, and whether lowering the design gyratory levels could create mixes that will stand design traffic loading without rutting and cracking.

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Paper : **4**

Investigation effect of using ACE fiber on pavement performance in the cold region - a Field and lab study

Negar Tavafzadeh Haghi, Phattaya (Tony) Dhitivara

Pavements in cold regions, including Alberta and Canada undergo extreme climate conditions. Prolonged cold winters, freeze-thaw cycles, and thaw season are some of the climatic loadings on the pavements. Meanwhile, climate change has pronounced the effect of these loads by imposing severe weather conditions such as more frequent freeze-thaw cycles. Considering sustainability and reducing in depletion of natural resources conservation, constructing more climate-resilient roads has become one of the prime strategies for road designers/owners.
One of the methods to construct a pavement that withstands the climate change imposed loads on top of the conventional loadings, is to modify the asphalt characteristics to have an improved mixture's performance, in terms of permanent deformation, fatigue cracking, and thermal cracking.
Reinforcing asphalts using fibers has been proven to be an effective method for improving the performance of asphalt mixtures. The objective of this research is to evaluate the performance of asphalt pavements using ACE fiber on test roads in Leduc County, AB, Canada. The project consists of five segments on two test roads that were rehabilitated or reconstructed in 2018. To effectively compare the field performance of ACE Fiber-incorporated and the conventional asphalt mixture, the two products were placed side by side in two different directions of the road.
A laboratory testing was completed at construction to evaluate the followings:
• Fatigue endurance resistance testing using Asphalt Pavement Analyzer (APA)
• Permanent deformation (rutting) resistance testing using APA and
• Moisture susceptibility testing using an Indirect tensile testing apparatus, AASHTO T-283 methodology.
To evaluate the field performance of the ACE fiber-reinforced pavement versus the conventional one, the test roads were visually inspected annually. The result of the field reconnaissance is included in this document. At the end of the 5-year study, Falling Weight Deflectometer (FWD) testing was performed to evaluate and compare the structural integrity of the test roads. The results were utilized to evaluate the rutting and fatigue cracking potential between the fiber-reinforced and conventional ACP

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Paper : **5**

Field Trial Sections of Lignin Modified Asphalt Mixes

Jean-Claude Carret, Sébastien Lamothe, Wesam Al-Falahat, Alan Carter

The asphalt pavement industry is often identified as an industry that is crucial but not very good for the environment. In fact, even if the use of recycled asphalt is now common, and that work is being done to reduce the energy consumption by reducing the temperature of the different asphalt mixes, more is expected from our industry in order to become a leader in terms of sustainable development. One of the possible tactics is to replace part, if not all, the asphalt cement in the mixes by a bio-sourced binder.

This paper covers a part of a study on the use of lignin to replace part of the asphalt cement in hot mix asphalt. Lignin, which is a biopolymer, is a by-product of the Kraft paper production process, and it's available at several locations in Canada. The overall project includes mix production methodology, in lab and in plant, as well as mix production, performance characterization and optimization, life cycle analysis and field test sections. This paper is specifically on the different field sections that were built with lignin-modified mixes in Canada and an introduction to life cycle analysis (LCA) of those different sections.

In the summer of 2021, four different field sections with lignin modified asphalt mixes were built in Canada. Two sections were constructed in the province of Quebec while another one in Ontario and a fourth one in Alberta. Two different processes were used, which are dry and wet process. In the wet process, the lignin was added directly in the asphalt cement by the asphalt cement supplier while in the dry process, the lignin was added at the plant after the asphalt cement in pre-weighted termofusibile bags. The amount of lignin, from 5% to 20% by weight of asphalt cement, and the addition process were tested in the laboratory beforehand. According to the laboratory results, lignin is easily added to asphalt mixes with either process with little differences in the obtained properties. The addition of lignin does increase the stiffness of the mixes at high temperature while having a limited effect on the low temperature performance when less than 10% is used. However, the addition of lignin does increase the viscosity of the mixes.

For all four trial sections, no compaction issues were perceived by the construction crews and the temperature of the mixes was not modified to take into account the presence of lignin. Other than the process of the addition of the lignin itself, the mix preparation process and the pavement construction was done without modifications. Visually no difference between the reference mixes, no lignin, and the lignin modified mixes were observed, and the properties of the lignin mixes prepared in the field are comparable if not better than the reference mixes. As for the LCA, it shows that the addition of lignin is a good option when compared to reference standard hot mix asphalt.

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Paper : **6**

A Simplified And Practical Approach To Asphalt Mixture Design To Enhance Durability

Gregory A. Harder, P.E.

To improve the field cracking/durability performance of their pavements, many highway agencies are actively working towards the implementation of a Balanced Mix Design (BMD) procedure. Most BMD approaches use performance index tests to balance asphalt pavement rutting performance with durability/cracking performance. Typical index tests for rutting include Hamburg wheel track test (HWTT), Asphalt Pavement Analyzer test (APA), or the High Temperature Indirect Tensile Strength test (HT IDT). The two most common cracking index tests include the Illinois Flexibility Index Test (FI) and the Indirect Tensile Cracking test (CT index).

Issues with BMD remain that could result in performance that fails to meet agency expectations of improvement.
• Most BMD applications do not perform long term oven aging (LTOA) of the mix bringing into question the validity of using BMD cracking criteria established using short term oven aging.
• Knowing the type of distress to be addressed is critical before choosing any index test. FI and CT index each function differently and each relate to different types of cracking.
• Selection of acceptance criteria is also critical. While many agencies may already have established criteria for rutting indices, benchmarking of current mixes is commonly used to establish cracking criteria with the mean value often chosen which could lead to a reduction in performance for some mixes.
• The process for selection of the design binder content for a balanced mix must also be considered. For a true "balanced" mixture, the optimum binder content selected should the midpoint between the minimum binder content required to meet the cracking criteria and the maximum allowable binder content allowed while still satisfying the rutting criteria. For some mixes this may not be appropriate as the range between minimum and maximum is too great.

The objectives of the paper are to:
• Determine the potential effect on HT IDT test results when using aggregate recovered from RAP using either the ignition oven method or by solvent extraction when compared to virgin mixes using the same aggregates;
• Demonstrate a simple method to select an optimum binder content for each mixture by:
o Start with completion of a volumetric mix design containing RAP – determine the volumetric design binder content (DBC)
o Prepare and test HT IDT samples at the DBC and also at -0.5%, +0.5%, and +1.0% binder
o Batch out additional samples at the DBC for HT IDT testing but before mixing, recover the aggregate from each RAP portion by ignition oven and/or solvent extraction and then blend with the virgin aggregate – add virgin binder to the DBC
o Plot the results on a chart with % binder vs. average HT IDT strength for each of the 4 different binder content mixes and connect the points – also plot the result from the mix containing recovered RAP aggregate
o Select the new optimum binder content as that binder content of the mix containing RAP that corresponds to the same HT IDT strength of the mix containing recovered RAP aggregate; and
• Demonstrate that this method addresses all of the previously discussed concerns.

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Paper : **7**

CHEMICAL ADDITIVE EFFECTS ON WMA RUT TESTING: ENHANCED RAP CAPACITY?

Christopher L. Barnes, Sina Varamini, Brandon Feener

Performance characterization testing of asphalt mixtures conducted by several agencies has shown that Warm Mix Asphalt (WMA) materials appear to be more susceptible than Hot Mix Asphalt (HMA) materials to higher levels of viscoplastic rutting and instability during laboratory Hamburg Wheel Tracking Tests, while this behaviour is not apparent in field performance. While reduced production temperatures are known to provide improvements in the as-placed Low Temperature (LT) grade of asphalt binders, continuous grade classifications of binders containing common WMA and anti-stripping chemical additives are shown to provide additional LT improvements. Following the approach of AASHTO R35 Appendix X2, it is shown that these additional improvements from these chemical additives may provide a significant contributing role in the elevated rutting behaviour observed in laboratory testing by shifting the critical stripping temperature of a mixture. This behaviour may encourage and enable higher Reclaimed Asphalt Product (RAP) content, resulting in more sustainable WMA and HMA concrete mixtures. Examples based on AASHTO R35 Appendix X2 blending analyses are presented along with the author's vision of research needs to evaluate this approach in laboratory and field testing prior to industry wide implementation.

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Paper : **8**

ESTABLISHING LOW-TEMPERATURE GRADE OF ASPHALT MIXTURES USING DIFFERENT PRACTICE-READY ASPHALT MIXTURE PERFORMANCE TESTING METHODS

Saeid Salehi Ashani, Sina Varamini and Susan Tighe

Thermal cracking is considered as one of the main asphalt mixture distresses that could affect pavements' serviceability. Unlike fatigue cracking, thermal cracking or the low-temperature cracking is referenced to be non-load associated distress significantly related to asphalt binder stiffness and relaxation. However, asphalt mixtures resistance to thermal cracking is also related to other mix components including aggregate gradation, physical and chemical interaction between binder and aggregate, and binder adhesion and cohesion of asphalt mix.

Through the years, a number of mix testing procedures have been proposed in North America to evaluate the thermal cracking resistance of asphalt mixtures. However, the majority of these tests could not gain acceptance within the industry as routine tests simply due to the level of complexity of these tests combined with lack of interest in incorporating performance testing as part of the mix design. However, with recent developments on the topic of Balanced Mix Design (BMD) and Engineered Mix Design (EMD), performance testing is becoming an integral part of the mix design development which requires considering cracking test methods.

To evaluate thermal cracking, fracture-mechanics based tests have been developed among which one of the most promising is the Disc-Shaped Compact Tension (DCT) test as per the ASTM D7313 test method. Generally, the DC(T) test has promising ability in capturing the resistance of an asphalt mix to the thermal crack initiation and propagation occurring at the tip of a notch by determining fracture energy. On the other hand, the BBR test, as a stress-controlled mode test, according to the AASHTO TP-125 test method is able to measure flexural creep stiffness, flexural creep compliance, the stress relaxation capacity of asphalt mixes as well as the stress induced in asphalt mixes at the desired cold temperatures.

For this study, five typical plant-produced surface course asphalt mixtures paved in Ontario meeting the SP 12.5 volumetric properties and containing asphalt grades of PG 52-40, PG 58-34, PG 64-34, PG 64-28, and PG 70-28 were selected to conduct DC(T) and BBR tests at multitude of temperatures, namely -18°, -24° and -30°. Furthermore, asphalt binders recovered from these mixes were evaluated using the BBR test method according to AASHTO T313 test method. This study, basically, will identify any relationship between the results of recovered AC properties and the results of DC(T) and BBR tests. Moreover, the critical thermal cracking temperature of asphalt mixtures will be determined based on the results of DC(T) and BBR tests. Furthermore, feasibility of adopting any of these methods, i.e., DC(T) and BBR tests, in Ontario will be evaluated and presented as a framework of capturing low temperature performance grade of asphalt mixtures.

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Paper : **9**

An Evaluation of The City of Calgary's First WMA Project - 16 Years Later

Lindsay Johnston, Art Johnston, Nasir-ul Mulk, Hawraa Kadhim, Bryan Palsat

The City of Calgary (The City) completed a Warm Mix Asphalt (WMA) technology demonstration project in 2005 to evaluate the (then) new technology and the potential benefits. Tetra Tech Canada Inc. (Tetra Tech), formerly EBA Engineering Consultants Ltd. (EBA), partnered with The City to complete the initial WMA technology evaluation in 2005. This project was one of the first evaluations of WMA technologies in Canada. In 2020 and 2021, The City and Tetra Tech completed a follow-up assessment of the same WMA project. This paper's focus is on the evaluation of the 2005 project data at the time of construction and the outcomes from a follow-up investigation completed 16 years later.

The WMA demonstration project was constructed in Calgary, Alberta, in 2005. The project compared three surfacing mix types: a conventional City of Calgary Mix B and two WMA alternatives including Warm Asphalt Mix (WARM Foam) technology and Evotherm® emulsion. The demonstration project team, which involved a collaboration between The City of Calgary, the paving contractor, and Tetra Tech, was successful in the design, production, and laydown of the new WMA technologies.

In 2021, The City and Tetra Tech completed a follow-up assessment of the 2005 demonstration project. The objectives of this assessment were to: 1) review details from the original project; 2) complete a field assessment of the in situ conditions; 3) develop and implement a suitable laboratory testing program; and 4) present the findings to The City. The intent of the investigation was to assist The City in determining the feasibility of further implementation of the use of WMA technology in the future.

The 2021 focus was on two fundamental pavement properties: the relative strength of the WMA layers and the properties of the asphalt binders used in the demonstration project:

 Strength Evaluation – This entailed using Falling Weight Deflectometer (FWD) on the three different WMA types and using back-calculation to focus on the WMA layers. The relative strengths of the three installations (Warm Foam, Evotherm®, and the Mix B control section) were assessed. The results were subjected to statistical analysis to determine the potential relative differences of the in situ strength properties.

 Binder Assessment – The assessment involved collecting samples of the mixtures to recover the asphalt binders. This was done by asphalt coring, asphalt binder extraction, asphalt binder recovery, and asphalt binder testing. Coring was undertaken to recover asphalt binders in sufficient quantity to undertake three performance grade characterizations for each of the binders (i.e., a total of nine binder assessments for each type). The binder extraction and recovery, which are critical in this process, were carefully performed to ensure not to artificially harden the binders during the recovery process.

It has been hypothesized that WMA binder should age more slowly given the reduced mixing temperatures and resulting in less aging. It would be important to the industry to determine if this hypothesis is in fact valid and, if so, to quantify the differences between binders.

The outcomes from this assessment show that the overall difference between the WMA and traditional Mix B both in observed field performance as well as in the laboratory data analysis was marginal. However, with respect to high temperature grading, the WMA products were graded marginally stiffer than the conventional HMA binder. This might be considered counterintuitive in that most practitioners might expect the WMA products to be less stiff than HMA due to less aging during production. This paper presents the steps taken as part of the investigation and reported outcomes that support these initial findings.

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Paper : **10**

Experience with High Friction Surface Treatment (HFST) in British Columbia

Manoj Jogi, Joy Sengupta

High Friction Surface Treatment (HFST) is a pavement surfacing system with exceptional skid resistant properties not typically provided by conventional materials such as the asphalt concrete or Portland cement concrete. At intersections, where vehicles often brake excessively and conflicts are high, HFST can improve safety significantly by enhancing the skid resistance quality of the pavement. In addition, HFST benefits locations with curves that need additional friction to improve sliding resistance.

HFST was used by BC Ministry of Transportation and Infrastructure (MoTI) in 2018 – 2020 to improve intersection and highway safety. This treatment is particularly suitable for locations where there is evidence of high proportion of intersection related collisions particularly, rear-end collisions. Fourteen signalized intersections and interchange ramps were selected based on input from Insurance corporation of British Columbia (ICBC). These were high collision locations with high traffic volume. In addition, one curved highway section was selected for HFST application. The Ministry developed HFST Special Provisions to be used for the projects that included testing requirements for the aggregates and the engineered polymer resin binder.

This paper describes these HFST projects in detail including construction and related issues and overall performance thus far. These locations are being continuously monitored. In addition, the paper describes the lessons learned and future consideration for HFST projects.

Paper : **11**

Increasing the performances of hot mix asphalt with RAP towards the use of pellets additive

Saeed Badeli, Saeed Badeli, Éric Lachance-Tremblay, Abdeldjalil Daoudi, Daniel Bissonnette

In Canada due to the extreme weather conditions, asphalt mixtures must have enough ability to withstands moisture damage, repeated freeze-thaw cycles and maintain an acceptable flexibility. As the industry is focusing on reducing its environmental impact, the use of Recycled Asphalt Materials (RAP) has increase rapidly in recent years. Previous studies have mentioned that using RAP poses some challenges in terms of early deterioration related to different types of pavement materials distresses.
In response to these challenges, the main objective of this study was to evaluate the practical performance of an asphalt mixture in regard to the Canadian context (cold climate) by using ready-to-use binder modifying additive (pellets). Additive pellets are a new generation of polymer modified bitumen that can be added at the asphalt plant and can increase the performances of the asphalt mixture. For this study, one type of asphalt mixture ESG-10 was considered. ESG-10 is a mix that is commonly used as a surface asphalt mixture in Quebec. Asphalt mixtures with 20% of RAP with and without optimal content of pellets were prepared in an asphalt plant as well as a reference mixture. Three (3) test sections were built in order to evaluate the in-situ performance.
The research methodology was divided into two parts: 1) in-situ evaluation, 2) laboratory testing. The quality control and quality assurance practices for different mixes were verified in the lab and the compaction results were checked in the field according to standard specification in Quebec. Pavement data survey analysis were completed on the test sections, such as the International Roughness Index (IRI) surveys as well as street view photos analysis. In the laboratory, the moisture damage susceptibility was evaluated with the indirect tensile strength (ITS) through the Tensile Strength Ratio (TSR) according to the AASHTO T 283 standard. Other laboratory performance analysis including The Thermal Stress Restrained Recovery Specimen Test (TSRST) for determining low temperature cracking and rutting resistance tests were completed in the Pavements and Bituminous Materials Laboratory (LCMB) at École de technologie superieure (ÉTS). The outcome of this research indicates that using pellets in RAP mix significantly improve the low temperature performances and bring more flexibility to the mix.

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Paper : **12**

Performance Assessment of High Content Reclaimed Asphalt Pavement Patching Mixes

Guangyuan Zhao, Frank Mi-Way Ni, Vince Aurilio, Susan Tighe

Asphalt pavements deteriorate over time under traffic loading and environmental impacts, leading to various distresses such as cracking and deformation. In most regions of Canada, the great temperature variation through the year can accelerate the degradation of asphalt pavements, creating more cracks (premature cracks) and potholes. Municipalities and road authorities typically implement the techniques to address cracks and potholes, including crack sealing, crack filling, and mill and replace. All these methods, especially the complete milling and replacing a section of roadway, utilize large quantities of virgin asphalt materials to repair the affected areas. However, the use of reclaimed asphalt pavement (RAP) in place of virgin asphalt materials has been recognized for decades for its economic and environmental advantages.

Nonetheless, because a high RAP content will increase the stiffness of the asphalt mixes and susceptibility to fatigue cracking and low temperature cracking, RAP content in an asphalt mixture for pavement preservation is typically no more than 35%, and the application is mainly limited to the unbound base layer, road shoulder, rural roads, and so on. Rejuvenators or recycling agents that consist of low-viscosity oil and certain modifiers can be added to improve the cracking resistance of high content RAP mixture. Still, the complicated interaction mechanism between the rejuvenator and RAP is unclear, particularly for high RAP mix.

This research aims to evaluate the performance of asphalt patching mixes using 100% RAP. Considering three types of rejuvenators and one RAP source in Ontario, four lab mixes and one field mix heated by infrared heating technology were prepared. Mix performance tests, including Hamburg wheel tracking, four-point bending, IDEAL-CT, and dynamic modulus, were performed, followed by a comprehensive mix performance evaluation of rutting resistance, fatigue life, cracking resistance, and stiffness. This research sheds light on the performance of asphalt patching mix using 100% RAP and rejuvenators, and the results can be useful in guiding asphalt pavement preservation treatments and maintenance using high content RAP mixes.

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Paper : **13**

Comparison of Low Temperature Cracking Tests with Field Monitored Results of HMA Test Sections

Joseph Podolsky, Michael Vrtis, Carolina Rodezno

As the asphalt pavement industry moves towards balanced mix designs that optimize expected rutting and cracking performance, there is still disagreement and regional preference surrounding the cracking test utilized. To address this, the Minnesota Road Research Facility (MnROAD) and the National Center for Asphalt Technology (NCAT) developed the Cracking Group (CG) experiment to build and monitor test sections in different climatic conditions to evaluate laboratory cracking performance tests. Test sections were constructed focusing on top-down cracking at NCAT's Test Track in Alabama, USA in 2015. MnROAD sections were designed to evaluate low-temperature cracking (LTC) performance tests by providing a range of field cracking.

The objective of this paper is to evaluate various laboratory LTC performance tests on eight unique asphalt mixtures from eight test sections at MnROAD constructed in 2016. To achieve a wide range of cracking performance, conventional Minnesota mix designs were modified to incorporate various levels of polymer binder modification, reclaimed asphalt pavement, and recycled asphalt shingles. Each section comprised two 12-foot travel lanes with a 10-foot driving lane shoulder and a 4-foot passing lane shoulder. Five inches of asphalt were placed in two lifts; the same mix was used in both lifts of a given section. The shoulders were paved with the same structure as the travel lanes.

Field performance from five years of traffic and five winter seasons is summarized and compared to lab tests on plant-produced unaged (reheated) and critically aged specimens. The critical aging procedure used was oven aging loose-mix aging at 135°C for 6 hours. The tests considered in this report are the Disc-Shaped Compact Tension (DCT), Low-temperature semi-circular bend (SCB), the Illinois Flexibility Index (I-FIT), the IDEAL CT, and the Texas Overlay Tester. Field performance was documented with regular measurements of cracking, rutting, and roughness. Cracking was the controlling distress in the field sections, however a forensic investigation identified delamination as the main source of the observed cracking thus making it difficult to discern LTC performance. The shoulders did not develop delamination or fatigue that was observed in the travels lanes and thus only had transverse LTC. The generally expected trend of cracking potential for each mix was observed; with the section using the softest liquid binder having no LTC and the section with a known poor-performing aggregate having the highest LTC. When comparing shoulder LTC and the performance tests, the DCT and Texas Overlay Test had the highest correlations on both reheated and critically aged material. The IDEAL-CT and I-FIT had low correlations, but the I-FIT was successfully able to identify the best and worst performing mixtures at both aging conditions. The IDEAL CT was able to identify the worst performer at both aging conditions. This study has found that each laboratory LTC test examined had some positive results and that the tests with better correlations also require greater sample preparation and testing time.

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Paper : **14**

Evaluate IDEAL-CT for Elastomer Modified Asphalt Concrete

Dandi Zhao, Mike Aurilio; Pejooohan Tavassoti; Hassan Baaj

The indirect tensile asphalt cracking test (IDEAL-CT) has demonstrated an excellent potential to evaluate asphalt concrete cracking performance. The development of the IDEAL-CT index (CTindex) uses the stress intensity factor initially developed for materials with brittle fracture. It works well for unmodified asphalt or reclaimed asphalt, which may exhibit a relatively brittle behaviour under certain loading conditions. However, elastomer modified asphalts exhibit a more ductile behaviour that was not considered in the original development of CTindex. Therefore, it is necessary to further evaluate this cracking index using elastomer-modified asphalts. This research uses PG 58-28 and PG 64-28 as a base binder and modified with increasing concentrations of styrene-butadiene-styrene (SBS). The IDEAL-CT tests were conducted using two different equipment to evaluate the reproducibility of the test results when using different setups. The loading device was found to play a significant role in the cracking test. The CTindex, the peak load, and its corresponding displacement show different trends as the dosage of polymer increases from both devices, whereas the toughness shows a more consistent trend. Nevertheless, the results show that the CTindex cannot effectively characterize the elastic response for elastomer-modified asphalt concrete specimens. Moreover, the elastic behaviour can contradict the observed changes in the current cracking index. The fracture energy density limit (EFf), the dissipated creep strain energy density (DCSEf), and the elastic energy (EE) were calculated and then compared with the results from the Linear Amplitude Sweep (LAS) Test. The fracture energy density shows an excellent correlation with the LAS test results and this suggests it is likely a better indicator to use when characterizing the cracking performance for the elastomer-modified asphalt concrete.

Paper : **15**

Industry Standardization of Asphalt Mixture Sampling, Preparation, and Aging for Performance Testing

Brandon Feener, Sina Varamini, Christopher Barnes, Fujie Zhou, Adam Marlin

Transportation agencies have been investigating and/or implementing a Balanced Mix Design (BMD) approach using performance-based asphalt mixture testing to optimize rutting and cracking resistance and to investigate their use for Quality Assurance (QA) and Quality Control (QC) during asphalt production. A critical component of BMD and the QA/QC framework is selecting performance verification tests and establishing aging conditions and acceptance criteria. This study evaluated performance-based testing results from two laboratories with the objective of characterizing several asphalt mixtures supplied for the province of Nova Scotia. Seven Plant-Mixed and Laboratory-Compacted (PMLC) asphalt concrete mixtures were assessed using the Hamburg Wheel Tracking Test (HWTT), IDEAL-RT, IDEAL-CT and Semi-Circular Bend (SCB) testing procedures. Analysis revealed inconsistencies between the participating laboratories which was linked to the procedures used for warming loose plant-produced materials prior to splitting and AASHTO R30 short-term conditioning. Consultation with other transportation agencies confirmed that industry lacks a standardized procedure for warming plant-produced samples. Variation in the size and shape of loose material samples was found to be impacting warming times which caused differences in mixture aging and reduced consistency amongst laboratories. It was determined that there is an imminent need within the Canadian asphalt industry for a collaborative approach to standardize sample size, geometries, and warming methods used to prepare plant-produced asphalt for conditioning and compaction to promote consistent results. The authors proposed a standardized nominal sample mass and geometry along with oven and microwave methods. It is recommended that these methods be further evaluated to refine and establish equivalence for variations in volumetric properties and asphalt binder grades.

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Paper : **16**

Developing a Framework for the Adoption of Performance Testing

Mike Aurilio, Mike Aurilio, Vince Aurilio, Stacy Diefenderfer, Jhony Habbouche, Ilker Boz

The adoption of performance-based testing is becoming more common as highway agencies implement balanced mix design (BMD). The merits of BMD have been well discussed, however there are still questions that need to be addressed. There are challenges with the selection of the most suitable performance tests, their associated conditioning, and aging protocols, in addition to proper data collection, understanding the correlation to field performance, and the relationship to quality control / quality assurance (QC/QA) specifications. The development of a specification from scratch can appear to be quite a large task. This paper will discuss these different aspects with the aim of proposing different approaches for developing a framework for the adoption of performance testing. A systematic approach to test selection and the development of field trials must be taken to avoid erroneous correlations and to understand how to make performance evaluation the central focus of the design process. In areas where there is little to no experience with performance testing, a significant, yet challenging shift in mindset may be needed. Testing programs can be designed in such a way that information can be collected on test variability, test sensitivity to different mixture parameters, and test correlation with field performance with the intention of developing specifications and growing an understanding of the methodology. The success of adopting a performance-based approach will rely on the practitioners' ability to evaluate mixtures using the appropriate criteria and modify the mixtures accordingly. The details of such a program can be difficult to determine, but this paper will propose different approaches which can serve as a template for collecting adequate information that can be applied towards the goal of adopting performance testing.

Paper : **17**

Things Don't Always Get Better with Age: Challenges with DeltaTc after 40 h PAV

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In recent years the asphalt industry has seen an influx of additives and softening agents to assist with the incorporation of higher percentages of RAP and to overcome a shortage of soft virgin binders in the market. The effects of these non-asphaltic materials on pavement performance are not always well-captured by standard Superpave™ testing requirements. This has led to the introduction of additional tests in an attempt to better differentiate performance. One common criticism of Superpave™ is that the 20 h PAV aging might not be harsh enough to enable observation of poor performance with certain additives. In turn, Delta Tc testing on 40 h PAV-aged binder has been proposed as an additional specification in some jurisdictions.
The requirement for 40 h PAV aging can create significant challenges in producing binders; thus, it is imperative to understand whether this extended aging provides additional information vs shorter aging protocols (20 h PAV, RTFO). The goal of this work was to identify methods to achieve robust quality differentiation without introducing significant production challenges. To that end, understanding of the quality differentiation provided by 40 h PAV in comparison to alternative approaches of performance discrimination was sought. To achieve that goal, several neat and blended asphalt binders were aged using several different methods and evaluated on the basis of rheology and composition. It was found that increasing the PAV time or temperature did not significantly change the relative performance ranking of the binders compared to 20 h PAV, particularly for straight-run asphalts. Furthermore, other metrics, including phase angle at constant modulus measured after 20 h of aging, were able to differentiate the binders in the same manner as Delta Tc after 40 h. Chemical analysis data for this sample set indicated that compositional changes occurred largely linearly with PAV time, again suggesting that it should be possible to assess oxidative aging susceptibility without extending PAV aging. The results of this study also highlight the inherent high variability of the 40 h Delta Tc test, and the variations introduced by running two 20 h PAV cycles compared to a continuous 40 h cycle.

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Paper : **18**

Effect of Rejuvenators and Anti-Stripping Agents on Creep Recovery Property of Modified Aged Binder

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Many studies have been conducted to develop a rheological parameter that can assess deformation and creep characteristics of modified bituminous binders, whereas very few studies show the effect of rejuvenators and anti-stripping agents on creep recovery performance of binders. This paper employs the Multiple Stress Creep Recovery (MSCR) test as per AASHTO T350 to understand creep recovery properties of aged binders. A PG 58-28 binder was conditioned using Thin-Film Oven Test (TFOT) to obtain the aged specimen. Next, the aged binder was blended with varying doses of three rejuvenators, namely, untreated waste cooking oil, treated waste cooking oil, and Hydrolene. Four different anti-stripping agents: ZycoTherm SP2, Kling Beta 2914, Pave Bond Lite, and AD-Here, were combined with PG 58-28 and modified with two different modifiers (i.e., SBS and Gilsonite) to analyze the influence of anti-stripping agents on the creep recovery performance. Then, Rolling Thin Film Oven (RTFO) protocol was followed to simulate asphalt production time aging. Performance of these binders was compared using non-recoverable creep compliance, stress sensitivity analysis, and percent recovery analysis. AASHTO M 332 specifications have been used to classify all the 39 binders based on the Jnr value at 3.2 kPa and stress sensitivity. In addition, Polymer and Quadrant procedures specified by the Asphalt Institute (AI) were employed to interpret the test results. According to the experimental data, 6% of treated waste cooking oil as a rejuvenator and 0.075% ZycoTherm as an anti-stripping agent modified with SBS satisfied binder performance requirements and showed the best creep recovery performance. Furthermore, SBS-modified binders outperformed Gilsonite-modified binders in terms of creep recovery performance.

Paper : **19**

Evaluation of the Impact of RAP Gradation on Cold Recycled Mixtures

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Throughout the duration of a Cold In-place Recycling (CIR) or Cold Central Plant Recycling (CCPR) project, the gradation of the reclaimed asphalt pavement (RAP) generated during production can vary over time from a number of factors such as ambient temperature, in-situ pavement materials, and extent of pavement distress. Although equipment adjustments can make slight variations to the pulverized RAP gradation, particularly controlling RAP top-size; few adjustments exist for contractors to manage the resulting gradation created during RAP generation. Whether from field-produced, lab-compacted specimens or the collection of cores, constraints around field testing and time create obstacles for agencies to specify strength or density requirements of the mixture. As a result, mix designs for these processes are performed across gradation bands in order to encompass likely encountered gradations in the field. Typical Quality Control (QC) protocol involves the collection of pulverized RAP, which is tested with a dry gradation analysis during production. Comparing the field and mix design gradations enables accurate adjustments to be made in the field to the amount of stabilizing agent, either foamed asphalt or asphalt emulsion, as well as the moisture added to the Cold Recycled mixture. This procedure demonstrates the importance of the mix design being performed to accurately reflect the cold recycling process, simulating possible differences in RAP gradation and ensuring the resulting mixtures exceed minimum specified test criteria.
The purpose of this study was to determine the impact of pulverized RAP gradation on the characteristics of resulting CIR and CCPR mixtures stabilized with emulsion. The study utilized samples of milled RAP collected after pulverization and prior to mixing with emulsion during various CIR and CCPR projects. The samples were initially collected for quality control testing, to verify the field-crushed gradations aligned with the respective project's mix design. The field gradation samples were retained, allowing lab specimens to be mixed with emulsion, compacted, and conditioned in a controlled environment, modeled after the CIR or CCPR mix design procedure. The resulting specimens underwent volumetric testing and Marshall Stability testing to measure cohesion in the resulting mixture. Trends were analyzed from samples collected across 7 distinct cold recycling projects, to determine if variation in RAP gradation influences mixture density and ultimately stability of the mixture.

2022 Paper Abstracts in Tentative Presentation Order

Paper : **20**

A Comparison of I-FIT and IDEAL-CT Cracking Tests for Traditional Superpave and Superpave5 Mixture Designs

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Agencies continue to show interest in better understanding field performance of Hot Mix Asphalt in the mix design phase. This interest is driving the industry to better understand Balance Mix Design (BMD). In addition to volumetric requirements, BMD includes additional testing that may indicate a mixture's rutting and cracking potential. As of 2022, the test methods that have gained the most interest from industry and agencies to understanding cracking potential are the Illinois Flexibility Index Test (I-FIT) and the Indirect Tensile Asphalt Cracking Test (IDEAL-CT).

While both tests are used to predict cracking susceptibility of mixtures, these tests are different in the way they produce results. I-FIT is classified as a crack propagation test where a crack is continued by a fabricated notch in the specimen. IDEAL-CT is considered a crack initiation test because the crack is created at the time the specimen is loaded into compression. These tests are similar in that the fracture energy is determined and additional information from the post-peak curve is utilized to calculate the cracking indices.

This research analyzes two Illinois Department of Transportation (IDOT) traditional Superpave mixtures (SP4) and two Indiana Department of Transportation (INDOT) Superpave5 mixtures (SP5). For traditional Superpave specifications, mix designs are completed to target 4.0% air voids and cracking tests are performed on specimens at 7.0% +/- 0.5. This higher air void content of the cracking test specimens reflects the anticipated air void content of the mixture at placement. Superpave5 mixtures are different in that they are designed and constructed to target 5.0% air voids, thus the performance tests were conducted at 5.0%.

In this research, results of each cracking test from the four asphalt mixtures and a select number of design iterations are evaluated to understand trends between the two tests. Variability, in terms of Coefficient of Variation (COV), will also be analyzed to compare the reproducibility of the tests. Discussion is provided on the production, specimen fabrication, and execution of each test method.