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

2024 Paper Abstracts in Tentative Presentation Order

Paper : **1**

Effect of Placing Hot Mix Asphalt on Strength Development Cold In-Place Recycled Layer

Arash Ghahremani, Jean-Martin Croteau

Understanding the strength development of asphalt emulsion-based cold in-place recycling (CIR) mixtures requires a comprehensive understanding of the physicochemical aspects of cold mixes, including asphalt emulsion characteristics and their interaction with aggregates.
Curing of cold in-placed recycled (CIR) mixes is typically considered time-dependent and prolonged due to the presence of water. This temporal evolution presents challenges, particularly in bridging the disparities between laboratory curing conditions and real-world field scenarios, which may lead to specification requirements that do not always align with practical realities. This study investigates the impact of heat and compaction associated with placing hot mix asphalt (HMA) on top of a CIR layer.
The research aims to evaluate the influence of heat transfer within the CIR layer and its subsequent interaction with overlaid HMA. Through a combination of heat transfer analysis and slab extraction from the field-constructed CIR layer, both before and after the placement of the asphalt overlay, the compaction profiles using a gamma densimeter bench-type device have been analyzed. This approach enables us to examine the efficacy of heat transfer and its impact on the curing process, as well as the overall performance and integrity of the cold recycling layer.
The findings of this research provides valuable insights into optimizing the CIR curing process by investigating the interplay between heat, compaction, and material properties. This study advances understanding of heat transfer dynamics in CIR applications and offers practical implications for improving construction practices.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **2**

Evaluating the Laboratory Rutting and Cracking Resistance of RAP Asphalt Mixtures Designed with 60 Percent RAP Binder Availability

Amma Agbedor, R. Michael Anderson, Wesley G. Cooper

It is generally accepted in the asphalt industry that performance testing needs to be incorporated into asphalt mix design methodologies to better predict performance, especially with mandates to increase RAP usage in asphalt mixtures. While the roadmap to the implementation of performance testing looks different for many agencies, it is important to work on solutions that agencies ? specifically agencies who may not be ready to implement concepts like balanced mix designs (BMD) due to budget constraints, availability of testing laboratories, etc. ? could utilize in the meantime.

This study investigates strategies to enhance the durability of asphalt mixtures with RAP, specifically focusing on increasing effective asphalt binder content and incorporating balanced mix design (BMD) concepts. The objective is to compare the performance test results of asphalt mixtures designed with different assumptions about RAP binder availability. The experimental hypothesis posits that assuming a lower percentage of RAP binder availability (60%) will result in asphalt mixtures with better resistance to cracking and meeting rutting performance requirements.

The study utilizes a Marshall asphalt mix design (Class 12.5 mm) provided by Alberta Transportation, comprising 66% Coarse Aggregate, 10% Manufactured Fines, and 24% RAP. The asphalt binder used is PG 52-34. Modified designs are tested using a Superpave Gyratory Compactor, with 50 and 75 gyrations to compare volumetric properties. Specimens undergo short-term and long-term oven aging before testing. Preliminary rutting, cracking, and recovered asphalt binder results indicate improved mix durability when assuming 60% RAP binder availability.

The findings also highlight the impact of compaction on test results, emphasizing the need for serious discussion on performance testing considerations. The study suggests that assuming a lower RAP binder availability leads to additional asphalt binder in the mix, improving compaction. However, this improvement is not fully captured in performance tests, raising questions about the validity of test procedures and their representation of real-world conditions concerning RAP binder availability. The study concludes with a call for reevaluation of mix volumetric requirements and consideration of compaction effects on performance testing.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **3**

Exploring the Laboratory Performance of High Reclaimed Asphalt Pavement Mixes for the Province of New Brunswick

Natalie Lee, Xiomara Sanchez-Castillo

To aid in the country's climate plan to achieve net-zero emissions by 2050, the asphalt industry must increase the content of reclaimed asphalt pavement (RAP) used in traditional asphalt mixtures. Although there are various benefits to using RAP, the aged binder it contains leads to reduced elasticity and flexibility, fatigue cracking, and inconsistent performance of the final mixture. Two approaches to mitigate these negative effects include using softer binders and using rejuvenating agents (RA). To investigate the effect of both softer binders and RA?s, three mix designs were created: one virgin mix with a conventional binder, PG 58S-28, one mix with 28% RAP content and a softer binder, PG 52S-34, and one mix with 50% RAP content and a bio-based RA. To follow best practices, the RAP was fractionated on the 4.75mm sieve. Each mix was tested to ensure conformance with the New Brunswick Department of Transportation and Infrastructure (NBDTI) specifications of percent air voids and voids in mineral aggregate (VMA). Each mix was subjected to the Hamburg Wheel Tracking Test, the Ideal Rutting Test, the Indirect Tensile Cracking Test, and the Resistance to Moisture Induced Damage test. The results were utilized to compare the rut depth, cracking susceptibility, and moisture damage of all three mixtures. This study provides insight into the impact of RAP and the effect of the use of a softer binder or an RA on the tolerance to rutting and cracking of the high RAP mixes compared to the performance of the virgin mixes. It is expected that documenting these efforts encourages both the government and local contractors to increase the RAP content in their mixes. However, to ensure the satisfactory performance of these high RAP mixes, the industry must adhere to best practices for RAP storage and usage. To further demonstrate the value and performance of these high RAP mixes, a field trial is also recommended.

Paper : **4**

Use of Milk of Lime to Protect Tack Coats

Martin Lavoie, Félix Doucet and Idir Benamara

Laydown of asphalt mix layers involves using tack coat to promote bonding between the asphalt layers. It?s known that adequate interlayer bonding is critical for the asphalt layers to behave monolithically and provide adequate strength, avoiding delamination, fatigue cracking and potholes. Frequently, construction vehicles and equipment pick-up the thin bonding layer on their tires and leave the existing roadway with little or no tack coat, mainly in the wheel paths. Tracking by truck tires may also results in deposits of tack coat material on adjacent pavement surfaces.
Pilot projects using a milk of lime to protect the tack coat during construction have been done in Quebec by the Ministère des Transports et de la Mobilité durable (MTMD) since 2022. This process has been used in Europe since many years to prevent tracking of the tack coat material. The MTMD projects spreading over three years allow to familiarize with the particularities of this process on construction sites and to verify his efficiency.
To study the effect of the milk of lime on the properties at the interface of the asphalt layers (bonding and density), laboratory tests were carried out on cores taken from monitored sites. The study mainly consisted of comparing sites with and without lime also verifying the effect of the liquid state of the lime. Tomodensitometry imaging analysis showed that the use of milk of lime does not affect the density of the layer over the lime. An apparatus to measure the adhesion of layers (AMAC) was used to measure the tensile strength at the bonded interface. The results show that milk of lime does not deteriorate the bonding strength between layers. An Interlayer Shear Strength (ISS) test currently under development will also be used to further study the effect of the milk of lime on the shear strength of the bonded interface.
The implementation of the use of milk of lime will continue in the coming years with the aim of making this process a common practice on the MTMD construction sites.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **5**

Experimental Analysis of Electric Road Pavement Structures in Heavy Vehicle Simulator Tests

Danial Arzjani, Jean-Claude Carret , Jean-Pascal Bilodeau, Amélie Griggio, Marc Proteau, Itai Koren, Diego Ramirez Cardona

Electric Road Systems (ERS) emerge as a powerful tool to foster the adoption of electric vehicles (EVs) and mitigate the environmental impact of the Canadian transportation sector, which is responsible for roughly a third of the country?s greenhouse gas emissions. Electric roads (e-roads), particularly those incorporating wireless inductive charging, play a pivotal role in enabling dynamic on-the-road charging, especially for heavy-duty vehicles. This technology extends the travel ranges of EVs and diminishes the necessity for frequent recharging stops while allowing for smaller battery sizes. Despite the recognized energy efficiency of inductive charging, there exists a research gap concerning the impacts of the integration of inductive charging coils into the pavement structure, which is addressed in this study for the Canadian context.

For this research, three distinct pavement structures were constructed within the large-scale laboratory test pit at Laval University (Quebec, Canada) to compare the mechanical behaviour of e-Road pavements including inductive coils and a conventional pavement structure. The pit's central section (4m long) is divided into three equal parts: "Section 1" (S1) and "Section 2" (S2), each incorporating inductive charging coils with surface course thicknesses of 7cm and 5cm, respectively. A third section, "Control," serves as a reference for a conventional road structure, featuring a 5cm thick surface course without inductive charging coils.

The pavement structures were equipped with various sensors, including strain gauges, load cells, temperature sensors, and humidity probes to strategically monitor their behavior from the surface course to the underlying soil. Mechanical tests were carried out on the pavement structures using a heavy-vehicle simulator (HVS) positioned over the test pit.

The test plan encompasses diverse traffic and environmental conditions, including different water tables (low and high), temperatures (-10, 0, 10, and 20 °C), loads ranging from 3500 kg to 5500 kg on a half-single axle using a wide base single tire, and three loading positions that account for wheel position in real-world traffic scenarios. Additionally, the freezing/thawing of the subgrade is considered. In each test scenario, dynamic data from seven replicates (passes) was averaged and exported to Excel using MATLAB codes. This paper presents vertical stress measurements at the top of the granular base layer in all sections exposed to the specified traffic and climate conditions, with a particular focus on the effects of freeze and thaw on the subgrade.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **6**

Evaluation of Asphalt Tack Coats in Saskatchewan

Rielle Haichert, Ania Anthony, Aziz Salifu, Kelly Pederson, Roberto Soares

Asphalt tack coats, when properly applied, are effective at bonding layers of Hot Mix Asphalt (HMA) pavement to ensure load transfer between pavement layers under traffic loading. Tack coats are particularly useful in providing shear stiffness at the interface between pavement layers. In recent years, Saskatchewan Ministry of Highways (Ministry) adopted the interlayer shear strength test (AASHTO TP114, known as the LISST test) to evaluate the bond strength of pavement layers with tack coats. In this study, a review of the conditions of various HMA pavement sections constructed in the last three years was conducted, and interlayer shear test results were assessed.

The LISST test applies a monotonic load to failure, which is not representative of the actual loadings that a pavement structure and tack coat are subject to during its in-service life. To further explore interlayer bonding, laboratory compacted HMA specimens with tack coats were tested using cyclic loading applied to the layer interface. To establish the loading conditions that a tack coat is subjected to, a nonlinear stress-dependent three-dimensional finite element analysis was performed on a typical rural highway structure under standard truck types, and the shear strain profiles in the tack coat were analyzed by various heavy truck loadings within the road structure. The shear stress condition from the finite element analysis was then encoded into the test apparatus to simulate the cyclic shear stress profile to which the tack coats are subjected, and the resultant strain/cyclic fatigue was evaluated. These results were then compared to the results of the standard interlayer shear test.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **7**

Assessing the Mechanical Properties and Ageing Effects of Recycled Plastic-Modified Asphalt Mixes

Carla De Oliveira Pinto, Gabriel Orozco, Alan Carter

Several by-products or waste of other industries find their way in asphalt mixes. One of those products is plastic. There are several types of plastics and their capacity to positively affect asphalt mix properties and performances strongly depends on the plastic type. Using recycled plastic in asphalt pavement offers several significant benefits, both environmental and practical. Recycled plastic incorporation in asphalt pavement presents a sustainable solution to the burgeoning plastic waste crisis while theoretically enhancing the performance and longevity of road infrastructure. By diverting plastic from landfills and oceans, this practice mitigates environmental degradation and reduces carbon emissions associated with traditional asphalt production. Moreover, it addresses the pressing need for circular economy initiatives by repurposing plastic waste into valuable construction material.

According to several studies, the inclusion of recycled plastic in asphalt formulations improves pavement durability and resilience. Plastic polymers enhance asphalt binder properties, resulting in superior resistance to cracking, rutting, and moisture damage. This leads to extended pavement service life, reduced maintenance requirements, and lowered life-cycle costs. However, there are many unanswered questions regarding compatibility issues between recycled plastic and bitumen and the recyclability of the plastic modified asphalt mixes. Another major concern is linked to the limited information available on how the mixes containing plastic change with ageing. Many plastics become brittle with time, and this could be detrimental to their use as partial replacement of the bitumen, mostly in cold climate like in Canada.

The goal of this study is to evaluate the impact of ageing on plastic modified asphalt mixes. To this end, a 0-10mm surface mix was designed with 1 or 2% recycled low-density polyethylene (LDPE) plastic added in the semi-dry method. In both cases, the bitumen content was reduced by 0,5%. The plastic modified mixes and the refence mix, without plastic, were then artificially aged in laboratory for six days at 85oC before being compacted and tested in complex modulus. The results have shown that the introduction of plastic do not significantly alter the aged properties of the mixes. The presence of plastic has little influence on the compactability of the mixes, but it does significantly increase the stiffness. There is a clear benefit from the plastic when looking at the high temperature properties without a significant decrease in properties at low temperature. The results obtained here show that using plastic as a partial replacement of bitumen is not only beneficial from an environmental point of view, but it is also positive when looking at the asphalt mixes mechanical properties.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **8**

Investigation of the influence of air voids and gradation on the complex modulus of asphalt mixtures using impact resonance tests

Morteza Rezaeizadeh Herozi, Jean-Claude Carret, Lucas F. A. L. Babadopulos and Kevin Bilodeau

The complex modulus of asphalt mixtures (AM) has a significant influence on the durability, performance and lifespan of asphalt pavements. Though, in most quality control procedures, the complex modulus of AM is not evaluated because standard testing methods are too expensive and time-consuming. Meanwhile, the complex modulus of an AM specimen is directly related to its resonance frequencies, that can be assessed through impact resonance tests (IRT). IRT is a rapid and cost-effective testing method in comparison to classical testing methods, in which the use of expensive hydraulic presses is required to determine the complex modulus of AM. Furthermore, understanding the influence of AM design variables such as gradation or air voids on the complex modulus could be useful for optimizing AM design and improving their quality. Therefore, this study aims to evaluate the influence of the gradation and air void content on the complex modulus determined from IRT at two different temperatures. To achieve this purpose, specimens of the same AM with three different gradations were compacted with the Superpave Gyratory Compactor (SGC). For each gradation, 4 SGC specimens were fabricated: one was compacted up to 200 gyrations, and 3 were compacted up to 80 gyrations. Then, one cylinder with a length to diameter ratio of 1.6 was extracted from each SGC specimen. IRT was performed on the 12 cylindrical specimens at ambient and -20°C temperatures. Finite element modeling was used to back-calculate the complex modulus of the specimens at the fundamental resonance frequency determined from IRT results. Finally, a statistical analysis was performed to evaluate how air voids and gradation influence the complex modulus determined from IRT. The results confirm that IRT can successfully be implemented to improve the quality control of AM. Also, the complex modulus is mostly influenced by the air void content, while the effect of the gradation is limited.

Paper : **9**

Phase Angle at Constant Modulus in Polymer-Modified Asphalts

Pavel Kriz, John A Noel, Anton Kucharek, Christopher M Campbell

While refinery asphalt production in Canada remains largely focused on processing heavy asphaltic crude oils from vast Canadian reserves in Alberta and Saskatchewan, the binder formulation used in Canadian roads continues to evolve during the last two decades. The changes are predominantly driven by economic and environmental considerations rather than availability of local, high quality refinery produced asphalts. The ask from the industry is to produce more economic and durable asphalt, while reducing its environmental impact. This has led to increased use of polymer-modified asphalts (PMA), recycled materials of several kinds, softening oils and bio-sourced materials to mention the most common.
The chemical composition of binders has thus significantly evolved since SuperPave? specification development and validation in the 1990s. It has been demonstrated that in some cases the current specification is no longer able to effectively screen out poorly performing binders. In our previous work, we have identified, that phase angle measured at a prescribed constant modulus can be a reliable and reproducible parameter to improve the specification ability to screen out poor performers. In fact, these are mostly binders suffering of poor colloidal stability and fast oxidative and physical aging rates. The parameter works well across varying compositions of distilled or blended binders. In elastomer modified asphalts however, the phase angle is no longer a simple function over a range of loading times. In some cases, the validity of time-temperature superposition principle is also questionable. It is not clear at this point if a phase angle limit is a justifiable specification parameter for PMAs. This work attempts to study phase angle dependency on complex modulus in polymer modified asphalts to shed some light if a currently proposed specification parameter has validity for PMAs.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **10**

Assessment of the use of industrial and construction byproducts in full-depth reclamation (FDR) under normal and freeze-thaw conditions

Maicon Basso Dos Santos, Éric Lachancce-Tremblay, Sébastien Lamothe, Jean-Claude Carret

Due to the emerging needs concerning the reduction of carbon footprint and fostering circular economy in infrastructure projects, finding techniques that provide it is an important aspect to improve the environmental performance of these projects. Taking into account Quebec?s context, the circularity index is only 3.5%. This result is lower than the global one (8.6%). One way to enhance this indicator is the use of road rehabilitation techniques that provide the full reuse of materials. In particular, the circular economy principles already apply to the Full-depth reclamation (FDR) technique. FDR is a pavement rehabilitation technique that is carried out in situ, at ambient temperature and provides the reusing of materials from the existing pavement. This technique, offers significant economic and environmental advantages, as the materials in place are 100% reused. Also, in 2018, this rehabilitation technique accounted for almost 53% of rehabilitated sectors on the Quebec Transportation Ministry (MTQ) network. With these aspects in mind, this project aimed to investigate the use and valorization of recycled materials, particularly industrial byproducts, in FDR mechanical stabilization. The recycled materials studied were: Reclaimed Asphalt Pavement (RAP), Reclaimed Concrete (RC), Virgin Aggregate (VA) and Steel Slag (SS). Three combinations of recycled aggregate were studied. The first one, RAP/VA (reference) was composed of 40% RAP and 60% of VA. The second one (RAP/VA/RC) was 30% of RAP, 45% of VA and 25% of RC. The third (RAP/VA/SS) was composed of 35% of RAP, 50% of VA and 15% of SS.

For laboratory testing, firstly, the optimum moisture content (OMC) and maximum dry density (MDD) were determined by the modified Proctor for each combination. Afterwards, the California Bearing Ratio (CBR) test was performed on each sample (or combination) under normal, unsoaked and soaked, conditions to measure their bearing capacity. After that, the same conditions were tested to 4 freeze-thaw cycles (FTC) in Nordic region conditions. Finally, the CBR test is carried out on the samples to see if FTC reduces the bearing capacity of the material.

The results showed that increasing the RAP content decreases the CBR value in usual, unsoaked and soaked, conditions. For the mixture VA/RAP/RC, CBR after soaking was higher than CBR in unsoaked condition. Additionally, higher CBR results were found for VA/RAP/RC, presenting a CBR of 60% in the normal soaked condition. For the mixture composed of VA/RAP/SS, there was no observed significant variation in the results from the soaked to unsoaked condition. Furthermore, the results were not greatly influenced by the FTC. Overall, results showed that SS and RAC can be used for base course mechanical stabilization. Moreover, pavement design simulation showed good performances in time for pavement with this kind of material as a base course. Finally, the results showed the importance of taking into consideration FTC when evaluating pavement material performance.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **11**

Rheological characteristics of high-float emulsion residues

Martin Jasso, Darren Anweiler, Brett Lambden

Asphalt emulsion technology has always played a vital role in pavement construction and preservation. However, despite the efforts of researchers, a performance-driven specification for asphalt emulsions has yet to be established. This is largely due to the intricate nature of asphalt emulsions, which differ significantly from hot and warm mix asphalts, and the long-term approach to asphalt emulsions as a trial and error. Particularly the additional step in asphalt emulsion technologies ? the breaking of emulsions and formation of asphalt film on aggregates associated with development of film internal structure is little understood.

The special type of asphalt emulsion with high-float characteristics became very popular in Canada. The high-float emulsions are formulated with tall oil soap that is responsible for the development of a gel-like internal structure. The altered internal structure has several advantages over simple asphalt emulsions. Among the most important belong greater film strength, higher resistance to bleeding and the use of softer asphalt for formulation of the emulsion. The gel-like character of high-float emulsions could significantly affect the structural changes and formation of asphalt film upon breaking of emulsions.

The aim of this study was to investigate the changes occurring in the internal structure of high-float asphalt emulsions after breaking. The study was performed using complex thermo-rheological testing in linear and non-linear viscoelastic regions. High-float emulsions were formulated with varying amounts of tall oil soap, including minimum, optimum and high. Two methods were used to obtain the emulsion residues: one, high temperature evaporation method, ASTM D6997 at 400°F, and the other low temperature evaporation method, AASTHO R78 Procedure B. Small amplitude oscillatory shear, steady shear viscosity, start-up of steady shear and creep and recovery experiments, together with conventional and performance tests were performed on the high-float emulsion residues. Their performance was compared with the behavior of straight-run asphalt and simple emulsion residue.

The behavior of high-float emulsion residues appeared to be completely different than behavior of the straight run asphalt or the residue from a simple emulsion, e.g., increasing values of viscosity at low shear rates and decreasing values of phase angle at high temperatures. The behavior of emulsion residues was also significantly affected by the evaporation method. The emulsion residues obtained via low temperature evaporation method appeared stiffer (lower values of phase angle, higher values of viscosity, lower values of the compliance function and higher values of stress overshoot) compared to emulsion residues obtained via high temperature evaporation method.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **12**

A Simplified Method to Estimate the Low Temperature Cracking Required Input for the AASHTOWare ME Using E* Data

Geoffrey Rowe, Sergio Raposo, Thomas Bennert, Christopher Ericson, Nick Cytowicz, Walaa Mogawer, Eshan Dave

During the late 1980s/early 1990s the use of the indirect tensile (IDT) creep test was developed as part of the Strategic Highway Research Program as a test method for evaluation of the cold temperature performance of asphalt mixes and then subsequently used to estimate the development of cold temperature thermal cracking of asphalt pavements. This computational procedure was then implemented in the mechanistic-empirical pavement design guide (MEPDG). The method required that Poisson?s ratio is measured and these measurements are used to estimate the creep compliance, D(t), master curve, the principal input to the prediction method. However, this method of testing has been found to be difficult by the laboratories participating in this study and there has been a slow industry adoption. Pavement life calculations within the MEPDG also makes use of a complex extension modulus, E*, master curve. This data is developed using AASHTO test methods and has become reasonably routine in laboratories with reasonable measurements techniques and associated accuracy and precision. Mathematically, interconversions exist between the two measurement types. As a consequence, we have explored the possibility of using the E* data to provide an estimation of the D(t) data as an alternate input into the MEPDG as an alternate to running the IDT creep test. Five mixes with varying properties are used to test the interconversion processes used and to develop the method. The method is then applied to a further four mixtures for which we have both E* and D(t) data, and then subsequently used to compute thermal cracking potential. This paper describes the work performed by these researchers and a frame work is proposed for a practical implementation of this method.

Paper : **13**

Evaluation of Asphalt Binder Aging Resistance through Asphaltenes Modification

Leila Hashemian, Nirob Ahmed, Mohamed Saleh, Taher Baghaee Moghaddam

Asphalt binder, an essential road construction material, is susceptible to aging due to exposure to factors such as sunlight, oxygen, moisture, and temperature fluctuations. The aging process is a complex phenomenon which can lead to changes in the asphalt binder properties, eventually causing reduced durability and performance of asphalt pavement over time. This study explored the potential of asphaltenes modification in enhancing the aging resistance of asphalt binders. Asphaltenes, a by-product material derived from Alberta oil sands bitumen, is known for its complex molecular structure. It has been increasingly explored for potential benefits in asphalt binder modification. In this research, a comprehensive investigation was conducted to determine the asphalt binder aging resistance modified with an optimal concentration of 12% asphaltenes (by weight of the binder). All the asphalt binders underwent a frequency sweep (FS) test at varying temperatures with a frequency range of 0.1 to 100 rad/s. Complex shear modulus and phase angle master curves were developed using the time-temperature superposition principle (TTSP) followed by the calculation of aging indices.
The obtained results demonstrated improved stiffness when complex shear modulus increased by 497% to 546%, and better resistance to rutting, with rutting parameter values up to 7 times higher at 0.1 rad/s after asphaltenes modification. A considerable improvement in the aging resistance of asphalt binders with optimized concentrations of asphaltenes was observed with 20% to 23% lower complex shear modulus aging index (CAI) values compared to neat binders. However, the asphaltenes-modified binders had greater phase angle aging index (PAI) values at the highest testing frequency of 100 rad/s in comparison with the unmodified binders. Nevertheless, the impact of both asphaltenes content and loading frequency on PAI was found to be statistically insignificant. The findings of this study contribute to the growing body of knowledge on asphalt binder modification aimed at improving pavement durability and sustainability, leading to cost savings and environmental benefits over the lifecycle of road infrastructure.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **14**

Relating Binder Parameters to Asphalt Mixture Cracking Tests in the Laboratory

R. Michael Anderson, Amma Agbedor and Wesley G. Cooper

During the Strategic Highway Research Program (SHRP), the asphalt researchers decided to use G*sin ? as an intermediate temperature parameter for the proposed performance-graded (PG) asphalt binder specification. This decision was based on fatigue cracking evaluation of field trials and mixture fatigue testing conducted as part of the asphalt research program.

It was clear from the start that many asphalt technologists were never completely happy with how intermediate temperature cracking was addressed in the PG asphalt binder specification. Unlike rutting, which is purely a load related distress, cracking can be load related (fatigue cracking caused by repeated traffic loading and flexing of the pavement) and non-load related (environmental cracking due to temperature changes and aging). It is important to understand how asphalt binder properties can relate to both types of cracking distress in mixtures. Although the asphalt binder parameter G*sin ? seems to have value in characterizing the stiffness of an aged binder ? which is related to fatigue cracking ? it mostly misses the relaxation component important to asphalt binders as they age and become more brittle.

To address this, a lab experiment was designed based on the hypothesis that when a standard asphalt mixture is tested at temperatures where the stiffness is the same, mixtures made with an asphalt binder having worse relaxation properties will have poorer lab cracking performance than mixtures made with an asphalt binder having better relaxation properties. Two asphalt binders with similar stiffness but different relaxation properties were used in a lab standard 9.5-mm NMAS (nominal maximum aggregate size) asphalt mixture and test specimens were produced at different aged conditions simulating short term and two levels of long-term aging. The mixture specimens were tested to determine stiffness (dynamic modulus) and cracking (flexural beam fatigue and IDEAL-CT) performance. Results from the cracking tests were related to current and proposed parameters for use in the PG asphalt binder specification. Additionally, the properties of asphalt binders were evaluated after being subjected to asphalt mixture aging procedures.

Findings from the experiment indicate that cracking is complex and not easily defined by one test or test condition. When temperature is removed as a factor, the IDEAL-CT test appears that it could capture relaxation similar to what ?Tc, phase angle, or R value do for asphalt binders. Flexural beam fatigue under higher strain conditions (thin pavements) should correlate with the Glover-Rowe Parameter of the asphalt binder.

Additionally, standard mixture aging (short-term and long-term) appears to be generally more severe than the aging conducted on asphalt binders for determining specification compliance using the Rolling Thin Film Oven (RTFO) and Pressure Aging Vessel (PAV).

2024 Paper Abstracts in Tentative Presentation Order

Paper : **15**

New performance-based approach for formulations of asphalt mixes with a high percentage of Reclaimed Asphalt Pavement.

Amélie griggio, Marc Proteau, Jacques-Antoine Decamps

Hot recycling of asphalt in plant is an increasingly present subject in the profession. It is one of the main levers for decarbonising road construction activities. Vinci Construction's Americas Technical Center has been actively working since 2018 on the subject of asphalt mixes with a high Recycled Asphalt Pavement (RAP) content, ?HR Asphalt mixes?, integrating a percentage of Recycled Asphalt Pavement higher than 30%.
The works carried out have led to the implementation of a complete protocol and a new range of formulations. To guarantee the performance and durability of HR asphalt mixes, the protocol is based on 4 main steps.
As a first step, the characterization of the stock of RAP and particularly of the bitumen is performed, by characterising its oxidation from a rheological point of view (PG grade) but also from a chemical point of view. Over the years, a database of bitumen characteristics from Recycled Asphalt Pavement in various regions of Canada has been developed.
Following this first analysis, the grade of the added bitumen is adapted to meet the performances required on the final bitumen, i.e. the mixture of new and recycled bitumen. In the Canadian climate context, compliance with the low temperatures of bitumen appears to be one of the most important criteria.
In a third step, the formulation of the asphalt mix is carried out, according to a "Balanced Mix Design" approach, with the validation of the performances in terms of rutting resistance, moisture resistance (Tensile Strength Ratio - TSR), modulus of rigidity, low temperature performance and also fatigue resistance for the base layers. Specifications have been developed according to formulation types and regions.
Finally, a validation of the "binder remobilization" is carried out, i.e. the effective and homogeneous mixture of bitumen from Recycled Asphalt Pavement and new bitumen, during industrial production of the asphalt mix in the plant. For this step, which is a key point for the success of this type of formulation, an exclusive ?sequenced stripping test? and chemical analysis of the recovered bitumen have been developed by Vinci Construction.
This article presents the approach implemented to validate the performance of these new asphalt formulations in laboratory, as well as feedback from the last years of experimentations in a Canadian climate.

Paper : **16**

Can One Mix Do it All?

Chris Campbell

The City of Regina (City) owns and operates its own Asphalt Batch Plant and Materials Laboratory. The original batch tower was purchased in 1977 from Barber Greene (Now Astec). Over the course of the last 44 years, it has seen many component upgrades and enhancements with some but not limited to goals of; emissions reductions, increases in mix quality, and efficiencies in production operations.
The City?s plant supports two main services (Asphalt Construction and Asphalt Maintenance). Under each of those sub-services there are three main sub-services; asphalt paving, pothole patching, and maintenance repairs (depressions, trench settlements, utility cut-repairs, etc.).
The City?s Materials laboratory is responsible for both our hot mix asphalt designs (utilizing the Marshall Method of Mix Design in combination with the Bailey Method) and quality control testing of plant produced mixes.
Over the last 18 years the City has been striving to find a balanced mix that will support all three sub-services of asphalt paving, pothole patching and maintenance repairs. This paper will endeavor to take you on a journey from 2006 to 2024 in our various plant upgrades and enhancements as well as the evolution of producing at one time up to four mixes on any given day, with the goal of one mix that can do it all.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **17**

Enhancing Pavement Longevity and Structural Capacity with Aramid Fiber Reinforcement: A Case Study and Comparative Analysis

Phillip B. Blankenship, Mary Rawls Whitby, Randy Travis

In the face of evolving transportation demands and changing climatic conditions, there is a critical need for durable and long-lasting pavement solutions. Highway agencies are actively seeking innovative materials that not only extend the service life of pavements but also delay the onset of deterioration. This shift allows for the strategic allocation of funds and resources to other vital projects. Aramid fibers have emerged as a promising material in this context, demonstrating significant resistance to rutting and cracking in asphalt pavements.

Despite these advantages, the existing literature offers limited guidance on the optimal design of asphalt mixtures that incorporate aramid fibers. This paper addresses this gap by presenting a detailed case study of a project that successfully implemented aramid fibers across various pavement layers. We analyze field data, including falling weight deflectometer (FWD) readings, and highlight the necessity of adopting an alternative structural coefficient for pavement design, particularly when utilizing the AASHTO ?93 method of pavement design.

Additionally, we discuss two independent projects that employed both falling weight deflectomer (FWD) and Automated Plate Loading Technology (APLT) to further validate our findings. The limited analysis demonstrates that incorporating aramid fiber throughout the pavement structure enhances the modulus by a minimum of 58% and the structural number by at least 20%. These improvements significantly bolster the pavement's structural capacity, paving the way for more resilient infrastructure.

Moreover, integrating aramid fibers in every pavement layer can yield substantial benefits, potentially resulting in exceptionally durable pavements or allowing for reduced layer thicknesses in areas with spatial constraints, such as beneath overpasses or around curb and gutter sections. This paper provides vital insights and practical guidance on leveraging aramid fibers for pavement reinforcement, contributing to the broader goal of developing robust and long-lasting transportation infrastructure.

Paper : **18**

Investigation of Low-Temperature Properties of Fibre-Modified High-Performance Asphalt Concrete

Leila Hashemian, Mohamed Saleh, Nirob Ahmed , Taher Baghaee Moghaddam

This study addresses the imperative of enhancing low-temperature performance in high-performance asphalt concrete (HPAC) for cold region pavement. The focus is enriching asphalt binders with asphaltenes, a by-product from Alberta oil sands, integrated with mixture modification using waste polyethylene terephthalate (PET) fibres to improve cracking resistance. The binder is optimized with 12% asphaltenes by weight of the binder, needed to achieve a high dynamic modulus of 14 GPa at 15°C and 10 Hz, suitable for high stiffness applications. Additionally, 0.15% of 12mm-long PET fibres by weight of the total mix are incorporated for asphalt reinforcement. The investigation includes evaluating cracking resistance at -20, -10, and 0°C through the creep compliance and indirect tensile strength test method. The low-temperature rheology of the binder is assessed using Superpave?s standard bending beam rheometer (BBR) test to measure low-temperature stiffness and relaxation properties of the control and asphaltenes-modified asphalt binders. Furthermore, since the low-temperature physical aging of asphalt binder varies with time and temperature, the extended BBR (E-BBR) test method is used to condition both the control and modified binder at 10°C and 20°C warmer than the low-temperature performance grade determined from BBR. E-BBR is then carried out for conditioning periods of 1 h, 24 h, and 72 h to simulate the effect of extended conditioning at two different cold temperatures. This approach for low-temperature investigation aims to create an eco-friendly, resilient, and cost-effective HPAC pavement, aligning with the circular economy principles and contributing to the sustainability objectives of the Canadian asphalt industry.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **19**

Development of a Graphene-Polymer Composite for Asphalt Mixes

Donn Bernal, Eytan Mazor

Development of a Graphene-Polymer Composite for Asphalt Mixes
Donn Bernal and Eytan Mazor

Graphene is a material that 200 times stronger than steel but has properties like rubber that can stretch up to 25% of its original length. It has commercial applications across many industries that include lubricants, coatings, adhesives, and clothing to name a few. However, producing high-quality graphene on a large scale at a low cost continues to be challenging for many of the industries. Universal Matter Inc. (UMI) is looking to change that with their new patent-pending process that utilizes a variety of carbon-based feedstock materials that includes recycled plastics and biomass. This proprietary process is based on an invention by Dr. James Tour, a professor at Rice University in Houston, Texas. He is also co-founder and scientific advisor at UMI.
This paper will outline the product development of the graphene material to its final form as a graphene-polymer composite in asphalt. The common PGAC tests have been conducted but will also include 40-hr PAV to help understand any aging effects of the graphene. Asphalt mix performance testing for rutting resistance, thermal cracking, and fatigue resistance will help understand its long-term durability and performance.
It will also describe field trials at the asphalt cement terminal, asphalt plant, and paving stage to better understand how the product reacts and performs to create an optimal and cost-efficient composite.
The objectives of the paper are:
? To illustrate the challenges of having a graphene-polymer composite (ie. Stability)
? To describe the methods of dispersing the graphene-polymer composite into asphalt
? How does it compare to a Styrene-Butadiene-Styrene (SBS) polymer asphalt cement and asphalt mix?
? What are the advantages of including graphene in an asphalt mix?
? How can this graphene-polymer composite improve the sustainability of the asphalt mix?

2024 Paper Abstracts in Tentative Presentation Order

Paper : **20**

Evaluating the Effectiveness of Geosynthetics in Reinforced Asphalt Overlays under Different Temperature Conditions

Thang Ho, Michel Vaillancourt, Ehsan Dave, Alan Carter

Reflective cracking is a pervasive issue encountered in hot-mix asphalt (HMA) overlays, necessitating the development of a comprehensive testing methodology to address it effectively. The occurrence of reflective cracking is influenced significantly by both traffic and thermal loads. The vertical deflections induced by traffic on pavements result in bending and shear stresses on the HMA overlay. Stress from both traffic and thermal loads contributes to the initiation and propagation of cracks, while lower temperatures further exacerbate the rigidity and brittleness of the HMA overlay, intensifying reflective cracking.

The primary causes of reflective cracking are identified as differential vertical deflections, the opening and closing of cracks or joints, and pavement temperature fluctuations, which impose significant maintenance costs on road authorities. The utilization of geosynthetic interlayers has emerged as an effective strategy to delay the onset of reflective cracking. In reinforced bituminous interfaces, cracks propagate upward until reaching the interlayer, where the higher stiffness redirects crack propagation horizontally along the interlayer plane, dissipating the crack's energy. However, further research is warranted to accurately quantify the reinforcement effects of geosynthetic materials in mechanistic-based design approaches.

To address these challenges, a laboratory test method employing the Crack Widening Device was developed to assess geosynthetic crack resistance and differentiate load-displacement curves among various reinforced bituminous interfaces. The study aimed to evaluate the influence of temperature and geosynthetic placement on asphalt interfaces using this innovative device. Bi-layer bituminous samples incorporating different geosynthetics, including geotextile and geo-composite, alongside reference samples, were meticulously tested. Consistent application of hot mixture to both the top and bottom layers mirrored real-world pavement rehabilitation scenarios. Temperature has a significant impact on the effectiveness of geosynthetics, particularly when the reinforced interlayer experiences critical temperature thresholds. Elevated temperatures, reaching around 40°C, can lead to delamination of the reinforced interface due to the decrease in viscosity of the asphalt cement. Conversely, extremely low temperatures, as low as -20°C, can induce brittleness, causing the samples to exhibit contraction behavior. Remarkably, at moderate room temperature, at approximately 25 ± 2°C, paving fabric (PF) demonstrated exceptional performance compared to both high and low temperature conditions as well as geo-composite and control tests. Geosynthetics placed one third from the bottom exhibited superior performance, particularly paving fabric, which demonstrated enhanced energy dissipation and stiffness modulus retention compared to geo-composite and control cases.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **21**

Enhanced Acceptance Testing of Recovered Asphalt Binder for the Betterment of the Road Building Industry

Prabuddhika Dharmarathna, Pramodya Undugoda, Jianmin Ma, and Simon A.M. Hesp.

It has been reported that pavement lifecycles in Ontario have reduced by more than 50-60 % over the last several decades (Auditor General of Ontario 2016, Ma et al. 2024). The 2019 Canada Infrastructure Report Card claimed that as many as 39 % of all roads were in fair, poor or very poor condition. Similarly, 43 % of roadways in the United States were reported to be in mediocre or poor condition according to the 2021 Report Card for America?s Infrastructure. This steady decline in sustainability has likely several root causes, including increases in traffic, increased frequency of extreme temperatures in both summer and winter, increased use of modified binders with excessive grade spans, a steady increase in the improper use of reclaimed asphalt, and the use of incomplete and consequently inaccurate materials acceptance specifications. There may also be more obscure issues, such as changes in refining practices or the addition of softening oils by wholesalers, for which there are currently no easy tests, that could be contributing to the reduced performance.

Research on prematurely cracked pavements and trial sections has shown that performance variations can nearly always be explained by differences in binder properties. Variable aging tendencies can lead to differences in grades as placed that exceed 6-12?C. Weather statistics shows that an error in the low grade of 6?C typically increases the chances that a road is exposed to damaging temperatures in any given year from around 2 % to 50 %. In addition, thermal stresses can easily exceed the design values by several fold. At the other extreme, recovered high grades that exceed the design by 6-12?C or more are not uncommon, which leads to a reduced ability to relax thermal stresses. Hence, it should come as no surprise that pavements fail prematurely when incomplete test methods are used, or the agency relies only on the testing of binder from the storage tank.

Implementation of the extended bending beam rheometer test method (AASHTO T 406-23) and the double-edge-notched tension test method (AASHTO T 405-23) for acceptance of the recovered asphalt binder in several Ontario municipalities has been able to turn the tide (Ding et al. 2017, Ma et al. 2024). Pavement lifecycles to a serviceability index of 50 % for the Regional Municipality of Durham have increased from a low 11 years in 2014 to a modest 25 years today. This paper will present an updated assessment of how enhanced acceptance testing can solve many of the woes that plague the industry and return lifecycles to their historical 40-50 years by using straight Alberta binders. There is enough crude bitumen available from the Alberta oil sands to produce quality asphalt to pave every road on earth for the next 100-200 years. Owing to their low wax contents, such asphalt binders will be most suitable for recycling and re-recycling in a truly circular economy (Kriz et al. 2017).

2024 Paper Abstracts in Tentative Presentation Order

Paper : **22**

Chemical and Rheological Analysis of the Impact of Styrene-Butadiene-Styrene (SBS) on Long Term Oxidative Aging of Polymer Modified Asphalt

Aditi Sharma, Roberto M. Aurilio, Mike Aurilio, Hassan Baaj, Pejoohan Tavassoti

Understanding the aging behaviour of asphalt materials is critical to creating a comprehensive pavement management plan and ensuring the longevity of flexible pavements. However, evaluating the aging of polymer-modified asphalts (PMA) can be more difficult as conventional tests focus mainly on changes in the rheological properties which have difficulty characterizing PMA performance. As such, more advanced chemical testing techniques are required to create reliable aging indicators for PMAs. Nuclear Magnetic Resonance (NMR) spectroscopy is a high-resolution analytical technique, often used in the polymer industry, to evaluate the molecular structure and to quantify the concentration of chemical species. This powerful technique provides detailed information about the chemical composition and interactions within a material through investigating the magnetic response of atomic nuclei, after applying strong radiofrequency pulses. Due to the complex chemical composition of asphalt cements, however, this technique has seen limited use in the asphalt industry.

Elastomeric polymers, such as the commonly used Styrene-Butadiene-Styrene (SBS), have been shown to produce PMAs with enhanced mechanical properties, thermal stability and aging resistance resulting in asphalt mixes that can withstand greater environmental and heavy traffic loading. This study attempts to explore the effect of increasing concentration of SBS on aged asphalt binders using both rheological and chemical testing. With the addition of Proton Nuclear Magnetic Resonance (H1 NMR) spectroscopy, this study identifies key parameters that relate to the rheological properties and chemical composition, while establishing correlations between them, therefore providing a holistic understanding of the oxidative aging behaviour of SBS-modified asphalt binders. For this study, two straight-run PG 58-28 binders, A and B, modified with SBS at concentrations 0, 2, and 4%, using a cross-linking agent were prepared. Specimens were then exposed to 20 hr, 40 hr and 60 hr of Pressure Ageing Vessel (PAV) aging to simulate long-term oxidative aging. The bending beam rheometer (BBR) was used to investigate the stiffness and relaxation of the asphalt cements at low temperatures, which is crucial for determining cracking susceptibility. The m-value and creep stiffness parameters as well as their relationship to increasing SBS content were examined. The m-value was only slightly affected by increasing SBS concentration, while the creep stiffness results decreased with increasing SBS content indicating a benefit to low temperature performance. H1 NMR spectroscopy was employed to investigate the effect of SBS on the chemical/molecular properties of asphalt binders. Temperature-frequency sweeps were also performed on the samples and master curves were constructed to illustrate the viscoelastic behaviour at different temperatures and loading frequencies.

By correlating the master curve and BBR parameters/results to the NMR data, this study attempts to provide molecular insights into how SBS incorporation affects the overall properties of asphalt binders and unveil key indicators or parameter from NMR data. This can be used to acquire an understanding of the physicochemical properties of SBS-modified asphalt binder, potentially estimate SBS content and assess the stability of the SBS polymer upon ageing. This multidimensional approach allows for a more comprehensive understanding of the complex relationship between the macroscopic performance of asphalt binders and their chemical/molecular composition.

2024 Paper Abstracts in Tentative Presentation Order

Paper : **23**

Synthesis on Structural Fiber Reinforced Asphalt Concrete

Phillip B Blankenship, Jason Bausano, Zack McKay

The practice of using structural fibers to reinforce asphalt concrete pavements has been around since the 1970?s. A large number of research studies has been performed in the past 5 to 10 years regarding structural fiber reinforced asphalt concrete (SFRAC) relative to improved performance of the resulting mixture and enhanced pavement life through pavement analysis. The primary goal of adding the reinforcement fibers to the asphalt concrete mixture is to enhance the mechanical performance in terms of cracking (fatigue and low temperature) and rutting resistance. Asphalt concrete pavements crack when the tensile strain exceed the allowable strain of the mixture. Thus, reinforcement fibers can be an alternative to improve the tensile properties of the mixture to improve performance. Typically, polymers (styrene-butadiene, styrene-butadiene-styrene, or reactive ethylene terpolymers) are used to improve the properties of the asphalt mixture. Aramid and other synthetic fibers can compete in terms of cracking and rutting resistance as presented in this synthesis. Numerous studies have been performed that quantify the benefits of using aramid and synthetic fibers in asphalt concrete mixtures. Some of these studies are based on laboratory test results while others are based on field data. These studies typically have a control mixture to quantify the benefit/improvement of the aramid and synthetic fibers. This paper aims to review, summarize, and quantify the benefits of aramid and synthetic fiber reinforced asphalt concrete materials while comparing to a control asphalt mixture without fibers.