41ST

Petersen Asphalt Research Conference

June 21-23, 2004 Cheyenne, Wyoming

41st Annual

PETERSEN ASPHALT RESEARCH CONFERENCE

Organized by

WESTERN RESEARCH INSTITUTE

In cooperation with FHWA

Conference Location: Hitching Post Inn Resort and Conference Center
Cheyenne, Wyoming, June 21-23, 2004

SUNDAY, JUNE 20, 2004

Registration	Pick up pre-registration materials	
4:00-5:30 PM	Late registration	Hitching Post Inn Lobby

MONDAY, JUNE 21, 2004

Registration	Pick up pre-registration materials	
7:30 AM	Late registration	Hitching Post Inn Lobby
8:30-8:40 AM	**Welcome and Opening Remarks**	***Raymond E. Robertson*** Western Research Institute
8:40-9:00 AM	**Welcome**	***Scott B. Smith*** Major General, USA (Retired) Chief Executive Officer, WRI
9:00-9:50 AM	**Keynote Speaker**	***Dr. K. Thirumalai*** Acting Associate Administrator Research and Special Programs Administration, USDOT
BREAK	9:50-10:10 AM	

SESSION 1: Asphalt Aging

Session Moderator: John Casola, Malvern Instruments

10:10-10:45 AM	Binder Oxidation and Fatigue in Asphalt Concrete Mixtures	Sung Hoon Jung (ChE-TAMU), Lubinda F. Walubita, Amy Epps Martin, and Robert L. Lytton (CE-TAMU/TTI), Arif Chowdhury and Eun Sug Park (TTI), and Charles J. Glover (ChE-TAMU/TTI)
10:45-11:20 AM	Aging by MICROWAVES (Dielectric heating) vs. RTFO + PAV (Conductive heating). Comparison Between the Two Methods As Applied to Constructed Lanes (CL) Binders of the Accelerated Loading Facility (ALF) at Turner Fairbanks Highway Research Center (TFHRC)	Aroon Shenoy (Turner-Fairbank Highway Research Center) and Safwat Bishara (Kansas Department of Transportation)
11:20-11:55 AM	Weathering and PAV Aging of SBS-modified Asphaltic Sealants	J-F. Masson, P. Collins, J. R. Woods, and S. Bundalo-Perc (National Research Council of Canada, Institute for Research in Construction)
LUNCHEON	11:55-1:10 PM	

SESSION 2: Modification of Asphalt and Aggregate

Session Moderator: John D'Angelo, Federal Highway Administration

1:10-1:45 PM	Evaluating the Field Performance of Natural Asphalt Primed Aggregate in Hot Mix Asphalt	Mark G. Bouldin (PebbleCrest Materials & Service Corporation), Steve Niederhauser (Utah DOT), and Raj Dongré (Dongré Laboratory Services)
1:45-2:20 PM	Effects of Polymer Additive on Simple Performance Testing of HMA Mixtures	Joe W. Button, Arif Chowdhury, and Amit Bhasin (Texas Transportation Institute)
2:20-2:55 PM	Factors Affecting Low Temperature Failure and Intermediate Temperature Fatigue Properties of Modified Asphalt Binders	Kitae Nam and Hussain U. Bahia (University of Wisconsin-Madison)
BREAK	2:55-3:15 PM	
3:15-3:50 PM	Effect of Acid and Other Modifiers on PG Binder Grading	Laird E. Weishahn (Nebraska Department of Roads), and John Dageforde and Magdy Abdelrahman (University of Nebraska)
3:50-4:25 PM	The Effect of Phosphoric Acid on the Physical Properties of Asphalt Binders	Mark G. Bouldin (PebbleCrest Materials & Service Corporation) and Raj Dongré (Dongré Laboratory Services)
4:25-5:00 PM	Effect of Polyphosphoric Acid on Aging Behaviour of Bituminous Binder	Gilles Orange and Jean-Valéry Martin (Rhodia Recherches) and Bruno Marcant (Rhodia, Inc.)

MONDAY EVENING—*Dinner on your own*

Trolley Service – Hitching Post to Downtown Cheyenne 5:30-9 PM

TUESDAY, JUNE 22, 2004

SESSION 3: Specifications, Specification Upgrades & Physical Property Determinations

Session Moderator: Andrew Parker, Tamko Roofing Products Inc.

8:00-8:35 AM	Investigation of Yield Stress of Asphalt Emulsions as a Potential Quality Control Parameter	Max Hetzer and Daniel De Kee (Tulane University), and Chris Abadie (Louisiana DOT)
8:35-9:10 AM	Separation and Characterization of Bitumen Waxes	Xiaohu Lu and Per Redelius (Nynas AB)
9:10-9:45 AM	Multi-Stress Creep Recovery - A New Approach to the Refinement of High Temperature Binder Specification	John D'Angelo (FHWA) and Raj Dongré (Consultant)
BREAK	9:45-10:10 AM	
10:10-10:45 AM	Understanding the AASHTO 2002 Pavement Design Guide	Raj Dongré (Consultant) and John D'Angelo, Leslie Myers, and Kathy Petros (FHWA)
10:45-11:20 AM	Using the Pressure Distribution Analyzer to Measure Sensitivity of HMA Compaction to the Zero Shear Viscosity of Asphalt Binders	Arif Khatri, Ahmed Faheem, and Hussain U. Bahia (University of Wisconsin-Madison)
11:20-11:55 AM	Determination of Asphaltene Content and Other Compositional Properties of Asphalts by Flocculation Kinetics Titrimetry	Adam T. Pauli and J. Miller (Western Research Institute)
LUNCHEON	11:55-1:10 PM PRIZES!!!	

SESSION 4: Instrumental Analysis for Performance Prediction

Session Moderator: Laurand Lewandowski, Goodyear Chemical

1:10-1:45 PM	A High-Resolution TGA Method for the Characterization of Bitumen and Bituminous Products	J-F. Masson and S. Bundalo-Perc (National Research Council of Canada, Institute for Research in Construction)
1:45-2:20 PM	Comparison of Asphalt Binders' Fatigue Measured using Parallel Plate Geometry with Torsion Cylinder Geometry	Wilfung Martono and Hussain Bahia (University of Wisconsin-Madison), and John D'Angelo (FHWA)
BREAK	2:20-2:40 PM	
2:40-3:15 PM	Use of NMR Imaging to Measure Interfacial Properties of Asphalts	F. P. Miknis, A. T. Pauli, A. Beemer, and B. Wilde (Western Research Institute)
3:15-3:50 PM	Results from the Use of Gel Permeation Chromatography to Determine Polymer Content in Asphalt	Joe Rovani, Martin McCann, and John Schabron (Western Research Institute)
3:50-4:25 PM	Road Trip on the Lincoln Highway: From Rock Boulevard to I-80	Chavawn Kelley (Western Research Institute)

***TUESDAY DINNER* -- Old West Museum, Lyons Park, Cheyenne**
Social Hour 5:30, Dinner 6:30 pm

WEDNESDAY, JUNE 23, 2004

SESSION 5: Damage Assessment and Repair
Session Moderator: Michael Falkiewicz, Astaris

8:00-8:35 AM	Mitigation of Reflective Cracking in Bituminous Overlays using High-modulus Fiberglass Membranes	David R. Jones, IV (Trumbull Asphalt), Reynaldo Roque (University of Florida), and Fujian Ni (Transportation College, Southeast University, Nanjing, PRC)
8:35-9:10 AM	Assessment of Moisture Damage Resistance in the Laboratory - An Evaluation of Various Tests	Jack Youtcheff (FHWA) and Raj Dongré (Consultant)
9:10-9:45 AM	"Warm Mix Asphalt" in Overnight Airport Runway Paving & Emergency Pavement Maintenance	Jeremy A. Day and Prem Naidoo (Sasol Wax Americas Inc.)
BREAK	9:45-10:10 AM	
10:10-10:45 AM	Comparison of Effects of Anti-Stripping Additives and Polymer Modification on Performance of Asphalt Mixtures in Laboratory	Kunnawee Kanitpong and Hussain U. Bahia (University of Wisconsin-Madison)
10:45-11:20 AM	State-of-the-Art Composite Systems for Creating Ultra-High Modulus Mixes for Structural Layers	Mark G. Bouldin (PebbleCrest Materials & Service Corporation) and Raj Dongré (Dongré Laboratory Services)
11:20-11:55 AM	Laboratory Characterization of HMA Surface Mixtures with Screened RAP	Baoshan Huang (University of Tennessee)
11:55-12 NOON	CLOSING REMARKS	

PARC 2004 ABSTRACTS

SESSION 1: ASPHALT AGING

Title **Binder Oxidation and Fatigue in Asphalt Concrete Mixtures**

Authors Sung Hoon Jung (ChE-TAMU), Lubinda F. Walubita (CE-TAMU/TTI), Amy Epps Martin (CE-TAMU/TTI), Robert L. Lytton (CE-TAMU/TTI), Arif Chowdhury (TTI), Eun Sug Park (TTI), and Charles J. Glover (ChE-TAMU/TTI)

Abstract Asphalt oxidation causes major changes to binder properties and is hypothesized to be a major contributor to age-related failure, including fatigue cracking. Neat asphalt oxidative aging stiffens the binder, leading to higher binder stresses under a given deformation; when these stresses exceed the strength of the binder, failure occurs. Thus, heavily-aged binders exhibit a significantly reduced failure strain (in direct tension, e.g.) compared to unaged binders. However, whether binder oxidation in mixtures leads to reduced fatigue lives has not been adequately addressed.

Recently, we have investigated the effect of binder aging on mixture fatigue. Binder aging was characterized by FT-IR carbonyl band growth and by changes in the DSR properties G' and G". Mixture fatigue was measured directly by the bending beam mechanistic empirical method and estimated by a calibrated mechanistic approach that includes surface energies (CMSE). Binders recovered from aged mixtures track across the DSR function map (G' vs. (eta'/G')), following the same path as neat binder aged in a 60°C environmental room, a path that previous work has shown correlates well with significant decreases in binder ductility. Mixture fatigue resistance also decreases dramatically in direct relation to binder oxidative stiffening.

Title **Aging by MICROWAVES (Dielectric heating) vs. RTFO + PAV (Conductive heating). Comparison Between the Two Methods As Applied to Constructed Lanes (CL) Binders of the Accelerated Loading Facility (ALF) at Turner Fairbank Highway Research Center (TFHRC).**

Authors Aroon Shenoy (Turner-Fairbank Highway Research Center) and Safwat Bishara (Kansas Department of Transportation)

Abstract Twelve lanes of the Accelerated Loading Facility (ALF) pavements were constructed between June 28 and October 29, 2002. The asphalt binders (3 control and 5 modified) that were used in the Constructed Lanes and designated as CL binders were subjected to two separate processes of microwave aging and RTFO + PAV aging. This work compares the rheological properties of the microwave-aged and the RTFO + PAV-aged products in order to see whether the conditions set up for the microwave aging process produce aged material similar to those that have undergone the combined process of RTFO followed by PAV aging.

Comparing the two methods by aging the CL binders generated data that agree with those obtained in previous work using the two methods to age the 8 SHRP core asphalts and a set of 15 modified binders.

Title **Weathering and PAV Aging of SBS-modified Asphaltic Sealants**

Authors J-F. Masson, P. Collins, J. R. Woods, and S. Bundalo-Perc (National Research Council of Canada, Institute for Research in Construction)

Abstract Crack sealants used for the maintenance of roadways are SBS-modified bitumens rich in SBS. These sealants allow for the study of aging in SBS modified bituminous materials. Three sealants were weathered in Montreal, Canada, for 1, 3, 5, and 9 years before they were analyzed by GPC, TGA, FTIR and DSR, along with the virgin unweathered sealants. The GPC, TGA and FTIR respectively provided the extent of SBS degradation, the loss of bituminous matter, and the level of oxidation. DSR provided the effect of the change in chemistry on the rheological properties.

The three virgin sealants were aged in the PAV for 8, 16 and 24h at 100°C and 2.1 MPa before being analyzed for degradation rates and mechanisms. The results indicate that PAV, in the conditions tested, could not mimic weathering. In general, PAV aging led to less bitumen oxidation than weathering and much too severe SBS degradation. The result was a much softer material than what was obtained in the field, even after only 8h of PAV. Given the similarity in the chemistry of crack sealants and SBS-modified asphalt binders for AC, current PAV aging procedures may well lead to inappropriate performance predictions.

SESSION 2: MODIFICATION OF ASPHALT AND AGGREGATE

Title **Evaluating the Field Performance of Natural Asphalt Primed Aggregate in Hot Mix Asphalt**

Authors Mark G. Bouldin (PebbleCrest Materials & Service Corporation), Steve Niederhauser (Utah Department of Transportation), and Raj Dongré (Dongré Laboratory Services)

Abstract A special Gilsonite-based natural asphalt primer has been developed for use in hot mix asphalt applications. It enhances the performance characteristics of hot mix asphalt in laboratory tests. In particular, the shear resistance, moisture resistance and durability are improved. The additive is a blend consisting of Gilsonite, an elastomeric modifier and a processing agent. The results in the Superpave gyratory compactor indicate that the mix handling and compactibility were essentially unaffected by adding the primer.

We also evaluated how field samples performed relative to the laboratory produced specimens. In general we found that the field samples outperformed laboratory produced specimens, and that the natural asphalt primer exhibited much improved properties over dry or hydrated lime treated hot mix asphalt.

The improved performance of the field samples over the laboratory samples was most likely due to the higher surface temperatures of the aggregate in the hot mix plant versus the lab conditions and may also partially stem from the fact that the mixing in the hot mix plant is more aggressive.

Title **Effects of Polymer Additive on Simple Performance Testing of HMA Mixtures**

Authors Joe W. Button, P.E., Arif Chowdhury, and Amit Bhasin (Texas Transportation Institute)

Abstract The objectives of this project were to test a variety of hot mix asphalt (HMA) materials using the proposed AASHTO 2002 Design Guide simple performance tests (SPT) and relate laboratory findings to field performance. The three SPTs consist of dynamic modulus (E*), accumulated strain from triaxial repeated loading, and resistance to tertiary flow under static creep. Rutting susceptibility of 12 widely different mixtures was estimated using the Asphalt Pavement Analyzer (APA). Fatigue performance was predicted using the indirect tension test (IDT).

Field mixtures from 9.5-mm to 19-mm maximum aggregate size with binders from PG 64-22 to PG 82-22 (including PG 64-40 [highly polymer-modified]) were obtained from six state DOTs. One mix was designed as highly rut-susceptible.

Flow time slope and flow number value provided the best correlations with the APA rutting. Correlations of the APA test parameters with dynamic modulus and FSCH tests were poorer than correlations of the APA test parameters with the flow time and flow number test parameters. Mixtures containing high PG grade binders and shown to be relatively very stiff by the permanent deformation tests performed poorly in terms of cracking resistance. However, the $|E^*| \sin \delta$ parameter indicated these mixtures should exhibit better cracking resistance.

Title **Factors Affecting Low Temperature Failure and Intermediate Temperature Fatigue Properties of Modified Asphalt Binders**

Authors Kitae Nam and Hussain U. Bahia (University of Wisconsin-Madison)

Abstract The effects of modifiers on failure and rheological properties at low temperatures were determined by using the Direct tension, the bending beam rheometer and the dilatometric glass-transition device. The direct tension tests (DTT) were conducted in order to evaluate the effect of modification on strength (σ_f) and strain tolerance (ε_f) of selected asphalt binders at multiple temperatures and strain rates. The sensitivity of the binders to the temperature and the rate of loading is one of the main topics discussed extensively in this paper. Some of the selected binders were long-term aged to show the relative effect of aging compared to the effects of temperature and loading rates on the cracking and overall rheological properties of these modified binders.

In addition, attempts were made to look at the potential to relate the low-temperature properties, such as strain at failure, to the fatigue life of the tested binders. In summary, this paper contains the relative importance of the various factors including testing conditions, aging, and the type of modifiers on failure and fatigue performance of binders. It offers an overview of the relative effects and provides some ideas to improve cracking resistance behavior of asphalt binders in the laboratory.

Title **Effect of Acid and Other Modifiers on PG Binder Grading**

Authors Laird E. Weishahn (Nebraska Department of Roads), and John Dageforde and Magdy Abdelrahman (University of Nebraska)

Abstract The grading of PG Binders and how the addition of acids and other modifiers impact the grading of binders was investigated. This study was initiated, as field observation showed the performance of same mixes with different modifiers was different. The study includes comparisons of binder properties made with different modifiers as interacting with mix containing anti-strip additives. In addition to variable percentages of acids, plastomers and elastomers the ability to process and characterize binder properties was included in this investigation. A concern of NDOR in comparing the performance of different binder modifiers is the ability to process modified binders, including extraction from field mixes, so that property evaluation can be equally conducted or achieved. The study presents results of laboratory testing on these processing of binders with different modifiers.

Title **The Effect of Phosphoric Acid on the Physical Properties of Asphalt Binders**

Authors Mark G. Bouldin (PebbleCrest Materials & Service Corporation) and Raj Dongré (Dongré Laboratory Services)

Abstract

Recently phosphoric and polyphosphoric acids have become increasingly popular as chemical modifiers in elastomeric systems. Initially this technology was used to facilitate the oxidation of asphalts, in particular, roofing fluxes and in Europe, in paving applications for so-called multigrade asphalts.

Reinke's patent for the use of phosphoric acid and polyphosphoric acid with Elvaloy was based on the assumption that the functional group in the Elvaloy would be hydrolyzed and, thus, "cross-link" with the asphaltenes. While this is most likely true we hypothesized that the prime effect originates from changes to the physico-chemical makeup of the asphaltenes in the asphalt.

In order to evaluate this and to study how phosphoric acid/phosphates may affect polymer-modified asphalts, in particular, elastomer-modified systems we evaluated a series of blends where the H_3PO_4 concentration varied between 0 and 1.6% by weight of binder. The data indicates that the colloidal structure of the asphaltenes is destabilized and the asphaltenes in the presence of phosphate assemble to large-scale, agglomerated structures. At very high concentrations the asphaltenes appear to precipitate out of solution. In addition we found that upon storage the phosphate reacted as a strong oxidizing agent and degraded the polymer and most likely the asphalt.

Title **Effect of Polyphosphoric Acid on Aging Behaviour of Bituminous Binder**

Authors Gilles Orange and Jean-Valéry Martin (Rhodia Recherches), and Bruno Marcant (Rhodia, Inc.)

Abstract

Polyphosphoric Acid (PPA) technology is now an extensively used method for asphalt modification. Rhodia recently proposed a chemical mechanism for this modification[1]. However, although the short-term performance benefits are well understood and recognized, there are still substantial questions regarding the long-term performance and durability of PPA modified asphalts. This is the reason we investigated the impact of PPA modification on short and long term aging of bituminous binders using the Rotating Cylinder Aging Test (RCAT) and a standard European Shell 70/100.

The DSR measurements show equivalent increases after short-term aging for both the neat and the PPA modified asphalt. With respect to long-term aging, the increase of the PPA modified asphalt is substantially higher than the neat asphalt, which may result in higher brittleness of the asphalt. However, the measurements using BBR do not show any differences between the neat and the PPA modified asphalt, both after short-term and long-term aging.

In order to highlight the difference between PPA modification and air-blowing, IR-ATR diamond spectroscopy is used to determine the chemical oxidation of the asphalt during aging, especially through carbonyl and sulfoxide band intensity. No differences were detected between fresh and short term aged neat and PPA modified asphalt. After long term aging, sulfoxide and carbonyl bands are observed on the neat asphalt. The PPA modified asphalt develops the same sulfoxide and carbonyl bands, but with less intensity. This means PPA-modified asphalt has a lower oxidation susceptibility which is consistent with the BBR results.

This work clearly demonstrates that PPA modification doesn't induce any oxidation phenomena or accelerated aging of the asphalt. High temperature stiffness is increased without any negative effect at low temperature. Moreover the oxidation sensitivity of asphalt during aging is slightly reduced with polyphosphoric acid modification. This chemical modification is fundamentally different from asphalt air blowing oxidation.

[1] "Chemical modification of bitumen through Polyphosphoric Acid: properties – microstructure relationship," G. Orange, D. Dupuis, J.V. Martin, F. Farcas, C. Such, B. Marcant, Paper 334, Eurasphalt and Eurobitume 2004, Vienna.

SESSION 3: SPECIFICATIONS, SPECIFICATION UPGRADES AND PHYSICAL PROPERTY DETERMINATIONS

Title **Investigation of Yield Stress of Asphalt Emulsions as a Potential Quality Control Parameter**

Authors Max Hetzer and Daniel De Kee (Tulane University), and Chris Abadie (Louisiana Department of Transportation)

Abstract The yield stress of asphalt emulsions was investigated as a potential quality control parameter. Viscometric data were determined using concentric cylinder, parallel plate and cone and plate geometries with rotational rheometers. We also investigated the use of a novel slotted plate technique, to determine the yield stress in a direct way. That is to say: without extrapolation. The Saybolt viscosity was determined with a Saybolt viscometer following the AASHTO T 72-97 standard procedure. We found that the slotted plate technique produced reproducible and consistent results, which were far superior to those obtained by rotational rheometer techniques. The yield stress of the emulsions appears to be a more accurate measure of the performance specification for asphalt emulsions than the Saybolt data.

Title **Separation and Characterization of Bitumen Waxes**

Authors Xiaohu Lu and Per Redelius (Nynas AB)

Abstract Waxes from different bitumens were isolated and characterized. In the wax isolation, bitumen was first separated into two fractions using the preparative size exclusion chromatography (PSEC), and wax precipitated from SEC-II at a low temperature. The isolation of wax was also performed using a distillation method (German DIN 52015). Various techniques were used to characterize bitumen waxes, including DSC, GC-MS, FIMS, NMR and HTGC. It was shown that wax (content) determination was greatly dependent on the method/procedure used. After isolation, the bitumen waxes differed considerably in crystallisation/melting process and in enthalpy. They also differed largely in the content of n-paraffins, as well as in paraffin distribution. Other crystallising materials, such as iso-paraffins, mono- and di-naphthenes, and aromatics, were found in the isolated waxes. It has also been indicated that, in determining the effects of waxy bitumens on mixture performance, only considering wax content is not sufficient, and wax type (structural characteristics) must be considered. Examples of such observations will be presented in this paper.

Title **Multi-Stress Creep Recovery - A New Approach to the Refinement of High Temperature Binder Specification**

Authors John D'Angelo (FHWA) and Raj Dongré (Consultant)

Abstract There are several parameters currently being proposed such as accumulated strain after 50 cycles (NCHRP 9-10) or single cycle creep of various loading and recovery times (Rowe et al.) or ETA' and ZSV to replace G*/sin delta as the binder high temperature grading criteria. Recent data has raised doubts about the use of storage viscosity (ETA') or zero-shear viscosity (ZSV) as a specification parameter to determine Superpave high temperature PG grade. Dongré et al. has shown in a paper presented at the 2004 annual TRB meeting that the stress level affects the rutting response of hot-mix asphalt in laboratory rut testers such as the Hamburg and the APA. None of the new parameters being proposed incorporate the effect of stress levels on rutting. We propose a new test where the binder creep and recovery test is performed at multiple stress levels. The data from this test is analyzed to determine a new parameter that represents the effect of stress on unrecoverable strain. Using this parameter asphalt binders are graded and compared to laboratory rut results from the Hamburg and APA testers. In this presentation we will discuss the results of the new test method, its analysis and use in determining high temperature PG grade of the binder.

Title **Understanding the AASHTO 2002 Pavement Design Guide**

Authors Raj Dongré (Consultant), and John D'Angelo, Leslie Myers, and Kathy Petros (FHWA)

Abstract As the finishing touches are being put on the new mechanistic empirical pavement design guide developed as the product of the NCHRP 1-37A project we take a look at its purpose, function, and impact on pavement design. The asphalt portion of the design guide was developed by the research team headed by Dr. Matt Witzak of Arizona State University. The first AASHTO pavement design guide was based on empirical design methodology using performance data obtained during the AASHO road test in the 1950's. There have been several versions developed since with essentially empirical refinements. The new design guide is based on mechanistic-empirical (M-E) performance prediction models. Hot-mix asphalt material properties required by the guide may be determined in the laboratory using a Simple Performance Tester (SPT) especially developed for that purpose. The guide is modular where any given model can be replaced when a better version becomes available. The new guide incorporates hierarchical inputs in the form of traffic, climate, material properties, and pavement structure. The guide is programmed into a software program that has a common shell for all inputs.

This presentation will cover the basic information about the guide. The impact on the industry will also be discussed. In particular, we will discuss the resources needed by users to take advantage of this guide such as how many testers (SPTs) are needed, how many coring rigs will be necessary, type and number of saws and lead time necessary to generate a pavement design using this guide.

Title **Using the Pressure Distribution Analyzer to Measure Sensitivity of HMA Compaction to the Zero Shear Viscosity of Asphalt Binders**

Authors Arif Khatri, Ahmed Faheem, and Professor Hussain U. Bahia (University of WI – Madison)

Abstract The objective of this study is to prove that there is no appreciable difference in the compaction effort to attain specified density when using compaction temperatures estimated based on equal zero shear viscosity (ZSV) values. The Pressure Distribution Analyzer (PDA) was used to measure the compaction effort being applied in the Superpave Gyratory Compactor (SGC) to reach a common value of density for several mixtures varying in gradation of aggregates and type of binder used. The real time load and eccentricity data obtained from the PDA was used to calculate the stresses experienced by the hot mix asphalt and the compaction energy required for densification. The control variables included 1 aggregate source, 2 gradations, 4 binders (3 modified), 2 compaction temperatures at optimum asphalt content. The compaction temperature was determined for the binders at a ZSV of 1500mm2/s. The data collected was analyzed to evaluate the effect of viscosity on the compaction effort to achieve the specification air voids at Nini, Ndesign and Nmaximum. The results show the relationship between the ZSV and the compaction effort required and thus explain the role of binders in densification of the mixtures. The results also show that the role of binders is different depending on the type of gradation and stage of densification.

Title **Determination of Asphaltene Content and Other Compositional Properties of Asphalts by Flocculation Kinetics Titrimetry**

Authors Adam T. Pauli and J. Miller (Western Research Institute)

Abstract A new method has been developed to measure rates of flocculation of asphaltenes in solutions of asphalt in toluene, titrated with iso-octane (2,2,4-trimethyl pentane). The flocculation rate process described by this method may be modeled using a simple second-order rate law defined in terms of a forward rate constant, k, and an effective maximum number of flocculated particles, n_{max}, which is actually measured in terms of the maximum amount of UV-visible light blocked, $(Abs_{adj})_{max}$, at 740 nm. This light "blocking" effect is due to the formation of flocs, measured as a function of time. Values of $(Abs_{adj})_{max}$ appear to correlate closely with "n-heptane defined" asphaltene content of whole asphalt, and thus, constitutes a rapid measure of asphaltene content in whole asphalts.

SESSION 4: INSTRUMENTAL ANALYSIS FOR PERFORMANCE PREDICTION

Title **A High-Resolution TGA Method for the Characterization of Bitumen and Bituminous Products**

Authors J-F. Masson and S. Bundalo-Perc (National Research Council of Canada, Institute for Research in Construction)

Abstract A high-resolution thermogravimetric analysis (TGA) method was developed and applied to bitumen and petroleum/bituminous products. The derivative TGA curve amounts to a thermogram reminiscent of a simple infrared spectrum. The thermogram shows three broad regions of mass loss, i.e. 50-360, 360-500, 500-600°C, that correspond to the light, medium and heavy hydrocarbons in bitumen. The method allows for fingerprinting bitumen from various sources as each region of the thermogram shows multiple peaks. The high-resolution method has been used to monitor the evolution of the various bitumen fractions upon aging. It shows potential for a rapid and solventless SARAs composition analysis of bitumen and of solids content in bitumen emulsions.

Title **Comparison of Asphalt Binders' Fatigue Measured using Parallel Plate Geometry with Torsion Cylinder Geometry**

Authors Wilfung Martono and Hussain Bahia (University of Wisconsin-Madison), and John D'Angelo (FHWA)

Abstract Fatigue damage is a distress observed in asphalt at moderate to low temperatures due to cyclic traffic loading. Recent developments in binder fatigue measurements have been made using parallel plate geometry to measure total dissipated energy and the change in energy with cycles. Recent studies, however, have raised questions regarding temperature and stiffness level at which true binder fatigue could be measured with the parallel plate geometry in the DSR. It has been claimed that at stiffness level (G*) lower than 10-20 MPa, the type of failure observed is instability effected by edge effects rather than true fatigue.

Using asphalt mastic samples 12 mm in diameter and 30 mm in height, called torsion cylinder, edge effects on binder fatigue can be studied. The torsion cylinder approach was developed originally by researchers at Texas A&M University. A modified version of this approach is used in this study. It is believed that the torsion cylinder geometry allows studying fatigue in asphalt binders with no possibility of edge effect.

In this presentation a comparison is made between results of the parallel plate and the torsion cylinder results at similar temperatures and testing frequencies. It is found that a simple shift parameter, based on testing geometry, could shift torsion cylinder result to be the same as the parallel plate. Binder stiffness role in similarities and differences is presented.

Title **Use of NMR Imaging to Measure Interfacial Properties of Asphalts**

Authors F. P. Miknis, A. T. Pauli, A. Beemer, and B. Wilde (Western Research Institute)

Abstract An NMR imaging method is being developed from which the interfacial surface tensions of asphalts can be directly calculated. The method is based upon acquiring NMR images of water drops on the surface of asphalt as a function of time. By expressing the contact angle for the water drop in terms of Young's equation for the initial placement of the water drop on the asphalt surface, and using the liquid lens equation for a later time when the water drop has sunk below the asphalt surface, two equations that incorporate the asphalt-air and asphalt-water surface tensions are obtained which can be solved analytically. The NMR imaging method was used to determine the surface tensions of the 8 SHRP core asphalts at 25°C. Asphalt-water surface tension values ranged from 25 to 40 dynes/cm, and asphalt-air surface tension values ranged from about 38 to 50 dynes/cm. These results are in general agreement with other asphalt surface tension measurements using the du Nöuy ring tensiometer, or Wilhelmy Plate method, and are of the same order as surface tension values of tar sand bitumens and asphaltenes reported in the literature. Other NMR imaging experiments involving water and asphalts will also be discussed.

Title **Results from the Use of Gel Permeation Chromatography to Determine Polymer Content in Asphalt**

Authors Joe Rovani, Martin McCann, and John Schabron (Western Research Institute)

Abstract The use of Superpave-Plus specifications is gaining in popularity. Part of the “Plus” portion of the specification is the adoption of a variety of test procedures to detect whether an asphalt binder has been modified. Rapid and reliable analytical methods are needed.

Gel Permeation Chromatography (GPC) is a laboratory technique that is used to separate sample components by molecular size. Typically, polymer modifiers used in asphalt are a minimum of ten times higher molecular weight than the largest molecules of asphalt, thus polymer-modified asphalts are candidates to be separated using GPC. To determine whether GPC could be used to classify modified and unmodified asphalts, experiments were conducted with eight unknown asphalts.

The analytical method and interpretation of data will be presented. The results demonstrate that five of the eight asphalts were correctly identified as neat asphalts, and the remaining three were correctly identified as polymer-modified. It is possible to quantify the asphalt for percent determination of modifier, and if alternate detectors are used in the GPC system or other analytical methods employed, it is possible to identify the type of polymer modifier.

Title **Road Trip on the Lincoln Highway: From Rock Boulevard to I-80**

Authors Chavawn Kelley (Western Research Institute)

Abstract While the Petersen Asphalt Research Conference brings together researchers and others devoted to the future of America's predominant roadway material, this presentation takes as its starting point the conference location on Cheyenne's Lincolnway for a look back at changing technologies and perceptions of road surfaces, driving, and cross-country travel. The idea for the Lincoln Highway, America's first transcontinental automobile road, is attributed to Carl Fisher, the man who brought us the Indianapolis Motor Speedway, Miami Beach and automobile headlights (though the seed may have been planted by Wyoming's own Good Roads "Moses," Ezra Emery). In 1913 the Lincoln Highway Association was formed to raise private dollars for the endeavor, to educate the public, and to pursue the ideal road building technologies of the time. This presentation follows Austin F. Bement, vice president and secretary of the Lincoln Highway Association, as he motors across the West in 1917, 1924 and 1939. Along the way are opportunities to observe America's evolving automobile culture and highway system, as well as a few local tourist spots. It is hoped that this break in the conference's technical proceedings will afford participants an opportunity to contemplate their own roles in the development of the transportation systems of the future.

SESSION 5: DAMAGE ASSESSMENT AND REPAIR

Title **Mitigation of Reflective Cracking in Bituminous Overlays using High-modulus Fiberglass Membranes**

Authors David R. Jones, IV (Trumbull Asphalt, Tampa, FL), Reynaldo Roque (University of Florida, Gainesville, FL), and Fujian Ni (Transportation College, Southeast University, Nanjing, PRC)

Abstract The use of high-modulus fiberglass mat has been investigated for the mitigation of reflective cracking in bituminous overlays placed over Portland cement concrete and bituminous pavements. Excellent resistance to reflective cracking has been seen in field sections with up to four years of exposure. The material has been placed in a wide range of climatic conditions, and over a wide variety of existing pavements, including both milled and unmilled surfaces, and in both maintenance and new construction applications. The material has been also been tested over cement-treated bases and soil cement to prevent the reflection of shrinkage cracks in those materials into the overlying flexible pavement.

Laboratory test data has been conducted to help explain the field performance of the fiberglass mat, and will be presented in this paper.

Pavements containing this material have been successfully milled, and the RAP has been shown to have no deleterious affects on mixture properties when used up to a level of 25 weight percent. In field experiments no difficulties were encountered with the milling of this material in a pavement section, a problem that has been encountered in some geotextiles used in highway applications.

Title **Assessment of Moisture Damage Resistance in the Laboratory - An Evaluation of Various Tests**

Authors Jack Youtcheff (FHWA) and Raj Dongré (Consultant)

Abstract Recently a new tester was introduced by Pine Instruments Incorporated of Grove City, PA, called the "RutWheeler". This device is primarily designed to test six-inch diameter superpave Gyratory compacted samples in presence of moisture (immersed in water). Testing may also be performed without water. When tested in presence of water, this testing is similar to the more well known Hamburg Loaded Wheel Tester (LWT). Testing in the Pine device is carried out using three steel wheels placed 120 degrees apart in a circular fashion. The centre of the circle incorporates the superpave gyratory sample of various heights between 70 and 120 mms. This loading arrangement allows the sample to be tested on its sides which are perpendicular to the direction of compaction. This device is a new addition to the available under-water rut testers on the market. A study was undertaken at Turner-Fairbank Highway Research Center (TFHRC) to determine the repeatability of the data provided by this device. Data was also collected to understand the performance of the Pine RutWheeler as compared with the Hamburg LWT.

This presentation will discuss the performance of the rutwheeler and the Hamburg LWT in predicting moisture damage resistance in the laboratory. Results of comparisons between the binder pull-off test (introduced in the past by Youtcheff et al.) and the rutwheeler and Hamburg LWT will also be presented.

Title **"Warm Mix Asphalt" in Overnight Airport Runway Paving & Emergency Pavement Maintenance**

Author Jeremy A. Day and Prem Naidoo (Sasol Wax Americas Inc.)

Abstract One of the key challenges of the paving industry is the construction of projects which will allow for the least disruption of traffic and be a cost as well as convenience factor. Examples are overnight pavement repairs and airport runways that need to be repaired or reconstructed and this paper presents the concept of "Warm Mix Asphalt" as applied to the Frankfurt International Airport's main runway North which is being reconstructed between the hours of 10.30pm when the last international passenger jet lands for the day to 6am the next morning so that the first international jet can land on the new surface. The project is 70% completed and serves as model for the "Warm Mix" concept and which can be extended to other applications such as steel bridge paving and emergency repairs. This paper shows how the "Warm Mix" concept has been designed to fit the USA PG requirements through binder modification and transpose the benefits to fit the USA specifications.

Title **Comparison of Effects of Anti-Stripping Additives and Polymer Modification on Performance of Asphalt Mixtures in Laboratory**

Authors Kunnawee Kanitpong (Graduate Student, University of Wisconsin-Madison) and Hussain U. Bahia (Associate Professor, University of Wisconsin-Madison)

Abstract Currently, the use of anti-stripping additive and some polymer modifications can cause a reduction of the susceptibility of asphalt mixtures to moisture damage. However, there is a question raised as to how these additives and modifications can change the overall performance of asphalt mixtures. The purpose of this study is to evaluate and compare the effect of anti-stripping additive and polymers on the fundamental properties of asphalt mixtures measured in the laboratory before and after the water conditioning.

Asphalt mixtures were produced with different modified binders and with two aggregate types. The binders were modified using anti-stripping additive, polymers, and oxidization methods. Granite and Limestone were selected as two types of aggregate sources. Three different mixture testing procedures including: the Indirect Tensile Strength Test, the Uniaxial Compression Permanent Deformation Test, and the Hamburg Wheel Tracking Test were selected to measure mixture performance in this study. Additionally, the fundamental properties of asphalt binders including adhesion, cohesion, and rheological properties were measured to compare the effect of different additives used. Results indicated that the performance of asphalt mixtures is highly dependent on modification techniques and water conditioning. From the study, the best practice for predicting effect of modification on performance of asphalt mixtures in the laboratory is described.

Title **State-of-the-Art Composite Systems for Creating Ultra-High Modulus Mixes for Structural Layers**

Authors Mark G. Bouldin (PebbleCrest Materials & Service Corporation) and Raj Dongré (Dongré Laboratory Services)

Abstract A multi-component natural asphalt-based system has been developed for creating easily compactable ultra-high modulus mixes which can significantly reduce the tangential strains on the bottom of the hot-mix asphalt layer. The original low temperature properties of the PG-graded base asphalt are maintained. This system is implemented in a two-step process.

First, Trinidad Lake Asphalt (TLA) and a processing agent are melted together and ratably injected into the base PG-graded binder. Then the TLA modified asphalt is sprayed onto the pre-treated aggregate. The aggregate is pre-treated (primed) using a Gilsonite-based system which improves the bond between the TLA-modified binder and the aggregate. This system eliminates the need for lime or liquid antistripping agents.

The data clearly indicates that at total addition levels as low as 12% by weight of binder the modulus at 20°C can increase by a factor three. Concurrently, the high temperature DSR value exhibits an increase of 50 to 300% depending on the base asphalt grade and source.

Using an elastic layer structural analysis we found that generally the required thickness of the pavement structure could be reduced by as much as 40% while obtaining smaller or equivalent tangential strains in the pavement.

Title **Laboratory Characterization of HMA Surface Mixtures with Screened RAP**

Author Baoshan Huang (University of Tennessee)

Abstract This paper presents the results from a laboratory study in which hot-mix asphalt mixtures with No.4 sieve screened reclaimed asphalt pavement (RAP) were characterized for their rutting, fatigue cracking and low temperature performance. A typical surface mixture commonly used in the state of Tennessee was evaluated at 0, 10, 20 and 30 percent of No. 4 sieve screened RAP materials. One type of aggregate (limestone) and two types of asphalt binders (PG64-22 and PG76-22) were considered in this study. Mixture rutting properties were evaluated through the Asphalt Pavement Analyzer (APA). Fatigue characteristics of mixtures were evaluated through indirect tensile strength, beam fatigue, and semi-circular fatigue tests. Low temperature characteristics were evaluated through the bending beam rheometer test for the binder extracted from the mixtures.

The results from this study indicated that the inclusion of RAP generally increased the stiffness, reduced rutting in APA, and increased indirect tensile strength and laboratory fatigue resistance for the mixtures studied. Low temperature cracking resistance decreased with the increase of RAP content. Mixture properties changed significantly at 30% RAP content as compared to those with 10 and 20 percent. Further field validations for the laboratory results were recommended.
