Acknowledgement

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Organized by
WESTERN RESEARCH INSTITUTE
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the
FEDERAL HIGHWAY ADMINISTRATION

Hitching Post Inn Resort and Conference Center
Cheyenne, Wyoming, June 20-24

Sunday, June 19

4:00-5:30  Registration
Pick up conference materials
Register for conference
Hitching Post Inn Lobby

Monday, June 20

7:30-8:30  Registration
Hitching Post Inn Lobby

8:30-8:50  Welcome and Opening Remarks
Raymond E. Robertson
Western Research Institute

8:50-9:00  Welcome and Introductions
Scott B. Smith
Major General, USA (Retired)
Chief Executive Officer, WRI

9:00-9:50  Keynote Speaker
Graham Hill
Director and Senior Counsel
for the Subcommittee on Highways, Transit and Pipelines,
Committee on Transportation and Infrastructure, U.S. House
of Representatives (See p. 22)

9:50-10:15  BREAK
SESSION 1  RECYCLED ASPHALT PAVEMENT, MODEL ASPHALT AND LOW-TEMPERATURE STUDIES

Session Chair—Raymond E. Robertson, WRI

10:15-10:50  How Does RAP Influence HMA Properties?  Jo Daniel  
             (University of New Hampshire)

             Binders Using ABCD  (Ohio University)

11:25-12:00  Design of Model Asphalts by Molecular Simulation  Michael L. Greenfield and  
             Liqun Zhang (University of Rhode Island)

12:00-1:15  LUNCHEON

SESSION 2  ADDITIVES AND FIELD STUDIES

Session Chairs—Michael Farrar and Theresa Bomstad, WRI

1:15-1:50  Enhancing the Performance of Asphalt-CRM Binders  Magdy Abdelrahman  
          With the Addition of New Polymer Modifiers  (North Dakota State University)

1:50-2:25  Lignin as an Antioxidant:  A Limited Study on Asphalts  S. W. Bishara (Kansas  
          Frequently Used on Kansas Roads  Department of Transportation),  
          R. E. Robertson (Western  
          Research Institute) and  
          Donna Mahoney (Kansas  
          Department of Transportation)

2:25-3:00  The Application of Fischer-Tropsch Hard Wax as a  Prem Naidoo  
          Warm Mix Asphalt Additive  (Sasol Wax Americas Inc.)

3:00-3:20  BREAK
PROGRAM

3:20-3:55  Development of a Longitudinal Joint Permeameter as a QC/QA Tool for HMA Pavements
Jo Daniel (University of New Hampshire) and Rajib Mallick (WPI)

3:55-4:30  The Impact of Binder Oxidation on Mixture Fatigue And Pavement Durability
Sung Hoon Jung (Texas A&M University), Lubinda F. Walubita and Amy Epps Martin (Texas A&M University/TTI), and Charles J. Glover (Texas A&M University/TTI)

4:30-5:05  Characterization of Polymer Modified Asphalt Cements Aged in the Lab and on the Road
Ioan I. Negulescu and William H. Daly (Louisiana State University), Louay N. Mohammad (LSU and Louisiana Transportation Research Center), Christopher Abadie (Louisiana Transportation Research Center), and Codrin Daranga, Ionela Chiparus-Glover and Rafael Cueto (LSU)

MONDAY EVENING—Dinner on your own

Tuesday, June 21

SESSION 3  ANALYTICAL CHEMISTRY, MICROSTRUCTURE AND MICROBIAL ACTION

Session Chairs—David Rowlett and Mark Pooler, WRI

8:00-8:35  Asphalt Mastic Characterization by Means of Chromatography
Shin-Che Huang (Western Research Institute), Jan F. Branthaver (WRI-retired) and Raymond E. Robertson (WRI)
8:35-9:10  Quantitative Measurements of Aromatic Contents, Mass Compositions and their Distributions in Asphalts by Multi-Dimensional HPLC  
Ashraf Z. Khan (Intertek Caleb Brett—Philadelphia Regional Laboratory)

9:10-9:45  The Structure of Asphaltenes in Asphalt and Crude Oil  
Per Redelius (Nynäshamn Bitumen)

9:45-10:10  BREAK

10:10-10:45  Asphalt Solidification: Theory, Methodology & Application  
Troy Pauli, Fran Miknis, Appy Beemer and Julie Miller (Western Research Institute)

10:45-11:20  Multi-Phase Structures in Bitumen: AFM and Cryo-AFM Studies  

11:20-11:55  Microbial Degradation of Asphalt – Does It Contribute to Road Failure?  
Deborah Sanchez, Mark Pooler, Steve Salmans and Janet Wolf (Western Research Institute)

11:55-1:20  LUNCHEON, Plenary Speaker  
Dr. K. Thirumalai  
Chief Engineer, Research and Innovative Technology Administration, US DOT (See p. 23)

SESSION 4  RHEOLOGY

Session Chair—James Petrie, WRI

1:20-1:55  Predicting Rutting Potential of Asphalt Binder using Multiple Stress Creep and Recovery Test (MSCR)  
John D'Angelo (FHWA) and Raj Dongrè (Dongrè Laboratory Services Inc.)
1:55-2:30 The Influence of Thermal History on Binder Rutting Indicators
Hilde Soenen (Nynäs Bitumen AB), Joelle De Visscher and Ann Vanelstraete (Belgian Road Research Centre) and Per Redelius (Nynäs Bitumen AB)

2:30-2:50 BREAK

Raj Dongré (Dongré Laboratory Services Inc.) and Leslie Myers and John D’Angelo (FHWA)

Raj Dongré (Dongré Laboratory Services Inc.)

Tonight:
CONFEREnCE DIINNTER
Cheyenne Depot
121 W. 15th Street
Social Hour 5:30, Dinner 6:30 pm

Cheyenne's historic Union Pacific depot, built in 1886, has been recently restored to the glory it knew when rail travel was king and it was considered the most spectacular depot between Omaha and San Francisco.

(Guest tickets may be purchased from Jackie.)
#### SESSION 5  CONSTRUCTION AND POLYPHOSPHORIC ACID

**Session Chairs—Deborah Sanchez and William Wiser, WRI**

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ABSTRACTS

Session 1: Recycled Asphalt Pavement, Model Asphalt, and Low-Temperature Studies
Session 2: Additives and Field Studies
Session 3: Analytical Chemistry, Microstructure and Microbial Action
Session 4: Rheology
Session 5: Construction and Polyphosphoric Acid

SESSION 1  RECYCLED ASPHALT PAVEMENT, MODEL ASPHALT & LOW-TEMPERATURE STUDIES

Title How Does RAP Influence HMA Properties?
Author Jo Daniel (University of New Hampshire)
Abstract Recent work conducted at the University of New Hampshire with one particular RAP source has shown a change in volumetric properties (VMA, VFA) with the addition of higher percentages (25% and 40%) of RAP. The VMA increases with the higher RAP percentages, and it is hypothesized that at the higher percentages, a significant portion of the RAP material acts like a black rock, creating a coarser effective gradation, which in turn causes the increase in VMA. When dynamic modulus and strength tests are performed on these mixtures, the higher VMA offsets the higher proportion of stiff RAP binder such that the dynamic modulus values for the higher RAP percentages are similar to those for the control mixture. In the current work, a second RAP source is being tested to determine if a similar phenomenon occurs. Testing to date has shown that the volumetric properties change in a similar manner. Dynamic modulus and strength tests are in the process of being conducted. In addition, these values will be input into the ME design guide to investigate the effect of the RAP on predicted performance.
Title Evaluation of Low-Temperature Performance of Asphalt Binders Using ABCD
Author Sang-Soo Kim (Ohio University)
Abstract An Asphalt Binder Cracking Device (ABCD) is proposed to determine the low temperature cracking potential of an asphalt binder. ABCD is a simple test method whose operating principle is based on the differential thermal contraction between the metal ABCD ring and an asphalt binder placed outside of the ring. As the temperature is lowered, the test binder shrinks more rapidly than the ABCD ring placed inside, which results in development of thermal stresses. When the developed thermal stress exceeds the strength of the binder, the binder specimen cracks. Strain gauges installed inside of the ABCD ring detect the fracture, and the temperature is recorded as the ABCD cracking temperature. Using a number of modified and unmodified binders, ABCD repeatability was studied. Based on this study, the ABCD and its test procedures were modified to produce repeatable results. From laboratory tests, ABCD showed the better correlation with Thermal Stress Restrained Specimen Test (TSRST) results than with the AASHTO M320 and MP1a procedure. When the strength data determined by ABCD were used in the MP1a procedure, its correlation with TSRST was significantly improved. Using binders with known field performance, validation of ABCD procedure is being studied.

Title Design of Model Asphalts by Molecular Simulation
Authors Michael L. Greenfield and Liqun Zhang (University of Rhode Island)
Abstract Molecular simulations are being used to devise mixtures of a few chemical compounds that exhibit physical properties of real asphalts. As a first step, single compounds were chosen to represent the asphaltene, resin, and maltene components. Mixtures of n-C22H46 and 1,7-dimethylnaphthalene were used to represent the maltene and resin, respectively. Two different asphaltene model structures were considered. The first has a large aromatic core with a few short side chains; the second contains a moderate size aromatic core with larger branches. Both types have been proposed in the recent literature based on experimental characterizations of asphaltene fractions. Significant differences in mixture properties were predicted based on these asphaltenes. For example, the temperature dependence of density suggests different glass transitions at the same mass fractions of asphaltene, resin, and maltene. The simulations also suggest differences in the way molecules in asphalt pack together. The dimethylnaphthalene molecules (resins) are oriented randomly, while asphaltenes exhibit both non-random and non-parallel orientations relative to one another.
Title: Enhancing the Performance of Asphalt-CRM Binders with the Addition of New Polymer Modifiers

Authors: Magdy Abdelrahman (North Dakota State University)

Abstract: Crumb-Rubber-Modifier (CRM) has been successfully used to improve the performance of asphalt binders. Modifications to asphalt properties using CRM are slightly different as compared to those of virgin polymers; SBS for example. The mechanism of interaction with asphalt that develops performance properties of asphalt binders is different from that of polymer modifiers. The effects of processing variables, for example interaction time and/or temperature, on the developed properties are different between the two mechanisms. CRM binders are sensitive to interaction time and temperature. Adding new (virgin) polymers changes the nature of the interaction mechanism between asphalt and CRM and that enhances the properties of asphalt-CRM binders. This presentation introduces an effort to characterize the changes in the properties of asphalt-CRM binders in the presence of new polymer modifiers. The presented data indicates that the nature of asphalt-CRM binders can be further controlled to produce an improved binder with enhanced and stable properties that is less sensitive to interaction variables; time and temperature.

Title: Lignin as an Antioxidant: A Limited Study on Asphalts Frequently Used on Kansas Roads

Authors: S. W. Bishara (Kansas Department of Transportation), R. E. Robertson (Western Research Institute) and Donna Mahoney (Kansas Department of Transportation)

Abstract: Preliminary research at Western Research Institute (WRI) has revealed the potential of lignin as an asphalt-binder antioxidant. The present work describes lignin’s effect on aging and rheological properties of some binders used for paving roads in Kansas over the year 2004. The first part of this study deals with selecting a group (eight) of the most frequently used binders, and ranking them according to both the physical properties (aging index at 25°C) as well as the chemical composition (sulfur and sulfide content, total polarity, vanadium and nickel content, colloidal instability index, and the carbonyl group formed on aging). From this ranking, the two extreme binders, that is, the least and most likely-to-be-aged asphalts were selected. The second part of this work involved the use of two different types of lignin (GE15 and B108) that were added at the concentrations of 0, 2, 4, 7, and 10 percent to each of the two selected binders. The stiffness was measured at high, intermediate and low temperatures. The effect of lignin on the aging index, as well as the high, intermediate, and low TC will be discussed.
**The Application of Fischer-Tropsch Hard Wax as a Warm Mix Asphalt Additive**

**Author** Prem Naidoo (Sasol Wax Americas Inc.)

**Abstract** Several new processes have been developed to reduce the mixing and compaction temperatures of hot mix asphalt without sacrificing the quality of the resulting pavement and one of these processes utilizes a synthetic long chain Fischer-Tropsch hard wax. Laboratory studies were conducted by NCAT (National Center for Asphalt Technology, Auburn University) to determine the applicability of the Fischer-Tropsch hard wax to typical paving operations and environmental conditions commonly found in the USA, including the performance of the mixes in quick traffic turn-over situations and high temperature conditions. Superpave gyratory compactor results indicated that the Fischer-Tropsch hard wax may lower the optimum asphalt content, so it should be added during the mix design process.

This Fischer-Tropsch hard wax was shown to improve the compactability of the mixtures in both the SGC and vibratory compactor and data shows an overall reduction in air voids with improved compaction noted at temperatures as low as 190°F. The addition of the Fischer-Tropsch hard wax does not negatively affect the resilient modulus or the rutting potential of an asphalt mix as measured by the Asphalt Pavement Analyzer at the lower temperatures. There is no evidence from the data to indicate differing strength gain with time compared to the controls and this means that the Fischer-Tropsch hard wax mixtures do not require a long cure period prior to opening to traffic at the lower temperatures employed.

Overall this additive is a viable tool for reducing mixing and compaction temperatures and can readily be added to hot mix asphalt without high shear equipment. Demonstrated benefits are substantial reductions in mixing and paving temperatures down to 190°F, 20% reduced heating fuel costs and substantial reduction in emissions.

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**Development of a Longitudinal Joint Permeameter as a QC/QA Tool for HMA Pavements**

**Authors** Jo Daniel (University of New Hampshire) and Rajib Mallick (WPI)

**Abstract** Often times, premature distress happens along HMA longitudinal joints due to the intrusion of water. Longitudinal joint permeability is a critical factor governing the performance of the longitudinal joint in both road and airfield pavements. Hence, the joint permeability can be used as a measure of the quality of joint construction. Permeability measurements also reflect the effectiveness of joint sealants, which density measurements can not do. In this ongoing study, a simple and effective falling head permeameter has been developed. The permeameter consists of three standpipes which are used to measure the flow of water through the joint and through the mat on either side of the joint. The testing performed thus far shows that joints have significantly higher permeability compared to adjacent mats, different types of joints have different permeabilities, and that treatment of joints with sealers and using improved joint construction techniques such as an infrared joint heater can reduce the permeability significantly. More testing of joints is being carried out, with the objective of developing specific criteria for using the joint permeameter for quality control of construction of longitudinal joints.
The Impact of Binder Oxidation on Mixture Fatigue and Pavement Durability

Sung Hoon Jung (ChE-Texas A&M University), Lubinda F. Walubita and Amy Epps Martin (CE-Texas A&M University/TTI), and Charles J. Glover (ChE-Texas A&M University/TTI)

Binders oxidize in laboratory mixtures, leading to binder embrittlement and decreases in fatigue life. Critical questions to pavement performance prediction are: 1) is this oxidation and embrittlement important in pavements, beyond the near-surface, 2) to what extent might embrittlement and decrease in fatigue life lead to a decline in pavement life, and 3) do different mixture designs react differently with regard to these questions.

Laboratory-aged (aged at 60 °C, 1 atm air) mixtures were analyzed for fatigue failure and mixture rheological properties. Their recovered binders were analyzed for oxidation and binder rheological properties. Laboratory-aged (aged at 60 °C, 1 atm) binders were analyzed for oxidation and rheological properties for comparison with the mixture-aged binders. Finally, binders recovered from field cores were analyzed for oxidation and rheological properties.

Field core data, supported by diffusion and reaction calculations, indicate that binders oxidize at depths below the near surface of a pavement (several inches below the surface, at least). Declines in mixture fatigue life due to oxidation, coupled with a Miner’s hypothesis analysis of cumulative damage, predict very significant decreases in pavement durability. Finally, different mixtures can provide dramatically different calculated pavement lives when this decline in fatigue with oxidative aging is considered.

Characterization of Polymer Modified Asphalt Cements Aged in the Lab and on the Road

Ioan I. Negulescu (Louisiana State University School of Human Ecology); William H. Daly (Louisiana State University Department of Chemistry); Louay N. Mohammad (Louisiana State University Department of Civil and Environmental Engineering and Louisiana Transportation Research Center); Christopher Abadie (Louisiana Transportation Research Center); and Codrin Daranga, Ionela Chiparus-Glover and Rafael Cueto (Louisiana State University Department of Chemistry)

A 76-22 PMAC sample was aged in the lab by multiple PAV operations in the absence and in the presence of water vapors. The same PMAC composition was sampled from a road after up to eight years of service. The uptake of oxygen and changes in the molecular mass of PMAC components of aged samples were estimated from FTIR and GPC analyses. Viscoelastic properties were determined by DSR. The point of interest was the temperature at which the tangent of the loss angle became unitary (delta = 45°) for f = 10rad/s.
SESSION 3  ANALYTICAL CHEMISTRY, MICROSTRUCTURE AND MICROBIAL ACTION

Title Asphalt Mastic Characterization by Means of Chromatography
Authors Shin-Che Huang (Western Research Institute), Jan F. Branthaver (WRI-retired) and Raymond E. Robertson (Western Research Institute)

Abstract Eight concentrated solutions of asphalts in cyclohexane were separated into non-polar and polar organic fractions by percolation through beds of pulverized aggregates (<200 mesh) mixed with a filter aid. The polar organic fractions were desorbed from the aggregate using a polar solvent. After drying, the polar organic fractions were weighed. Infrared spectra showed that polar functional groups are concentrated in polar organic fractions. Weights of polar organic fractions from eight asphalts separated on seven aggregates were recorded. Separately, the rheological properties of neat asphalts and their mixtures with 20% of different fillers (granite, limestone, basalt, gravel, greywacke) over the entire range of frequencies at both 25°C and 60°C using a research-grade rheometer were performed. The mass percentages of the polar fractions of different asphalts obtained by chromatography on seven different fillers are correlated to the rheological parameters (dynamic viscosity, modulus, and phase angle) of asphalt mastics. Results show that the polar organic fractions of asphalt binder separated from chromatographic technique using aggregate fillers as the adsorbent correlate well with the loss tangent of asphalt mastics. Results indicate that too much adsorption of polar organic molecules by an aggregate might conceivably adversely affect binder properties, particularly if the binder is deficient in polar constituents.

Title Quantitative Measurements of Aromatic Contents, Mass Compositions and Their Distributions in Asphalts by Multi-Dimensional HPLC
Author Ashraf Z. Khan (InterTek Caleb Brett – Philadelphia Regional Laboratory)

Abstract Determination of chemical compositions in asphalts has been gaining importance in recent years. This is, partly, because of the dependence of properties like oxidative aging, interactions with aggregates, binder modifiers et al. on the chemical compositions of asphalts. In spite of the necessity of reliable and affordable techniques, there are only a handful of modern techniques that can effectively examine asphalts. Also, due to the complex molecular nature and high boiling points of asphalts, most separation techniques become unsuitable for handling asphalts. A High Performance Liquid Chromatography (HPLC), originally designed for analyzing heavy distillate materials in refining industries, has recently been found to be suitable for asphalt analysis at molecular levels.

In our laboratory, a multi-dimensional HPLC fitted with two detectors (Photo Diode Array and Evaporative Light Scattering) and two normal phase columns (PAC and DNAP) and operated with Chemstation software has been successfully applied for quantitative determinations of aromatic core contents, aliphatic side chains, mass compositions and their distributions in six hydrocarbon fractions of asphalts. These fractions are saturates (naphthenes and paraffins), mono, di, tri, and tetra aromatics and polars (higher than tetra aromatics and N- and O-containing heterocyclic compounds). This technique is based upon an efficient separation of hydrocarbon fractions using solvent gradients and ‘chromatofocussing’, a procedure for wide-range calibrations of the detectors and unique algorithms for the conversion of UV spectra to aromaticity. We show that the HPLC offers a number of advantages, particularly the simplicity of sample preparation procedure and the easiness of data acquisition, that very few techniques could offer. Such an analytical system exhibiting data for 20 key parameters from a single injection is environmentally safe and suitable for an attendance-free operation. It is an affordable and a reliable technique for asphalt investigation.
The Structure of Asphaltenes in Asphalt and Crude Oil

Per Redelius (Nynäshamn)

Abstract

It has generally been claimed that Asphaltenes may form ordered structures in crude oils and bitumen, usually referred to as micelles. This statement has however been challenged many times and an intensive debate has been going on during the last twenty years regarding the existence of asphaltene micelles in bitumen or not. Asphaltenes are generally defined as the fraction of bitumen or crude oil which is insoluble in n-heptane. The discussion will be based on known chemistry of asphaltenes, Hansen solubility parameters of asphaltenes and maltenes, interaction energies of organic molecules, the rheology of bitumen and finally by X-ray scattering techniques.

The conclusion is that there is basically two ways of causing instability in crude oil and bitumen, one is to create a solubility gap by adding components (solvents, additives, polymers) with different solubility parameters compared to the bitumen or by processing which may change solubility parameters of components in the bitumen.

The usefulness of the solubility model will be demonstrated by some examples which will be illustrated by a computer program developed by WRI. The program is able to estimate Hansen 3D solubility parameter and the 3D solubility sphere based on a large set of solubility data.

We will present enough evidence, based on general chemistry of asphaltenes as well as own experiments, to suggest that no ordered structures of asphaltenes exist either in crude oil or bitumen.

Asphalt Solidification: Theory, Methodology & Application

Troy Pauli, Fran Miknis, Appy Beemer and Julie Miller (Western Research Institute)

Abstract

A fundamental concept that arose out of the Strategic Highway Research Program (SHRP) was that chemical/compositional properties of asphalt-binders, which dictate physical/rheological properties, should readily lend to the prediction of pavement performance. Over the past 10 years (the post-SHRP era), the micro-structural properties of asphalt-binder have been studied intensively to bridge the gap that links compositional properties to rheological properties. One of the approaches taken by WRI to establish such a link has been to develop a model of asphalt-binder that considers both the thermodynamic and kinetic processes that apply to construction, curing, and aging periods in the lifecycle of a pavement. Hence, a non-equilibrium statistical thermodynamic model of asphalt-binder solidification will be presented, along with experimental protocols and potential real-world applications, in order to highlight some of the major tenets of the present model.
Title **Multi-Phase Structures in Bitumen: AFM and Cryo-AFM Studies**


Abstract Bitumen (asphalt cement) has been used in construction applications since biblical times, yet its internal structure is still the subject of debate. The issue is of importance because microstructures and the arrangement of phases in multi-phase materials affect material characteristics and performance. In an effort to contribute to the understanding of bitumen microstructure, twelve SHRP bitumens were analyzed at room temperature by atomic force microscopy. Seven bitumens were analyzed by cryo-AFM down to –55°C.

The investigation with a Jeol JSPM-5200 microscope provided images of unprecedented resolution and clarity. The various bitumens could be classified in three groups based on their structure. Some bitumens showed “bee” structures, the area of which correlated poorly with the asphaltenes content. A good correlation was obtained between the surface area for the bees and the metals content.

The observation of bitumen after cooling revealed structures not visible at room temperature. As the material stiffened, the contrast between various phases increased. At –55°C, a remarkably clear dispersion was attributed to non-crystalline paraffins based on measurements of Tgs by modulated DSC. The findings challenge the standard micellar model for bitumen.

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Title **Microbial Degradation of Asphalt – Does It Contribute to Road Failure?**

Authors Deborah Sanchez, Mark Pooler, Steve Salmans and Janet Wolf (Western Research Institute)

Abstract Asphalt pavement failure results from a complex set of physical, chemical, and environmental factors. Microbial degradation of the asphalt binder is one factor that has been largely overlooked and not well understood by the transportation community. Many common species of bacteria and fungi which are indigenous to soil and dispersed widely in nature are capable of degrading complex hydrocarbons, including polyaromatic hydrocarbons under varied environmental conditions. Since 1956, several field and laboratory studies have linked microbial action to pavement failure.

This presentation discusses the conditions necessary for microbial degradation of pavement to occur, summarizes the literature search of this phenomenon, describes field and laboratory studies, outlines possible mechanisms of microbial degradation of pavement, and discusses ways to inhibit this type of pavement degradation.

In addition, the results of a query of state DOT's from several areas of the country representing varied moisture and soil conditions are presented. State representatives responded to questions regarding evidence of microbial degradation in their states and what measures are taken to mitigate the effects.
**SESSION 4  RHEOLOGY**

**Title**  
Predicting Rutting Potential of Asphalt Binder Using Multiple Stress Creep and Recovery Test (MSCR)

**Authors**  
John D’Angelo (FHWA) and Raj Dongré (Dongré Laboratory Services Inc.)

**Abstract**  
The adequacy of G’/sin (delta), the current Superpave binder parameter to mitigate rutting, has been questioned by many researchers. Several field and accelerated testing studies have confirmed its inadequacy. A new characterization technique called the Multiple Stress Creep and Recovery Test (MSCR) is being investigated at FHWA. In this technique the asphalt binder is subjected to increasing levels of creep stress (from 25 Pa to 3200 Pa). The creep and recovery time duration at each stress level remains the same (1 s creep followed by 9 s recovery). The testing is conducted at high PG grade temperature (25 mm plate DSR n stress control) by applying ten creep and recovery cycles at each stress level.

Several asphalt binders with different high temperature rutting behavior were characterized using MSCR. Some of the binders tested were obtained from field sites with known performance, while others had accompanying APA and Hamburg hot-mix rutting information. The MSCR data was analyzed to determine the non-recoverable compliance (Jnr) as a measure of rutting. It was found that Jnr was successful in explaining the contradictory rutting behavior observed in the APA and Hamburg rut testers. Jnr also showed reasonable correlation with field rutting. Although it is a preliminary at this point, but it seems that Jnr may also be able to distinguish between asphalt binders that damage excessively beyond a certain stress level and those that do not.

The details of the Jnr testing and its use in predicting rutting behavior of asphalt binders will be discussed. Issues related to sample integrity during testing asphalt binder will also be explored.

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**Title**  
The Influence of Thermal History on Binder Rutting Indicators

**Authors**  
Hilde Soenen (Nynäs Bitumen AB), Joelle De Visscher and Ann Vanelstraete (Belgium Road Research Centre), and Per Redelius (Nynäs Bitumen AB)

**Abstract**  
Binder properties, believed to relate to asphalt rutting, were investigated and compared with each other. Included are: parameters derived from oscillatory tests (e.g. the “zero” shear viscosity and the SHRP rutting parameter), parameters derived from static and repeated creep tests and the traditional R&B softening point. The measurements in oscillation mode were made with different rheometers in different labs, to study repeatability and reproducibility. Test results on 4 selected binders, including polymer modified binders will be presented in detail, during the presentation.

This study demonstrates the importance of storing and preparation conditions prior to the rheological measurement, especially in the range of long loading times or low frequencies. For SBS modified binders, the homogenization temperature and the corresponding change in micro-structure are most important. For EVA modifiers, which are often semi-crystalline, the storage time and storage temperature before testing introduce large changes in the polymer network building up. The thermal history effects in rheological tests can be related to variations in crystallinity, as shown by calorimetry, or to variations in morphology, as revealed by fluorescence microscopy.

This study shows that handling conditions prior to rheological testing as well as sample preparation conditions can be extremely important for the properties of polymer modified binders and should be controlled better, especially for testing at low frequencies or long loading times (ZSV and creep, repeated as well as static tests).
Title  
Effect of Conversion of Testing Frequency to Loading Time on Performance Prediction in The NCHRP 1-37A MEPDG

Authors  
Raj Dongré (Dongré Laboratory Services Inc.), and Leslie Myers and John D’Angelo (FHWA)

Abstract  
This paper examines the impact on performance prediction of the erroneous conversion from frequency domain to time domain inherent in the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide (MEPDG). The error in the MEPDG in determining loading time during master curve generation is that frequency in hz (f) is directly converted to loading time (t in seconds) by taking the inverse of f (i.e. t = 1/f). The choice of the unit of frequency (Hz vs. rad/s) is very important when converting from frequency domain to loading time domain. The most widely used (correct) approach in Rheology is to first convert the cyclic frequency in hz (f) to angular frequency in radians/s (ω, rad/s = 2πf) and then taking the inverse to determine loading time (t=1/2πf).

In determination of the dynamic complex modulus |E*|, testing is conducted at a selected temperature and one frequency or at multiple frequencies (frequency sweep). An example of such testing is the new Simple Performance Test (SPT) suggested by the researchers of NCHRP 1-37A. The results from the SPT test include |E*| as a function of frequency for a total of six frequencies (0.1, 0.5, 1, 5, 10, 25 hz). The testing frequency is reported in hertz units (hz, cycles per second) in spite of the fact that the commonly used fundamental unit of frequency in Rheology is radians per second (rad/s, also known as angular frequency). The MEPDG requires that the |E*| is input as a function of frequency in hertz units at various temperatures. From this data, the MEPDG erroneously internally generates an |E*| master curve as a function of loading time (in seconds).

Title  

Author  
Raj Dongré (Dongré Laboratory Services Inc.)

Abstract  
This paper examines the stepwise process by which |E*| is used in the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide (MEPDG) to predict pavement performance. Starting from the initial measurement of |E*|, its use in calculating stresses and strains, and eventually its effect on prediction of pavement performance will be discussed. The Dynamic Modulus, |E*| is defined as the ratio of the absolute value of the maximum axial stress (at peak) and the maximum recoverable axial strain (at peak) for a material subjected to a sinusoidal loading. |E*| is measured in the laboratory using the Simple Performance Tester (SPT) which was developed as part of the NCHRP 9-29 “Superpave Mix Design” project. The SPT |E*| test is conducted in stress-control mode, a process in which an axial compressive load is applied to hot-mix asphalt (HMA) specimen and the resulting recoverable axial strain response is measured.

The NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide (MEPDG) consists of three alternative procedures for pavement design, called levels, which require varying amount of complexity of data inputs. The Level 1 design is the most sophisticated procedure and requires the user to input laboratory measured |E*| data at various temperatures and frequencies. Levels 2 and 3, which are less rigorous, use predictive equations to determine |E*|. The NCHRP 1-37A design guide is different from the existing AASHTO 93 design guide, in that it incorporates mechanistic calculations to determine stresses and strain in the pavement. AASHTO 93 uses an entirely empirical pavement design approach. The “mechanistic” portion of the design comes in the form of materials characterization (laboratory measured |E*|) to compute stresses and strains. The “empirical” part of the MEPDG uses damage prediction models that relate stresses and strains to damage accumulation to predict performance.
**Comparative Studies on Liquid Anti-Strip and Lime in HMA Mixtures**

**Title**

Comparative Studies on Liquid Anti-Strip and Lime in HMA Mixtures

**Authors**

Peter E. Sebaaly (Western Regional Superpave Center and University of Nevada, Reno)

**Abstract**

In the late 1970s and early 1980s a significant number of pavements in the United States began to experience distress associated with moisture sensitivity of hot mixed asphalt (HMA) mixtures. Premature rutting, raveling and wear were observed on many pavements. The causes of this sudden increase in pavement distress due to water sensitivity have not been conclusively identified. Practitioners and researchers suggest that changes in asphalt binders, decreases in asphalt binder content to satisfy rutting associated with increases in traffic (traffic volume, traffic weight and tire pressure), changes in aggregate quality, and poor quality control were primarily responsible for increased water sensitivity problems.

Materials engineers typically use anti-strip additives to improve the resistance of HMA mixtures to moisture damage. The primary goal of an anti-strip additive is to eliminate moisture sensitivity of the HMA mixture through improving the bond between asphalt binder and aggregate. This binder-aggregate bond is a fundamental property of the HMA mixture which can not be evaluated through testing of the individual components (i.e. binder or aggregate). The most effective method of evaluating the effectiveness of an anti-strip additive is to evaluate a fundamental property of the HMA mix such as the resilient modulus (Mr) as it is subjected to multiple freeze-thaw cycling.

This research evaluated the resilient modulus properties of HMA mixtures treated with liquid anti-strip and lime as they were subjected to multiple freeze-thaw cycling. The mixtures were sampled from two projects in South Dakota and one project in Idaho.

**Acid Modified Asphalt: Its Influence on the Properties of Asphalt Binders and Mixes**

**Title**

Acid Modified Asphalt: Its Influence on the Properties of Asphalt Binders and Mixes

**Authors**

Leni M. Leite, Cristina P. Bittencourt and Luis Alberto H. Nascimento (Petrobras Research Center, Rio de Janeiro), Laura G. Motta (Federal University of Rio de Janeiro), and Jorge B. Soares (Federal University of Ceará)

**Abstract**

Acid modification of bitumen with polyphosphoric acid is a way to improve asphalt binders properties. Improvement on thermal susceptibility is obtained at a low addition content. The rheological and ageing properties of asphalt binder were studied using dynamical shear rheometer, chemical analysis and conventional empirical methods. The results showed that the properties of the acid modified binders were largely dependent on the characteristics of the base bitumen. Mechanical tests results of dense bituminous mixes using acid modified binders showed no effect on induced water damage of the mixes. They were submitted to the following mechanical tests: indirect tensile strength, resilient modulus and fatigue life. The results indicate improvement of the mixture properties due to acid addition. A comparison between the results of performance tests with acid modified binder and other modified mixtures is also shown.
Chemical Modified Asphalt Properties: Influence of Polyphosphoric on Asphalt Mixes Granulates Adhesion

Jean-Valery Martin (Innophos) and Gilles Orange (Rhodia Recherches)

Binder adhesion to aggregate is one of the most important properties that influence the durability of an asphalt mixture. Adhesion corresponds to the interface interaction between two different substrates: the binder and the aggregate. This interaction is usually not easy to assess as many parameters may be involved in this phenomenon, for example: asphalt composition and its evolution with pavement aging, aggregate surface porosity, chemical nature of aggregate surfaces, etc. Adhesion capabilities of asphalt mixes are usually characterized by their resistance to moisture and in different temperature conditions. In such conditions the binder cohesion influences the test results as water must reach the aggregate-binder interface to modify the adhesion. Asphalt additives usually modify one major property of the binder. In the case of polymers, the cohesion level and consistency are modified. In the case of adhesion promoters, the resistance to moisture is modified. Neither polymers nor adhesion promoters influence both at the same time. Polyphosphoric acid has been used for many years to modify the asphalt binder properties and very few studies were done on its influence on binder adhesion to aggregate.

This paper discusses the impact of polyphosphoric acid onto the binder moisture resistance with or without being combined with polymers. A specific section is dedicated to polyphosphoric acid compatibility with different adhesion promoters.

Emulsification of Polyphosphoric Acid Modified Asphalt: Effects on Emulsion Stability and Original Binder Properties

Delmar Salomon (Pavement Preservation Systems, LLC) and Huachun Zhai (Integrated Asphalt Solutions, LLC)

Researches on Polyphosphoric acid (PPA) modified asphalt have indicated that there are some adverse factors when amine antistripping agents are used with PPA modified asphalt. Amine antistrip tends to nullify high temperature improvement brought by PPA. Since the majority of the emulsifiers used in the asphalt industry are amine based, will a PPA modified binder retain its original binder properties under emulsification?

In this study, PPA modified binders were emulsified using different emulsifiers (both amine and non-amine based) into both cationic and anionic emulsions. The emulsion residues for different emulsions were tested. It was found that PPA modified asphalt cannot be emulsified at the normal emulsifier level. The tests on the emulsion residues indicated that PPA modified asphalt base was nullified by the amine based emulsifier. The G*/sin δ and penetration were reduced to close pre-PPA modification level. PPA in asphalt also has an adverse effect on the emulsion stability. These results indicate that caution needs to be taken when PPA modified asphalt is used for emulsification. Like in any good quality system, the emulsion manufacturer should know the type of modification used to achieve the binder’s PG grade when it is purchased in the open market.
An NMR Study of the Behavior of Polyphosphoric Acid in Asphalt

F. P. Miknis (Western Research Institute)

Phosphorous-31 NMR spectroscopy has been used to study the behavior of polyphosphoric acid in asphalt. A sample of SHRP asphalt ABD was treated with 1.5 wt % of 105% polyphosphoric acid and blended in a shear mixer at 3,000 rpm for 30 minutes at 140 °C. Phosphorous NMR spectra were acquired on the PPA modified asphalt sample immediately after blending, and on samples that were stored at 135 °C for different periods of time. The initial NMR spectra showed resonances characteristic of phosphorous atoms in orthophosphate, and in middle and end groups in phosphate chains. However, over time the number of phosphorous atoms in the middle and end groups decreased, indicating a preference of polyphosphoric acid to revert back to the orthophosphate in the presence of asphalt. The NMR data did not suggest the formation of organic phosphate esters as a result of PPA modification. Phosphorous NMR spectra were also acquired on asphalt samples modified with Elvaloy and SBS in which polyphosphoric acid was used as a catalyst. The data showed that over time only one type of phosphorous atom remained in the asphalt.

PPA-Modified Asphalt: Possible Mechanism of Action and Other Observations

Ken Thomas, Fred Turner and Troy Pauli (Western Research Institute)

Polyphosphoric acid, PPA, is used as a modifier in asphalt pavements. It is reported to increase the high-temperature PG grade and not have an impact on the low-temperature PG grade. In practice it increases the high-temperature grade about 3°C; thus, it can be used to shift a marginal asphalt that doesn’t quite meet the required higher grade to an asphalt that does meet the required specifications. Even though PPA is used in commercial applications, the mechanism of action of PPA in asphalt is still the subject of considerable investigation.

This presentation will cover the preliminary results of an investigation that addresses the mechanism of action of PPA in asphalt. The results obtained through the use of many different instrumental techniques are presented. The techniques include Fourier transform infrared spectroscopy, modulated differential scanning calorimetry, atomic force microscopy, etc. The presentation will address, in part, such diverse topics as storage stability, aging of asphalt, changes in DSC heat-flow profiles, and the dispersive properties of PPA.
Mr. Graham Hill

Director and Senior Counsel, Subcommittee on Highways, Transit & Pipelines, Committee on Transportation and Infrastructure, U.S. House of Representatives

Graham Hill is the Director and Senior Counsel for the Subcommittee on Highways, Transit and Pipelines, United States House Transportation and Infrastructure Committee, chaired by Congressman Don Young of Alaska.

Mr. Hill is a Texas native from the San Antonio region of south Texas. He earned a BA in Political Economy and Political Science from The University of the South and a JD from Tulane Law School. Mr. Hill worked in Mexico as a consultant to the Department of State, for Senator Phil Gramm of Texas and Senator Trent Lott of Mississippi, and for Haley Barbour at the Republican National Committee. Mr. Hill practiced law in New York before his return to Washington in 1999 to become Counsel and Legislative Director for Congressman Chip Pickering of the House Energy and Commerce Committee. In 2001, Mr. Hill became Counsel to the House Transportation and Infrastructure Committee for Investigations and Oversight. Two years ago, Mr. Hill moved within the Committee to become the Counsel for the Highways, Transit and Pipelines Subcommittee, the source of the reauthorization effort for TEA-21.

In 2002 Mr. Hill was appointed by President Bush as a member of the National Council on Disability (NCD), an independent federal agency that makes recommendations to the President and Congress on issues affecting Americans with disabilities. The NCD promotes policies, programs, practices and procedures that guarantee equal opportunity for all individuals with disabilities. The NCD was the original author of the Americans with Disability Act of 1990 (ADA).
Dr. K. Thirumalai
Chief Engineer, Research and Innovative Technology Administration, US DOT

Dr. K. “KT” Thirumalai is Chief Engineer, Research and Innovative Technology Administration with the U.S. Department of Transportation. He oversees the development and management of multimodal research programs, strategic planning of DOT’s research and development activities, and the management of the University Transportation Research Centers programs. He is nationally recognized for his leadership in promoting and implementing innovative solutions to critical issues in transportation and engineering practice.

Prior to joining U.S. DOT he held the following leadership positions:

- Senior Manager for Advancing Transportation Technologies with the National Research Council's Transportation Research Board (TRB) and Manager for the Strategic Highway Research Program, Washington, D.C.
- CEO of Science and Technology Institute, a technical R&D services firm in Virginia
- Director of National Science Foundation’s Civil, Mechanical and Structural Engineering Research, Washington, D.C.
- Technical Manager for Nuclear Waste Disposal Technology Development with DOE Hanford Operations in Richland, Washington
- Director of Safety Technology Development for Mine Safety and Health Administration (Department of Labor) and Head of Mining Research with U.S. Bureau of Mines (Department of Interior)

Dr. Thirumalai graduated as a Doctor of Engineering from the Technical University in Freiberg, Germany, with research in geo-mechanics and failure of structures. He is the author of more than 200 research and technology publications in advancing technologies, R&D and technology policy, fracture and fragmentation mechanics, safety, and hazard and disaster mitigation.
About WRI’s Transportation Technology Research and Services

Western Research Institute is proud to be a research partner of the Federal Highway Administration, working to discover how the physical properties of highway materials contribute to their performance in the nation’s roadways. WRI research seeks to distinguish asphalt characteristics not being distinguished today, including what characteristics cause asphalt pavements to fail; what characteristics serve as predictors of long pavement life; what characteristics can be measured and which critical performance measurements are missing. Over the years, WRI has provided significant findings on variables that contribute to the life-cycle performance of asphalts and has introduced practical instruments and test methods used by government and industry.

Instruments and tests developed or adapted by WRI include:

- Automated Flocculation Titrimeter for determining the internal stability and blending compatibility of asphalts (winner of a 2002 American Chemical Society Industrial Innovation Award).
- Modified German Rolling Flask (developed with Advanced Asphalt Technology, LLC, http://www.advancedasphalt.com)
- Dynamic Shear Rheometry SuperPave® Test
- Pressurized Aging Vessel Adapted for SuperPave® Test
- Asphalt Aging Test Using Capillary Inverse Gas-Liquid Chromatography
- Fatigue Damage Test (developed with Texas A&M University, http://tti.tamu.edu/)
- Microwave Aging of Asphalt (with Kansas Department of Transportation, http://www.ksdot.org/about.asp)

Laboratory methods pioneered by Western Research Institute used by industry and researchers:

- Infrared Spectroscopic Functional Group Analysis
- Preparative Size Exclusion Chromatography
- Non-Aqueous Potentiometric Titration of Asphalts
- Glass Transition Temperature of Asphalts Using Modulated Differential Scanning Calorimetry
- Atomic Force Microscopy for determining adhesion and frictional force in asphalt thin films

Innovative research projects have included:

- Development of a procedures to understand the use of crumb rubber in roads
- Evaluation of the life cycles of twelve sulfur-extended asphalt pavements (joint research with Rauhut Engineering Company in 1995)
- Evaluation of shale oil additives in roads for improved performance characteristics (joint project with the New Paraho Corp. and US Department of Transportation Western Federal Lands Highway Division in 1994)
- Field Validation Sites with Arizona, Kansas, Nevada and Wyoming transportation departments (ongoing)
- Sealer/Rejuvenator Validation Sites in Arizona, California, Michigan and Minnesota (ongoing)

COMMERCIAL SERVICES

We put our know-how to work for asphalt, additives and roofing suppliers, trade associations and transportation agencies—anyone with a need for greater insight into asphalt and other transportation materials.

- Analytical services and material characterization, including chemical, rheological and physical testing
- Custom test method and instrument development
- Troubleshooting and materials failure investigations in the field or laboratory
- Materials consulting and R&D (asphalt, aggregates, additives)
WHEREAS, in the early years of the 19th century, the Lincoln Highway, America's first paved transcontinental automobile road, was a narrow two-lane that traced parts of the old Mormon/Oregon Trail, Overland Stage Line and Pony Express routes across Wyoming from Pine Bluffs to Evanston; and

WHEREAS, today, Wyoming benefits from an excellent highway system, upon which motorists have traveled 8.1 billion miles, and which is the economic, cultural and social lifeblood of the state; and

WHEREAS, the highway research community in Wyoming, including the Wyoming Department of Transportation, the University of Wyoming, and Western Research Institute, contributes significantly to improving highways in the state and nation; and

WHEREAS, the Petersen Asphalt Research Conference and the Pavement Performance Prediction Symposium bring together a national and international community of university, government and industry researchers, state highway officials and asphalt and additive producers, all seeking to improve the specification and performance of asphalts; and

WHEREAS, the exchange of knowledge that the conference, now in its 42nd year, and the symposium, now in its 5th year, contribute to longer-lasting asphalt roadways, reduced construction costs, safer construction zones, greater purchasing power of the Highway Trust Fund, and better, safer roads.

NOW THEREFORE, I, DAVE FREUDENTHAL, Governor of the State of Wyoming, do hereby proclaim June 20 – 24, 2005 to be

ASPHALT RESEARCH WEEK

in Wyoming.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Executive Seal of the Governor of Wyoming to be affixed this 23rd day of June, 2005.

[Signature]
Governor
A Glimpse of Cheyenne History...

On July 4, 1867, the first tents were pitched on the site now known as Cheyenne by the crews of the Union Pacific Railroad. The town quickly grew to be a lively place, with five “variety” theaters operating simultaneously and every other building a saloon. The cattle industry was another factor in Cheyenne’s development, with the town attracting many wealthy men from the East and Europe, cattle barons who spent their summers in Cheyenne and winters abroad.

The first telephone directory and yellow pages in the world were published in Cheyenne in 1881. It was actually one yellow page that included six ads and the phone numbers for all 102 residents and businesses with telephones. Two ads for boot sellers both claimed to have the lowest prices in the city.

The discovery of gold in the Black Hills was the impetus for the famous Cheyenne–Deadwood Stage, which ran for more than eleven years. Miners used it to get to the gold fields, and the lucky ones used it to ship their gold back to Cheyenne and on to points east and west via the Union Pacific Railroad.

In 1887, Phatty Thompson, an entrepreneur of the highest order, decided that his road to riches lay in selling pets to the dancehall girls in Deadwood. He paid Cheyenne boys twenty-five cents for each stray cat they collected. He loaded the boxed cats onto his wagon and took off for Deadwood. Unfortunately, he tipped the wagon and all the cats escaped. It took him a while, but eventually he recaptured and reloaded most of them. Once he got to Deadwood, he sold the cats to the dancehall girls for $10 to $25 each.

Today, Cheyenne Frontier Days is the world’s largest outdoor rodeo and western celebration. Watch for the 8-foot high painted cowboy boots that grace Cheyenne streets, plazas and businesses, each highlighting an aspect of Cheyenne’s rich and colorful history and culture.

Dongre Laboratory Services PCMS

Dongre Laboratory Services PCMS has emerged as a leader in the field of asphalt laboratory services for the paving and roofing industries.

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Laboratory Services Include:
- AASHTO Binder Testing
- Traditional Binder Testing
- Hot-Mix Asphalt Testing
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- Hamburg Wet or Dry Testing
- Custom Formulations
- Materials Consulting
- On-site Training
- Crude Assays
- NCHRP 1-37A Design Guide