FHWA
Asphalt Binder
Expert Task Group
July 26-27, 2007
Denver, CO

The meeting of the FHWA Asphalt Binder Expert Task Group (ETG) was held on July 26 and 27, 2007 in Denver, Colorado. Chairman Gaylon Baumgardner of Paragon Technical Services, Inc., Co-Chairman Raymond Robertson of the Western Research Institute, and Secretary John D'Angelo of the Federal Highway Administration (FHWA) conducted the meeting. Allen Cooley and Jimmy Brumfield of Burns Cooley Dennis, Inc. were present with Dr. Cooley acting as Secretary and Mr. Brumfield assisting with the meeting.

*The following members of the FHWA Binder ETG **were** in attendance:*

Gaylon Baumgardner, Paragon Technical Services, Inc. (Chairman)
Raymond Robertson, Western Research Institute (Co-Chairman)
John D'Angelo, Federal Highway Administration (Secretary)
Dave Jones, Trumbull Asphalt, a Division of Owens Corning
Gayle King, GHK, Inc.
Dean Weitzel, Nevada DOT
Bruce Morgenstern, Wyoming DOT
Ioan Negulescu, Louisiana State University
Darren G. Hazlett, Texas DOT
Gerald Reinke, Mathy Construction
Mihai Marasteanu, University of Minnesota
Dr. Ludo Zanzotto, University of Calgary
David Anderson, Consultant - Advanced Asphalt Technologies
Henry Romagosa, ICL Performance Products LP

*The following liaison member of the FHWA Binder ETG **was** in attendance:*

R. Michael Anderson, Asphalt Institute

*The following "**friends of the Binder ETG" were** in attendance:*

Howard Anderson, Utah DOT
Satish Belagutti, FHWA/OTA
Derek Bell, DB-SI
Ramon Bonaquist, AAT
John Casola, Malvern
Matthew Corrigan, FHWA
Roberto de Dios, CDOT
Raj Dongré, DLSI
Mike Farrar, WRI
Frank Fee, Citgo Asphalt
Eli Fini, UIUC
Roy Guevara, CDOT
Andrew Hanz, UW-Madison
Lila Harnan, CDOT
Mike Harnsberger, WRI
Rick Holmgreen, Conoco Phillips
Andy Horton, Heritage Research Group
Shin-Che Huang, WRI

Richard Kim, North Carolina State Univ.
Julie Kliewer, Arizona DOT
Bob Kluttz, Kraton Polymers
Laurand Lewandowski, PRI Asphalt
Jean-Valery Martin, INNOPHOS
Eyad Masad, Texas A&M University
Richard May, Sem Materials, L.P.
Andy Mergenmeier, FHWA
Mandy Monjaras, Sem Materials, L.P.
Karrisa Mooney, Citgo Asphalt
Steve Mueller, FHWA
Frank Osmon, Anton Paar USA
Troy Pauli, WRI
Jean-Pascal Planche, TOTAL France
Simon Prout, Malvern Instruments
Olga Puzic, Exxon Mobile
Pedro Romero, University of Utah
Judie Ryan, Wisconsin DOT
Bob Statz, Consultant
Peter Sebaaly, University of Nevada
Fred Turner, WRI
Kevin VanFrank, Utah DOT
Eric Weaver, FHWA
Haifang Wen, University of Wisconsin
Shih-Hsien Yang, UIUC
Jack Youtcheff, FHWA

OBJECTIVE

The primary objective of the FHWA Asphalt Binder Expert Task Group is to provide a forum for the discussion of ongoing asphalt research and also to provide technical input for future research related to fundamental properties and advanced modeling.

DAY 1 - Thursday, July 26, 2007

Welcome and Introductions – Gaylon Baumgardner (Paragon Technical Services, Inc.)

Chairman Baumgardner called the meeting to order at 8:02 AM and welcomed everyone and requested for self-introductions from all attendees. Copies of the agenda and sign in sheets were handed out.

(1) Review of Action Items from the last meeting - John D'Angelo (FHWA)

Secretary D'Angelo reviewed the action items from the last meeting and gave an update on the progress achieved since the last Binder ETG meeting held in Phoenix, AZ on February 5-6, 2007.

(2) Compressional Rheometer - Satish Belagutti (FHWA)

Satish Belagutti provided an update on research being conducted by the FHWA on compressional rheometers (Attachment 1). At a previous ETG meeting, the members had expressed interest in compressional rheometers. The approach for evaluating the device included the following parameters: 1) ease of use; 2) comparison of G* and δ test results; and 3) advantages and disadvantages. Four different binders were tested in two different aged conditions. Three temperatures were used during testing.

The asphalt binders included within the evaluation were an air-blown; SBS modified PG 64-40, SBS LG and PG 70-27. The two DSRs included were the CP50

(compressional rheometer) and SmartPave (Paar Physica – Superpave Rheometer). Original and RTFO aged conditions were included. Belagutti presented the comparisons of G* and δ, strain sweeps and frequency sweeps tested on original & RTFO aged binders between the CP50 and SmartPave test results. Comparisons for the G* results on original binders showed some large differences between the two pieces of equipment. For the RTFO binders, there were again differences between the CP50 and SmartPave devices; however, the differences were not as large. Generally, the CP50 equipment resulted in lower G* results than the SmartPave equipment for both aged conditions. For δ results, the two were reasonably comparable. There was, however, a slight bias with the SmartPave resulting in slightly higher δ values. An observation on the δ data was that as δ became closer to 90 degrees, the two pieces of equipment yielded similar results. At lower δ values, the SmartPave yielded slightly higher values.

The frequency sweep data indicated that at low frequencies, the two rheometers resulted in similar G* results. However, as the frequency increased, the difference between the two became larger. The SmartPave device resulted in higher G* values. This was consistent for both original and RTFO aged binders. Finally, Belagutti presented the advantages and disadvantages of the compressional rheometer. Advantages included: simple and easy to operate; compressed air not required; portable; uses less counter space; and cost effective. Disadvantages include: difficult to conduct temperature calibration; intermediate temperature testing is not yet possible because of software issues; multiple step creep and recovery testing capability is not currently available; and negative bias in test results. Future work on the compressional rheometer will include intermediate temperature testing if the adjustments are made to correct the bias. Belagutti also solicited suggestions from the ETG.

Following the presentation there was discussion about test results derived from the compressional rheometer. Part of the discussion centered on the algorithm that calculates G*. The graphs presented by Belagutti suggested straight line relationships between G* determined with the two devices. Additionally, the δ values and the viscosity standards were similar. Therefore, it was suggested to re-evaluate the algorithms for calculating G*. A question was asked about how sample temperature was maintained. Temperature is controlled from the lower plate and the whole sample is covered. This means that the sample is passively controlled from the top. Water is added to help maintain temperature. It was also suggested that because of the size and anticipated cost of the compressional rheometer, it may be appropriate for quality control testing.

(3) High Temperature Task Group - John D'Angelo (FHWA)

John D'Angelo provided an update on work being conducted with the multi-stress creep and recovery test (MSCR) (Attachment 2) as part of the High Temperature Task Group. D'Angelo began with an overview of the test method. When rutting occurs in a HMA layer, the aggregate particles reorient within the shear plane. This causes very high strains within the asphalt binder. The MSCR method entails applying a series of creep stresses to a binder sample using a DSR. Each stress cycle includes a 1 sec creep loading followed by a 9 sec unloading. The strain level at each stress state is then normalized versus time and used to determine the non-recoverable compliance.

D'Angelo presented results of MSCR testing on eight binders that were utilized on test sections from the ALF experiment. Next D'Angelo presented two plots. The first plot showed the relationship between G*/sin δ and rutting on the ALF mixes which had a relatively poor correlation. The next plot was the non-recoverable compliance determined at 3.7 psi versus ALF rutting that showed a stronger relationship. D'Angelo discussed several observations that were made during the analysis which include: linear binder tests will not correlate with high temperature failures unless the binder is a viscous fluid; to accurately address mix failure at high temperatures non-linear binder properties have to be evaluated; and creep and recovery testing at different stress levels are needed to describe binder properties in the non-linear range.

D'Angelo presented several items related to using the MSCR test for high temperature criteria. First, non-recoverable compliance describes the stress dependency of the binder. Next, creep and recovery testing conducted at multiple stress levels on one sample can be run to describe the stress dependency of the binder. Finally, non-recoverable compliance can be correlated to mix testing done at different stress conditions and related to performance. D'Angelo states that the current Superpave binder specifications works very well for neat asphalt binders and should not change. However, D'Angelo states that specifications should be developed using the MSCR test. He then stated that all testing should be conducted near the end of their linear range.

D'Angelo presented recommendations for grade bumping binders using the MSCR test. The recommendations are based upon MSCR testing conducted at the project environmental conditions. For standard pavements, the compliance should be a maximum of 0.4. For heavy traffic pavements, the maximum compliance should be reduced by half to 0.2 while pavements subjected to standing traffic should have a maximum compliance of 0.1.

D'Angelo presented a series of graphs that showed the effect of polymers, percent polymers and cross linking. He concluded that the MSCR test can identify how the polymer, binder and processing can affect performance. Work will continue to test a full matrix of binders, evaluate interactions and effects of various additives and evaluate whether the percent recovery determined in the MSCR test is related to durability and fatigue.

Following the presentation, there were discussions about the use of the MSCR test for high temperature specifications. A draft test method for AASHTO will be published and currently working toward getting an ASTM standard adopted. As such, the recommendations for grade bumping could be implementable. Work is underway with the equipment manufacturers to get upgrades for DSRs to conduct the MSCR test.

A comment was made about the use of the MSCR test for specifying emulsions. The question was asked whether this ETG should be evaluating emulsions and whether the MSCR was appropriate for emulsions. It was decided that more discussions were needed at a later date.

(4) High Temperature Task Group - Eyad Masad (Texas A&M University)

Eyad Masad presented a viscoelastic analysis of the MSCR test (Attachment 3). Masad began by discussing viscoelastic models and indicated that linear viscoelastic theory has not been successful for modeling rutting.

Masad presented a series of graphs that illustrate the method to separate the recovered strain from the permanent strain. Four binders were tested and analyzed at various stress levels and temperatures. A macro was written in EXCEL to analyze MSCR test data to separate recovered strain from non-recovered strain. The test data indicated that the recovered strain seems to exhibit a linear response while the permanent strain is nonlinear.

Following the presentation there was discussion about regions of linearity and nonlinearity in the test results. Specifically, it was asked whether neat and polymer modified binders both showed nonlinearity. It was suggested that at high strains, the polymer chains are sliding past each other in binders. It was stated that there is a lot of published data on mix stresses; however, binder stresses are high and localized when failure occurs. Based upon some data, strains in the mastic are 3 to 9 times higher than the mix upon failure. Masad indicated that a viscoplastic elastic model may be required to model binder failure.

(5) Evaluation of DSR - Mike Anderson (Asphalt Institute)

Mike Anderson presented work conducted by the Asphalt Institute (AI) to compare results from the MSCR to mixes used in the 1996 Kentucky PG 70-22 study and Interstate 64 near Winchester (Attachment 4). Information from the Kentucky PG 70-22 study was previously published in AAPT. The I-64 study included duplicate 1 mile sections using each asphalt binder. Asphalt binder and mixture testing were conducted for each of these projects. Additionally, AI went out five years after construction and evaluated performance. Anderson indicated that there was very little rutting in any of the sections.

Anderson presented the results of MSCR testing on the various binders; he then presented a series of graphs depicting relationships between non-recoverable compliance and various mix properties. The mixture test that Anderson compared compliance results to was the repeated shear at constant height (RSCH) test at 58°C. Based upon the comparisons, Anderson presented a statistical comparison between the RSCH results and the non-recoverable compliance results at 70°C. Based upon the statistical comparison, there was some overlap when evaluating the RSCH data; however, the MSCR data did a better job of differentiating the various binders. Two relationships that were noted by Anderson from the data included: 1) as the non-recoverable compliance increased, the permanent strain from the RSCH test also increased and 2) as the recovery went down, the permanent strain went up.

Following the presentation, there were discussions about the conditions of the binder during testing. Anderson indicated that testing was conducted on RTFO aged binders. Mixes were short-term aged prior to testing. It was also asked whether other parameters were related to the RSCH results. Anderson indicated that both $G^*/\sin\delta$ and phase angle were evaluated. The $G^*/\sin\delta$ data did not provide a good relationship but there did seem to be a relationship with phase angle.

(6) FHWA Acid Study - Jack Youtcheff (FHWA)

Jack Youtcheff presented work being conducted by the FHWA on phosphoric acid modification of asphalt (Attachment 5). Seven items that were highlighted as part of the action plan includes: development of analytical methods, understanding the chemical bonding, effect of acid grade, effect of asphalt from different sources, environmental effects, effects of anti-strip additives, and effect on fatigue.

Youtcheff stated that a simple qualitative method of identifying the use of phosphoric acids is being developed at TFHRC. The qualitative method being developed at TFHRC is based upon ASTM D515, "Standard Test Method for Phosphorous in Water." The method requires no special equipment or expertise and is relatively rapid and simple. Youtcheff stated that 0.5 percent PPA can be detected in asphalt. Currently the lower limit of detection is not known and the method is being optimized.

The effect of acid grade and asphalt source on rheological properties showed that all acid grades resulted in similar increases in stiffness, grades containing water exhibited foaming problems and the change in stiffness was found to be source dependent.

The effect of asphalt binders containing 1% phosphoric acid aged in PAV at various time intervals for 15 days showed that the aging rates were asphalt dependent. The BBR beams and direct tension samples of neat binder and 50 percent mastics were soaked in a 45°F water bath were evaluated to determine the environmental effects with the presence of water. The results showed that water absorption increased with increasing PPA, particularity at levels greater than 1 to 1.5 percent. The neat binders also showed some loss of stiffness and phase angle.

Youtcheff presented the effects of anti-strip additives in the presence of phosphoric acid modified binders. The evaluation began by finding which anti-strip additives worked with a historically moisture susceptible aggregate (a Maryland sandstone) when no PPA was used and then repeating the experiment with PPA modified binders. A Hamburg Wheel Tracking Device was utilized to estimate moisture susceptibility. Two anti-strip additives were evaluated. Test results indicated that PPA had no effect on stripping when lime was added, and if the binder contains 0.5 percent of anti-strip additive and 1 percent PPA, then approximately 25 percent of the PPA is neutralized by the amine. He also stated that the performance of the two anti-strips were different with the selected asphalt binder and aggregate. Youtcheff indicated that PPA modification would not be expected to affect performance when this anti-strip is added; however, this was not true. Future work is also planned with a limestone and Georgia granite. Work is also planned to evaluate the effect of fatigue.

Following the presentation, it was observed that tests had been conducted at high temperatures and for fatigue. The question was then raised whether there were plans to conduct any low temperature tests. Youtcheff indicated that there were plans for low temperature testing. There are also plans to write this evaluation up for a TRB paper.

(7) Binder Aging, NCHRP 9-36 - Dave Anderson, Consultant - AAT

Dave Anderson provided a status report on NCHRP 9-36 (Attachment 6). The objective of this study is to select, refine and validate an improved method for the short-term laboratory aging of asphalt binders. The primary use of the selected method will be

for use as a conditioning procedure within asphalt binder purchase specifications. The requirements for selection of the aging system to meet the project objectives are : 1) replicate RTFOT aging for neat binders; 2) correlate with short-term laboratory aging of mixtures; 3) provide quantitative measure of volatile loss; and 4) extendable to long-term aging (desirable but not required).

Anderson described four different studies that have been conducted. Two different aging methods were selected for evaluation: the Modified German Rolling Flask (MGRF) and Stirred Air Flow Test (SAFT). Based upon published literature, both of these methods replicate the amount of aging that takes place in the RTFOT. Therefore, the first study was to conduct an experiment to compare long-term aging obtained with the SAFT, PAV, and MGRF. Evaluation of test results suggested that the SAFT had more potential for long-term aging.

The second study entailed developing a volatile collection system for use with the SAFT. Initial observations indicated that the mass loss after SAFT aging was much less than RTFOT aging. A simplified filter system was developed in an effort to improve volatile collection. Conclusions from the volatile collection system study included: RTFOT mass change is not a good indicator of volatile loss and if the loss of volatile hydrocarbons is important then an appropriate test is needed.

The third study was conducted to optimize the SAFT test conditions. The purpose of this study was to verify minimal aging during the 20 minute heat-up and to select test conditions to replicate RTFOT aging on neat asphalt binders. The revised aging conditions included a 20 minute heat-up and 50 minute aging time. The temperature control setting depends upon binder viscosity and, therefore, the device settings have to be adjusted according to binder grade. Additionally, the residue must be degassed.

The final study was a verification study which included twelve different binders. Half of these binders were modified and half were not. The various binders were aged with the SAFT and RTFOT. Rheological master curves were developed and compared for each of the binders. Additionally, HMA mixtures were aged using the short-term aging procedure. An aging indices using modulus ratios of aged to unaged binder/mixture were then developed for each binder. These aging indices indicated that the HMA mixture short-term aging procedure aged the binder more than the RTFOT; however, the mixture rankings were in closer agreement with the RTFOT than the SAFT.

It was concluded that the SAFT was not an acceptable replacement for the RTFOT. The MGRF may be a more viable replacement for the RTFOT test.

Discussion following the presentation centered on the applicability of the mass loss requirement within the RTFOT test. Anderson stated that because of the research results, a replacement was needed for mass loss that shows less hydrocarbons being lost. The point being that the mass loss test is giving the EPA false information on the amount of volatiles being lost. An ETG member vehemently opposed changing the mass loss requirement until something new is developed and adopted. The EPA and state environmental agencies use mass loss for permits.

(8) Fatigue Task Group Report - Raj Dongré (DSLI)

Raj Dongré presented work to evaluate a surrogate fatigue test for binders (Attachment 7). The goal of the research described by Dongré was to develop a surrogate

criteria or test based on existing test data to specify binder's fatigue resistance. The approach utilized a damage analysis using viscoelastoplastic continuum damage (VEPCD) concepts. Binders included in the work were part of the California Fatigue Study conducted by Carl Monismith. Binder properties were compared to laboratory mix performance data. The number of cycles to failure in beam fatigue testing was compared to results of Direct Tension Testing and the surrogate binder fatigue parameter. Dongré concluded that the approach did not work. Future work will entail evaluating the MSRC test at intermediate temperatures as a possible fatigue specification.

(9) CEN Performance Based Test Methods - Jean-Pascal Planche, TOTAL France

Jean-Pascal Planche presented an update on Europe's effort to develop a performance related specification for asphalt binders (Attachment 8). The process being utilized includes four primary steps which include: 1) identify binder properties linked to asphalt pavement performance; 2) select and standardize appropriate test methods to measure these properties; 3) collect data and ensure field validation; and 4) review the grading system according to the new specifications. The first step has been completed and they are currently between the second and third steps.

At a Eurobitume Workshop in 1999, binder properties related to asphalt performance were identified. Six different performance requirements were highlighted: resistance to permanent deformation, resistance to surface cracking due to binder aging; resistance to low temperature cracking, structural strength, resistance to fatigue cracking and constructability. For resistance to permanent deformation, the rheological properties of binders at elevated temperatures were deemed important. The aging characteristics of binders in both short and long-term conditions were identified for resistance to low temperature cracking. For structural strength, the complex modulus was selected. Viscosity versus temperature and storage stability was selected as related to manufacturing and construction.

The first tests (or batches) selected for standardization were the DSR, BBR and PAV. These standards were published in 2005. The second series of standards included zero shear viscosity (ZSV) and rolling cylinder aging test (ZCAT). These were published in 2006. Future work is planned for standardizing the DTT, a fracture toughness test, and an adhesion/moisture sensitivity test.

The second and third steps in developing performance related binder specifications are linked together and being run in parallel. For the selected tests, data is being collected on typical European binders. This allows the users to gain experiences with the tests and provides the data needed for correlating results with performance. Additionally, the correlations with performance provide the information for recommending specification limits. Planche described how producers are conducting the testing program and reporting results. He then described the BiTVal project which is correlating test results, specifications and performance. Current recommendations from the BiTVal project are available for download at http://bitval.febrl.org/.

Planche provided a timeline for developing the performance related specifications. The years 2006 to 2009 are considered transition years. Data will continue to be collected and the system refined. From 2008 to 2012, implementation of the performance specifications will take place.

Following the presentation, several comments/questions were raised. The first was about the MSCR test. Planche indicated that the MSCR was not available at the time tests were being considered. Next, a member asked who was funding this large research effort. Planche indicated that both agencies and industry were funding. Industry is currently populating the databases. A comment was then made that a number of the selected tests were good qualitative tests to rank binders, but do not provide fundamental properties. Planche indicated that the selected tests were the ones that were available without the need for further research. They are, however, keeping an open mind about new tests that become available.

(10) Vacuum Degassing Study - Gerald Reinke, Mathy Construction

Gerald Reinke presented some work conducted to investigate the need for vacuum degassing of PAV aged binder prior to BBR and DSR testing (Attachment 9). Reinke indicated that the purpose of the investigation was to provide justification for the argument that if the DTT is not used in specification testing then there is no need to conduct the vacuum degassing of PAV aged binder prior to BBR and DSR testing; however, he also stated that vacuum degassing should remain for reference testing.

Testing within the investigation included two factors: degassing and binder grade. Two levels of degassing, with and without, and four different binder grades were included. Of the four binder grades, two were neat binders and two were polymer modified. Three responses were measured for each factor-level combination, BBR stiffness, BBR m-value, and PAV DSR. For all three responses, there was no statistical difference between samples that had been degassed and those that had not. Therefore, it was concluded that there appears to be no need to continue the vacuum degassing procedure if the DTT test is not going to be performed.

Following the presentation, there was discussion on whether a recommendation was needed from the ETG. Some discussion centered on whether it was smart to change the routine just to change the routine. However, it was pointed out that the degassing procedure took 30 minutes. The consensus of the group was that members should evaluate their binders before making any recommendations. A degassing subtask group was appointed to evaluate additional binders. This group included Mike Anderson, Gerry Reinke, Clarisa Mooney, Gaylon Baumgardner, and Lauren Luwendowski.

(11) Warm Mix Asphalt

Laboratory Evaluation: Warm-Mix Asphalt Binder Wax Additives - Gaylon Baumgardner, PTSi

Gaylon Baumgardner provided an update from the Warm Mix Task Group (Attachment 10). The objective of this task group is to evaluate the effect of wax additives on the physical properties and characteristics of asphalt binders. The group has divided the waxes into two categories: paraffin wax and non-paraffin wax. Criteria for categorizing the waxes are the molecular size of the additives. Non-paraffin waxes are further subdivided into natural waxes, modified natural waxes, partial synthetic waxes and full synthetic waxes. A single paraffin wax, Astra 3816 Refined Paraffin is being

evaluated. Several additives are being evaluated for the modified natural, partial synthetic and synthetic type non-paraffin additives. Romanta Normal – MonTan, Romanta Asphaltan A and Romanta Asphaltan B are modified natural additives being evaluated. Partial synthetic additives being evaluated include Clariant Licomont BS100 and Luxco Pitch. Synthetic additives include Sasobit and Allied (polyethylene). A suggestion from the group was to include another Fischer-Tropsch synthetic wax. A second manufacturer uses different catalysts with different branching.

Baumgardner presented an experimental plan that was divided into additive testing and binder testing. Four tests were presented for additive testing. FTIR, GPC, MDSC and NMR. A suggestion from the group was to also include coefficient of thermal expansion testing. A number of tests were presented for binder testing: master curve development using the DSR, determining the true Superpave grade, physical hardening using the BBR, MSCR, glass transition, atomic force miscroscopy and binder stress sweep fatigue. A question was asked about the condition of the binder when conducting some of the testing. Baumgardner indicated that RTFO aged binders would be used.

Planned mixture testing includes physical hardening using the BBR, sand cylinder fatigue and glass transition. One group member questioned the reason for not including any facture or failure tests.

Warm Mix Asphalt and Binder Specifications in the PG System - Jack Youtcheff, FHWA

Jack Youtcheff provided an update on work being conducted by the FHWA on Warm Mix Asphalt and binder specifications in the PG system (Attachment 11). He began by presenting TSRST fracture temperatures for mixes having different WMA additives. Based upon these results, Youtcheff observed less variation in the test results when 3 percent Sasobit was added to the binder. In other words, the 3 percent Sasobit did not greatly affect the temperature properties. A group member asked how the samples were conditioned prior to testing. Youtcheff indicated that they were conditioned for about a week and a half. Two samples were tested per set.

Youtcheff presented the results of an early opening experiment. SMA field mix was sampled from a truck with and without Sasobit and brought back to the lab. The mixes were then compacted into slabs with thermocouples embedded and heated to a temperature of 110°C (230°F). Next, the heated slabs were loaded in a French PRT wheel tracking device. To simulate early opening, the temperature was not held constant; rather the mixes were allowed to cool. Results showed that the mixes containing Sasobit did not rut as much as the control mix. Therefore, Sasobit may not cause a concern for premature rutting in SMA's. Youtcheff did acknowledge that SMA may not have been the best aggregate structure to evaluate; however, the Sasobit was added to provide a compaction aide.

(12) RMAUPG T315 Changes - Mandy Monjaras, Sem Materials, L.P.

Mandy Monjaras made a presentation to the group entitled, "Changes to AASHTO T315 and T240 Suggested by Rocky Mountain Asphalt User Producer Group

(Attachment 12)." She indicated that in October 2005, the RMAUPG steering committee directed the development of a technical workshop for binder technicians. This was reaffirmed by the steering committee in October 2006. In December 2006, the steering committee appointed a committee to make it happen.

The workshop was to be designed for technicians and the RMAUPG would budget for one agency technician to travel to the workshop. Attendance was capped at 40 and included a facilitator. Little or no involvement from equipment manufacturers was allowed. The desired outcome of the workshop was for technicians to better understand the various binder test methods, uncover possible sources to test result variation, share best practices, and attempt to standardize test methods across RMAUPG.

The workshop took place on March 21, 2007. A total of 30 participants were involved with 14 being agency personnel and 16 being industry. Based upon the workshop, the "Make It Happen" committee was directed to suggest changes to methods, where needed.

Monjaras presented recommended changes to AASHTO T315 and T240 based upon the outcome of the workshop and are shown below:

- Added guidance on maintaining constant flow of fluid for valid calibration.
- Added clarification on calibration of portable thermometer – common AMRL deficiency.
- Added clarification on how to calibrate using silicone water and reference fluid.
- Added guidance on heating samples.
- Added requirement to pour enough binder to require trimming.
- Added time limit for testing a poured sample (8hrs).
- Added time limit for chilling sample in freezer (10 min.)
- Added guidance on trimming tool temperature.

After making the recommendations, there were several comments/questions. First, there was a comment that the time allowed for testing a sample should be 1 hour instead of 8 hours. Another comment was that most of the issues raised are addressed in the Asphalt Institutes manual for binder technicians. It was then stated that the AI manual is not a specification. A question was asked about whether the RMAUPG had a binder certification program, which the answer was no. It then followed that a certification program may solve some of the issues.

Next, Monjaras provided recommendations for improving AASHTO T240. She indicated that there were no procedural recommendations; rather, language needed to be added in the "Apparatus" section of the standard on calibration frequencies. The frequencies should be consistent with AASHTO R18.

There were several comments following Monjara's presentation. One member indicated that all the recommendations could not be supported; however, some are likely needed. One meeting participant wondered if AMRL was supposed to submit problems they encountered (with no answer provided). Someone stated that there is a device you can buy for checking the levelness of RTFO bottles. Finally, Monjaras stated that the RMAUPG plans to continue evaluating various tests.

(13) New Task Groups, Binder Curing, WRI - John D'Angelo, FHWA

The Binder Curing Task Group led a discussion on problem mixes that remain tender after compaction, sometimes for several days. Three instances were highlighted where a mix had been placed and compacted, but remained tender for a day or more. These instances were in Utah, Maryland and Nebraska. The occurrence in Utah was a SMA mixture. After three days, the mix was still showing some tenderness while at five days the mix was bearing coal trucks. Testing of the binder (no specific tests given) showed an early set followed by a softening of the binder and then increasing stiffness. A question was asked about whether the binder was modified which was answered with a yes. A comment was made about whether a crosslinking issue was occurring. The Maryland and Nebraska problems were considered to potentially be related to the use of PPA, but no specifics were available. A recommendation from a participant was to look at aggregate water absorption.

A subtask group was appointed to try and identify tests on the binder to eliminate the binder as being a contributor to the problem. This group included Mike Anderson, Gaylon Baumgardner, Rick Holmgreen, Kevin Vanfrank, Clarisa Mooney and Ion Negulesque.

DAY 2 - Friday, July 27, 2007

(14) WRI Fundamental Properties

Introduction - Ray Robertson, Western Research Institute

The second day of the meeting was devoted to describing the "Fundamental Properties of Asphalt and Modified Asphalts," contract between WRI and FHWA and the Asphalt Research Consortium (ARC). Ray Robertson began the discussion by providing a general overview of the two efforts (Attachment 13). The ARC is comprised of five partners including WRI, Texas Transportation Institute, University of Nevada-Reno, University of Wisconsin-Madison, and Advanced Asphalt Technologies. The Congressional Budget for the ARC is $30M over five years with the actual federal share being $21M over five years and a cost share of $5.25M over five years. The first year funding has been committed.

For the Fundamental Properties contract, the Congressional Budget is $21M over five years. The actual maximum contract value is $14.9M over five years.

Technology Transfer (ARC) - Ray Bonaquist, AAT

The first presentation on the ARC was on Technology Deployment and was made by Ray Bonaquist (Attachment 14). He began by stating the hypothesis and objective for the Technology Deployment portion of the ARC. The hypothesis of the Technology Deployment phase is early identification of implementable research products and further refinement of those products by ARC members to lead to rapid acceptance of the products by practicing engineers and technicians. Bonaquist identified several work elements: early products, mid-term products and long-term elements. Early products are

those in which the research is already completed. Approximately, ten ETG members will be needed to review the products. Mid-term products will be those that are the result of early ARC and Fundamental Properties research. Long-term products are those that will come from the ARC and Fundamental properties research projects.

Bonaquist presented a flow diagram that described the approach for identifying, refining and implementing appropriate products. The approach begins by developing a rating system and executive summaries for the potential products. The rating system would be developed to rank the products on relevance to current issues and potential for implementation. The rating system and executive summaries would then be provided to the appropriate FHWA/ETG chairs. The ETGs would then rate each product. It is envisioned that this step could be handled by email. Based upon the rankings of the various products, a prioritized list would be developed. For each selected product, a product review committee would be assigned to track progress and recommend changes.

Following the presentation, there was discussion on the approach. The first comment was that the approach seemed like it could take years to implement. Bonaquist stated that there are a number of products from the previous Fundamental Properties research that are currently in draft AASHTO format and may be ready for Technology Deployment. There was then discussion on the direction of the various research areas of the ARC and Fundamental Properties contract is not always clear. The group agreed that direction is needed to "pull everything together." Therefore, the ETG should provide more guidance on the direction; however, some of the research has already been completed and it is unclear where the research needs to go for a specific end product. It was then stated that there are some long term goals within the work plan and that annual reviews of the strategic plans and work plans should solve some of these problems.

Finally, Bonaquist presented a schedule for immediate product evaluations. The ETG requested that executive summaries for the products be developed. Bonaquist stated that the first batch of executive summaries will be ones an ETG has already identified that might be included within a specification. On future products, ETG will be heavily involved in decision making. A suggestion was made stating that the products, where applicable, should be submitted as a package. A package will have a better chance of being implemented.

Overview of Fundamental Properties, III Plan - Fred Turner, WRI

Fred Turner provided an overview of the Year -1 work plan for the Fundamental Properties contract (Attachment 15). Within the contract between WRI and the FHWA, the stated objectives are "to conduct fundamental research on asphalts and modified asphalts, as well as their individual components, and through partnership with other research initiatives and innovation, significantly increase fundamental knowledge so that technological capabilities develop and superior practices proliferate in support of FHWA's Strategic Pavements Roadmap."

The contract structure includes four tasks. Task 1 is entitled "Coordination." Within this task, activities will include literature reviewing, developing personal contacts and partnerships, and future planning. The Task 2 will involve research. Six topics have currently been identified for this task: moisture damage, aging, nanotechnology, low-temperature properties, modified asphalts and monitoring of existing validation sites.

The low-temperature and modified asphalt efforts will be in the first year only. Task 3 of the contract will be indefinite delivery, indefinite quantity projects in which ideas will come from FHWA, WRI or the ETGs. Turner listed eight potential IDIQ projects: 1) Development of new techniques for measurement or analysis of asphalt properties; 2) Partnerships to develop molecular models of asphalt performance; 3) Examination of new paving technologies, for example; WMA; 4) Development and utilization of forensic tools; 5) Specialized analyses for FHWA; 6) Complete core and sample analyses for Minnesota validation site; 7) Low-temperature cracking; and 8) Multiple modification of binders. The final task of the contract will be information deployment. Within this task will be communication and outreach, a website, databases and semi-annual meetings.

The current status of the contract is that first-year work plans have been submitted under Task 2. Written comments from FHWA and ETG have been received and the work plans have been approved. White papers, proposals, and detailed work plans are being developed for Task 3 IDIQ projects. Turner indicated that the ETGs will be heavily involved in selection of appropriate projects under task 3. The IDIQ system was employed in order to provide a mechanism to evaluate current needs.

Validation Site Monitoring - Mike Harnsberger, WRI

Mike Harnsberger presented work to be accomplished under Subtask 2.6, Field Validation (Attachment 16). Initially, Harnsberger described previous contract activities related to field validation. On previous projects, experimental pavement sections have been constructed with the major variable being the crude source of the binder. For these projects, a reasonable quantity of materials have been collected. Each year the performance of the different sections has been monitored. Because the various projects are located in different areas, direct comparison between different sites may be difficult at best.

Under the current contract, it is anticipated that monitoring of the various pavement sections will be done annually. Core samples will be obtained, as necessary. Also, it is planned to review utility and availability of the Asphalt Institute's PPA sections.

Harnsberger briefly described different test sections that are currently in existence. Test sections are located in Wyoming, Nevada, Arizona, Kansas and Minnesota. All sections are being monitored using the LTPP Distress Survey Protocols which includes distress mapping and classification, transverse profiles and photos. Core samples are planned for post compaction and after 1, 2 and 5 years of service. Harnsberger also acknowledged that pavement distress may trigger the need for core samples at other times.

In order to assist with validation of ARC research studies, new test pavement sections will be built in co-operation with state DOTs. Some WMA test sections in Yellowstone National Park have already been identified.

Following the presentation, it was asked whether the researchers were open to other activities if the ETG identifies critical issues. Harnsberger indicated in an affirmative.

Validation Site Monitoring - Mike Farrar, WRI

Mike Farrar presented the work plan for Subtask 2-2.3, Age-Hardening-Field Validation Sites (Attachment 17). Farrar began by listing a series of goals for this Subtask. The first goal is to develop a rapid FTIR method to map chemical moietes, related to oxidative age hardening, on the face of a core. Secondly, review and establish correlations between carbonyl, sulfoxide and aromatic moieties, and low and high temperature rheological properties. The third stated goal was to map rheological properties based on correlation with chemical moieties. The next goal is to use the validation sites to revisit the Global Aging System. This would include either revising the current model or developing a new long-term age hardening model. The final goal is to determine if the FTIR can be applied to sealer/rejuvenators and OGFCs.

Farrar described the Global Aging System and listed its shortcomings. He mentioned that the testing of mix was difficult with the FTIR test. A rapid quantitative FTIR is being developed in order to be able to test cores taken at various times of a pavement's life. He briefly described the work plan anticipated to evaluate the technology.

Following the presentation, there was a question that asked about the final product from the research. Is the goal to evaluate the FTIR as a tool to look at long-term oxidation? Farrar indicated that the short-term goal was to try and relate FTIR results to rheological properties. Long-term, the rheological properties could be determined at depth using cores. Another potential outcome is that the test results might tell when rejuvenators or sealers are needed. A group member again asked what the objective of the research would be; see how the FTIR can be used or modifying the Global Aging System. Farrar stated that the problem with aging models has been that there has not been a good method for measuring the effect of aging with depth; this methodology will allow an almost infinite number of point measurements with depth. A group member then referenced some work by Glover at TTI that indicated there was little difference in aging between the pavement surface and underlying material until a depth of about 6 inches. It was then stated that Glover did not take into account the effect of air voids and it was emphasized again that the ultimate goal needed to de defined.

Aging - Shin-Che Huang, WRI

Shin-Che Huang presented work plan for Subtask 2-2.1, Asphalt Aging in the Presence of Water (Attachment 18). The hypothesis of the research is that the presence of water during aging accelerates asphalt oxidation rates by altering the internal structure of the binder. Huang stated the objectives as: 1) to evaluate the impact of water on the long-term aging characteristics of asphalt binders and 2) to determine if there is correlation between the rheological properties and chemical properties of asphalt binders after long-term oxidation aging.

Huang presented a series of graphs to describe the concept. Oxidation master curves were developed using the time-temperature superposition principle. He presented some relationships between the aging shift factor and carbonyl content. Huang presented some data from the Arizona field site. Future work will entail developing more

oxidation master curves and correlating the master curve parameters to chemical properties. FTIR, NMR, DSC and Heithaus are all planned for testing.

Following the presentation, a question was asked whether there is any degradation of polymer modified binders. Huang indicated that only neat binders had been tested to date. Some polymer modified binders are planned for use in future work. A statement was made that shift factors imply that time-temperature superposition holds after aging; however, experience indicates that this does not always work. It was suggested to plot Black curves. Black curves may not be as smooth.

Low Temperature Properties - Fred Turner, WRI

Fred Turner provided an overview of work planned in Subtask 2.4, Low-Temperature Properties (Attachment 19). Turner began by providing the topics to be covered during the presentation which included: 1) glass transition region and parameters, 2) relationships of glass transition parameters to low temperature specifications, 3) wax and other limitations on structural relaxation; and 4) research direction and examples. Turner was asked to define the goal of this work which he indicated was to try and develop a surrogate specification for low temperatures. Turner presented the glass transition region and typical parameters. He then presented typical glass transition values.

Turner made several observations on the correlation of glass transition with current low temperature specifications. He indicated that DSC measurements correlate with Superpave low temperature specifications if stiffness controls. He also stated that the DSC can be used to quantify the low temperature properties of some waxy modifiers. Turner then presented the effect of PPA on glass transition characteristics. The cumulative effect on the change in glass transition temperature was a decrease; however, change in the height and width parameters was binder specific.

Turner presented the work plan summary. This was done through a series of graphs. Essentially, glass transition profiles will be developed. Binders will be tested in three conditions: neat, RTFO aged, and RTFO/PAV aged. The profiles will be evaluated to determine if there is something to signify that the binders are m-controlled.

Following the presentation, a statement was made that the stated goal of the research does not match the presentation. Turner stated that you can't evaluate the effect of additives on low temperature properties without the concept to which there was agreement; however, that was not the stated goal. Another member questioned whether the researchers have tried to correlate the change in low temperature properties from RTFO to PAV to the R-factor. Turner indicated this has not been done yet.

Nanotechnology and Molecular Dynamics - Troy Pauli, WRI

Troy Pauli presented an overview of Sub-Subtask 2-3.1 Nanotechnology: Asphalt Thin Film Properties (Attachment 20). The philosophy of this work is that capillary thin films are holding the binder and the aggregates together. Pauli stated the hypothesis for the research as phase separation (transformation) mechanisms between (within) asphalt components contribute to fatigue cracking and healing.

Pauli presented several experimental approaches for accomplishing the research. First is thin-film coating techniques including solvent spin casting, thin-film smears and light refraction. The second approach is Atomic Force Microscopy which includes phase contrast (morphology, adhesion mapping), friction (lateral), functionalized tip techniques, spinodal-blends and fractured film development. The last approach described by Pauli was nanoindentation and pull-off force work of adhesion which includes aggregate hardness, aggregate friction (adhesion hysteresis) and asphalt thin-film stiffness. Pauli then described these concepts as well as providing the theory.

Pauli listed a number of Year-1 goals which include setup of laboratory test equipment, development of experimental protocols and materials selection. He then listed the 5-year goals as follows:

- Further development of fundamental material science theory (i.e., gain a more fundamental, understanding of the adhesion mechanisms of asphalt coatings to aggregates).
- Development of test methodology derived from nanoscience to measure compositional and rheological properties of asphalt and aggregate surface (adhesion) properties.
- Development of experimental and computational tools (software packages) to quantify asphalt aggregate adhesion propensities to fatigue, self healing, moisture susceptibility, and impact of polymen modification.

Modified Asphalts - Shin-Che Huang, WRI

Shin-Che Huang presented an overview of the work plan for Subtask 2-5, Modified Asphalt (Attachment 21). The hypothesis of the work is that the addition of PPA to asphalt changes the long-term aging mechanism of asphalt binders. The objective is to determine how the rheological and chemical properties of PPA (105%) modified asphalts (1.5 wt %) vary with aging time at temperatures in the pavement temperature range when compared with untreated asphalts.

Huang began by presenting the characteristic parameters of a master curve. He states that steady state viscosity, crossover frequency, limiting stiffness temperature and rheological index are important parameters to characterize the linear viscolelastic properties of asphalt binders. The addition of PPA generally increases the steady state viscosity of asphalt. However, the effect of PPA on the change of steady state viscosity after aging is not significant. The addition of PPA also decreases the change of rheological index due to temperature. Addition of PPA extends the limiting stiffness temperature before aging and generally extends the limiting stiffness temperature after aging. The addition of PPA increases the zero shear viscosity of binders prior to aging; but does not affect the amount of zero shear viscosity change substantially with respect to PAV aging.

Huang stated that there is a good correlation between chemical and physical properties for asphalt binders with respect to long-term oxidative aging. The addition of PPA alters the linear relationship between physical and chemical properties with respect to long-term aging. It appears that the addition of PPA increases flow properties (phase angle) after aging.

Huang indicated that future work will: 1) evaluate the effect of water on aging characteristics of PPA-modified asphalt binders; 2) evaluate the effect of lime aging characteristics of PPA-modified asphalt binders; 3) evaluate long-term aging characteristics of multi-modified asphalts such as RAP mixes with warm mix asphalt additives; 4) evaluate oxidative aging kinetic master curve for multi-modification systems; and 5) utilize field validations sites.

Following the presentation, there was a comment that most commercial use of PPA and recommendations from manufacturers is that PPA usage is less than the 1.5% being used in the research.

Moisture Damage - Fred Turner, WRI

Fred Turner presented the proposed work plan for Subtask 2-1, Moisture Damage (Attachment 22). Turner listed the following as topics to be covered: 1) use of the Hamburg Wheel-Track Device to evaluate moisture susceptibility (Year 1 start); 2) evaluation of the impact of microbes on the performance of mixes; 3) synthesis of modifiers to elucidate the combined effect of polymer and antistripping agents; and 4) correlation of freeze-thaw results with asphalt and aggregate surface energies.

One of the issues to be investigated is the nature of turbidity produced during Hamburg testing. The Micro-Deval test will be used to evaluate the durability of aggregates used in the Hamburg tests and to produce fines for comparison with those generated in the Hamburg. The researchers will analyze organic material extracted from the Hamburg water baths and from aggregates using FTIR. Finally, the researchers will determine the mineralogy of fines from Micro-Deval and Hamburg water baths using electron-probe microanalysis and powder x-ray diffraction.

Turner described an experiment to look at the relationship between the number of freeze-thaw cycles to failure and various predictor variables. Good correlations were found between freeze-thaw performance and acid insolubility (inverse), calcium/loss on ignition/zeta potential (inverse), silicon (direct), aluminum (inverse), potassium (inverse), iron (direct), pore ratio (inverse), and surface area (direct).

Following the presentation, there was discussion about the mechanisms of moisture damage. It was noted that there are two moisture damage models, one from Delft and one from TTI. The model from TTI is looking at adhesion, etc., but does not evaluate the effect of scour like the Delft model. Turner stated that the notion of emulsification is true, the Pull-Off model showed this. Maybe a property of the asphalt that is needed is the tenacity. That is something that may need to be considered. A comment was made that there are no tests to look at the effect of scouring. Someone answered that the DMA may be able to evaluate scour. Another comment was made that the DMA will not capture scouring due to high water pressures. The Hamburg test may be too severe for evaluating scour.

WRI Wrap-Up – Ray Robertson

Ray Robertson provided a wrap-up for the Fundamental Properties portion of the agenda. He stated that HMA is what is available for building roads and that there are things that cause damage. The long-term goal of the research is to use the tools that were

described in the presentations to develop methodologies that will lead to the specifications to improve performance. Finally he thanked the presenters, the members and the attendees for their participation.

Meeting Wrap-Up - John D'Angelo, FHWA

Mr. D'Angelo presented the following action items:

1. High Temperature Task Group – Mr. D'Angelo will be presenting the complete specifications at the next meeting.
2. Vacuum Degassing – More asphalt binders will be evaluated before making any recommendations. A degassing subtask group was appointed to evaluate additional binders. This group included Mike Anderson, Gerry Reinke, Clarisa Mooney, Gaylon Baumgardner, and Lauren Luwendowski.
3. Warm Mix Task Group – Warm mix task group will continue the work planned for the warm mix study and present the results at the next meeting.
4. Changes to AASHTO T315 Specifications - Monjaras presented the changes to AASHTO T315 recommended by the Rocky Mountain Asphalt User Producer Group. Mr. D'Angelo will forward the recommended changes to AASHTO at their next meeting.
5. Curing - A subtask group was appointed to try and identify tests on the binder to eliminate the binder as being a contributor to the problem. This group included Mike Anderson, Gaylon Baumgardner, Rick Holmgreen, Kevin Vanfrank, Clarisa Mooney and Ion Negulesque.
6. WRI Contract – WRI to provide the problem statements for the past contracts to the ETG group. ETG members to review the problem statements and provide suggestions, comments and recommendations to Jack Youtcheff and Eric Weaver. Task groups in several areas such as Moisture damage, Low-temperature properties, aging; modified asphalts and Nanotechnology will be appointed as part of the WRI contract to provide guidance, recommendations and to track the activities in each of the research areas.

Mr. D'Angelo discussed the location and time for the next meeting. The next meeting is scheduled during the week of February 24th in Tampa, Florida. Details of the exact dates and location will be made available at a later date.

Meeting Adjourn

Chairman Baumgardner adjourned the meeting and thanked all for their attendance and participation.