FHWA Asphalt Binder Expert Task Group Meeting
March 15 and 16, 2011
Hyatt Regency Hotel
Phoenix, Arizona

Binder ETG Purpose
The primary objective of the FHWA Expert Task Group is to provide a forum for the discussion of ongoing asphalt binder technology and to provide technical input for research, development and implementation.

A total of 60 individuals attended the meeting (16 members, 2 contract personnel, and 42 visitors, excluding the attendees via the Webinar). The meeting was held at the Hyatt Regency Hotel in Phoenix, AZ. Members of the FHWA Asphalt Binder ETG that were in attendance at the March 2011 meeting included:

Gaylon Baumgardner, Paragon Technical Services (Chairman)
John Bukowski, Federal Highway Administration (Secretary)
Chris Abadie, Louisiana Department of Transportation
John D'Angelo, Consultant
Gayle King, GHK, Inc.
Mihai Marasteanu, University of Minnesota
Bob McGennis, Holly Asphalt Company
Bruce Morgenstern, Wyoming Department of Transportation
Ioan Negulescu, LSU
Gerald Reinke, Mathy Construction
Henry Romagosa, ICL Performance Products LP
Geoff Rowe, ABATECH
Fred Turner, WRI
Kevin Van Frank, Utah Department of Transportation
Ludo Zanzotto, University of Calgary, Canada

Liaison Members: Michael Anderson, Asphalt Institute

Meeting Coordinator: Lori Dalton (SME, Inc.)
Meeting Notes: Harold L. Von Quintus, (ARA, Inc.)

[Attachment A is the meeting agenda, Attachment B includes a listing of the ETG members, Attachment C includes a listing of the Binder ETG Task Group members, and Attachment D is the Work Plan entitled "Assessment of Binder and Mixture Properties following Extended Periods of Isothermal Storage."]

"Friends**"** of the Asphalt Binder ETG that were in attendance included:

Hussain Bahia, University of Wis.-Madison
Mark Belshe, Rubber Pavements Assoc.
Szaboks Biro, Ecopath
Steve Burhans, Paramount Petroleum
Doug Carlson, Liberty Tire Recycling
John Casola, Malvern
Audrey Copeland, FHWA
Matthew Corrigan, FHWA
Codrin Daranga, Blacklidge
Mike Farrar, WRI
Frank Fee, NuStar Asphalt
Lee Gallivan, FHWA
Tejash Gandhi, MWV
Ron Glaser, Western Research Institute
Beth Griffin, DuPont
Elie Hajj, University of Nevada at Reno
Mike Harnsberger, WRI
Rick Holmgreen, Concoco Phillips
Gerald Huber, Heritage Research Group
Sam Huddleston, Mactec Engineering
Darin Hunter, Anton Paar USA
Carl Johnson, Stark Asphalt
Greg Kamykowski, TA Instruments
Bob Kluttz, Kraton Polymers
Jean V. Martin, INNOPHOS
Jeff Mentel, Malvern
Louay Mohammad, LSU/LTRC
Ala Mohseni, Consultant
Karissa Mooney, NuStar Asphalt
Chuck Paugh, ESC Inc./FHWA
Troy Pauli, WRI
Katherine Petros, FHWA
Jean-Pascal Planche, WRI
Judie Ryan, Wisconsin DOT
Delmar Salomon, Pavt. Preservation Sys.
Jeff Smith, International Surfacing Sys.
Darin Tedford, Nevada DOT
Shauna Tecle Marian, U.S. Oil
Jack Van Kirk, Basic Resources, Inc.
Scott Veglahn, Mathy
George Way, CONSULPAV
Eric Weaver, FHWA
Jeff Withee, FHWA

Tuesday, 15 March 2011

1. Call to Order – Gaylon Baumgardner (Paragon Technical Services); Chairman

Welcome and Introductions –Chairman Gaylon Baumgardner called the meeting to order at 1:05 PM and welcomed all participants. Baumgardner asked that all attendees introduce themselves. He noted an attendance sign-up sheet was distributed for all members and visitors to log their attendance at the meeting. Copies of the agenda were distributed.

Secretary Bukowski reported that copies of the meeting agenda are available, which is the same as submitted to ETG members prior to the meeting. He also noted that the meeting minutes were distributed to the members prior to the meeting.

2. <u>Review Agenda/Minutes and Action Items from September 2010 Meeting</u> – John Bukowski (FHWA); Secretary

Bukowski reviewed the action items from the September 2010 Asphalt Binder ETG meeting. He commented that anyone not receiving the minutes to please see him during the meeting. The following is a listing and status of the action items from the September 2010 ETG meeting.

1. Task Group will provide suitable wording to describe/define asphalt additives/modifiers in lieu of current terms such as organic, soluble, etc. Task Group members, D'Angelo, Rowe, Bahia, and Romagosa.
   UPDATE: Action item is on the agenda.

2. Binder Specification Fatigue Issues – Effect of Polymer Content; Raj Dongre will draft a test protocol that explains and defines the experiment details and the materials to be used in the experiment. This will be presented at the next ETG meeting. Task Group will evaluate comparison of mixture bending beam and push-pull tests. Task Group members, Youtcheff, Williams, Azari, M. Anderson, Dongre, Reinke, and Rowe.
   UPDATE: Action item is on the agenda.

3. Bukowski will forward the agreed wording to SOM to include in R28 for degassing of binder.
   UPDATE: Action item is on the agenda. Dave Anderson sent in some minor changes and those will be included prior to sending it onto the SOM.

4. DSR Specimen Preparation; Bukowski will report to the SOM that the ETG supports the 4-hour testing time limit.
   UPDATE: Action item is on the agenda. There is still some discussion on the procedure and what it should say relative to the time period. This will be discussed later in the meeting. Recommendation will be forwarded to the SOM.

5. Bahia will distribute to ETG members for review a procedure for performing the Linear Strain Amplitude Test. ETG members are asked to return any comments and data from using the linear amplitude strain test to Bahia. Gerald Reinke and Hussain Bahia will serve as LAS Co-Task Group leaders. Members also include Kevin VanFrank, Audrey Copeland, Chris Abadie, Karissa Mooney, Jim Barnet, Mike Farrar (WRI), Haleh Azari, and Leonard Lewandowski (PRI). This item will be added to agenda of the next meeting.
   UPDATE: Action item is on the agenda.

6. When available, Bukowski will distribute to the ETG members information from the completed NCHRP 9-39 effort "Procedure for Determining Mixing and Compaction Temperatures of Asphalt Binders in Hot Mix Asphalt". Mike Anderson will lead a Task Group to perform the recommended procedure with data and report at the next meeting.
   UPDATE: Action item is on the agenda.

7. The GTR Task Group (Baumgardner, Copeland, D'Angelo, Hazlett, and Abadie) will prepare a statement that describes the parameters for performing a precision and bias evaluation of DSR on binder containing GTR. The agreed wording will be forwarded to the GTR P&B Task Group (Corrigan - lead, McGennis, Bumgardner, Abadie, West, and Bennert) and a discussion item at the next meeting. Included will be the definition of CRM (use the ASTM D8 version for the definition).

UPDATE: Action item is on the agenda.

8. ETG members are asked to forward comments/recommendations to Rowe on direction to proceed on current effort on low temperature evaluation of binder with the BBR. Rowe will plan the initial testing for Step 2 and have some results available and will present the results at the next meeting.
   UPDATE: Action item is on the agenda.

9. RAP Task Group will provide an update on this topic at the next ETG meeting.
   UPDATE: Action item is on the agenda.

John Bukowski asked if there were any additions or changes to the action items or minutes from the September 2010 meeting. None were noted for the action items or minutes.

3. Multiple Stress Creep Recovery (MSCR) Task Group Activities

Baumgarnder noted that three task group reports were planned and are on the agenda, but Raj Dongre is not in attendance, so the first report entitled ***Effect of Polymer Content Testing Procedure*** will be skipped.

Presentation/Report #1 Title: ***Report of Group Lab Testing*** - *NEAUPG Interlaboratory Study (ILS) to Determine the Precision of AASHTO TP70 - the Multiple Stress Creep Recovery (MSCR) Test;* John D'Angelo (D'Angelo Consulting) and Mike Anderson (Asphalt Institute)

Summary of Presentation/Report:

John D'Angelo gave the report. D'Angelo overviewed the ASTM standard practice for determining repeatability or precision of a test method – ASTM E 691-05, "Standard Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method." He reviewed the important parts of the test standard and the factors contributing to variability for quantifying repeatability and reproducibility of the test method. The two main factors are: repeatability and reproducibility. D'Angelo reported that 27 labs from the NEAUPG, DOT, industry, Universities, and FHWA are participating on this study.

D'Angelo overviewed the different materials and their conditions that were included in the study. One sample was sent out without any aging and the labs were to do the short term aging. The focus was to look at materials typically used by industry. D'Angelo overviewed the instructions that were given to the participants: becoming familiar with AASHTO TP70 and temperature calibration. It was requested to the laboratories, that the same technician run all of the tests. This requirement was to take out the repeatability issues caused by changing technicians.

ETG Interlaboratory study (ILS) – D'Angelo provided a review of what had been previously done. He identified the different binders used in the experiment, including the PG76-22 as the verification binder. All binders are commercially available. D'Angelo showed typical results from the first ETG ILS. D'Angelo commented; except for lab #5, the reproducibility was extremely high. His observation – a single technician can reproduce the results extremely well,

but between the labs there is a lot more variability. D'Angelo stated; the repeatability between labs is large because the target was near zero, so the variability was very small, also the reason the coefficient of variation is very large.

D'Angelo listed or identified some of the reasons or factors why the within lab variation was so small but between lab variability was large; operator, equipment, etc. related. One reason given by D'Angelo – it is sensitive to temperature, which is more constant within the lab, as opposed to between labs. This relates to the issue of temperature equilibrium.

D'Angelo provided a summary table of the results from the NEAUPG ILS Repeatability and Reproducibility study and noted that the PG76-34 had more variability. The reason for the higher variability was unknown. D'Angelo showed results from binder #5 (PG 52-28) and #8 (PG 76-22); in terms of a graph of Jnr, 3.2. He reported that one set of the results for binder #5 was considered an outlier, which was probably related to an incorrect temperature or the operator doing something else wrong. The same was true for the PG76-22. One data point was considered an outlier and that data was removed.

D'Angelo overviewed and showed a tabular listing of the data with reproducibility of results. He considered the data to be very good. He also reported the two issues that resulted in high variability but did not deviate from the actual value that much. He noted again; the percent values are high because the target was near zero.

D'Angelo included a comparison of the two ILS studies. One study was highly controlled and the other based on experience. Both showed results to be relatively close.

Geoff Rowe commented; the specification you have is on a log scale and the number has an important value, so why look at the error of the number rather than the error of the log number. D'Angelo replied, because some would not understand that difference.

D'Angelo concluded the report with a summary of the conclusions from the two ILS studies. NEAUPG ILS has slightly higher variability than the ETG ILS, but the NEAUPG had more labs and inexperienced labs which could explain the higher variability. He went back to the NEAUPG ILS Repeatability and Reproducibility tabular of results. The RTFOT did not add a lot of variability to the results – it appears to be working okay. Both the ETG and NEAUPG ILS studies indicate that there may be an issue with the equipment regarding temperature equilibrium; Jnr is more sensitive than G*. However, sample handling could be causing the higher between lab variability.

ETG Discussion, Comments, and Questions:
Kevin VanFrank asked if the instruments might not be adequately designed for the test? D'Angelo replied; no that is not what he was saying. The samples are not at the temperatures that we think they are at. The equipment itself is at the temperature, but the binder itself may not be at the required temperature or within its allowable variation. Asphalt is a good insulator, so the temperature of the binder can be off and you might need more time to reach a constant

temperature within the binder. It is not the equipment itself, it is that the time to reach equilibrium and that varies by material using the current specification or requirement.

Gayle King – With the Bureau of Land studies, the materials used were very soft, but they found good or relatively low variability. The issue there was with one equipment manufacturer. King agreed that the issue is only when you go to soft binders without modification so we may have to change the temperature from the high side for soft binders. King also agrees that the issue is not with the MSCR test.

Karissa Mooney commented; when they did the ETG study, all of the raw data was sent to Mike Anderson to make sure the data were compatible. She asked if D'Angelo looked at how the data were collected. Mike Anderson replied most of the labs recorded data that came from the DSR itself, but some used a spreadsheet and some of those labs did not have the latest spreadsheet, so there was a problem in some cases. Anderson noted they eliminated that data out of the comparison. Anderson reported, there was a combination in the data comparison – some used the DSR, while others did the calculations external to the DSR.

Matt Corrigan asked if it was envisioned that there would be a precision and bias statement that is temperature dependent. D'Angelo relied, no it would not be temperature dependent. For most of the PG76-22 samples there was no problem, but if you test it at a PG58 climate you get small values or results. Corrigan followed up with a question; what about grade bumping, where they still specifying at the grade temperature but testing at the climate temperature? There will be times when you specify a stiff binder but the climate temperature is lower so what is the best transition? D'Angelo – looking at the purchase specification because you cannot live with a 50% variation; if you are just testing you will get reasonable results and you will be in the general area even though it can be off by 50 percent. Corrigan commented; the benefit of using the MSCR is testing at the climate temperature.

Ludo Zanzotto – He noted that we may be testing at a high test temperature, but his opinion is the test is good and that we may want to change the grading system. He believes that we should identify the high temperature grade regardless of how much traffic is being used. Zanzotto's opinion or recommendation; we need to start thinking about the grade and not relate the grade to traffic.

Mike Anderson – a clarification comment; from the ETG ILS that was completed for the binders that had a Jnr value less than 1, had a standard deviation of 0.1. On an actual number basis we are still talking about numbers that are very low; the percentages are skewing what we are talking about.

Gerald Reinke – We need to start thinking about what Geoff Rowe was recommending based on the log or actual number. He suggests that the data being calculated was taken exactly at 1 and 10 seconds or at least extrapolated to those values. He did not think that was the case, so much of the variability is a result of how the numbers are being reported.

Kevin VanFrank again asked if there is unique equipment being built to run this test, or are we using equipment inappropriately or outside the range for which it was designed and that is causing the variability? He noted this type of problem when they started running the Hamburg test. D'Angelo again commented that there is no problem with equipment built after 1990. The problem is with the analysis or interpretation of the data collected by the equipment. However, equipment built prior to 1990 could be a problem.

Bob Kluttz – In response to Reinke's comment, the procedure is explicit on how the data are recorded and how the measurements are made and reported. Corrigan – We all have the raw data files for which some have reported or recorded it in different ways. This is a simple activity to convert the data to complete a one to one comparison in the data. D'Angelo believes that is not the issue; the biggest issue is with the temperature equilibrium. Corrigan stated that he understands that position, but still recommends this correction in the data be done because it is an easy correction and that would eliminate it as an issue, so why not do it? D'Angelo agreed with that comment.

Presentation/Report #2 Title: ***Implementation Update****;* Mike Anderson (Asphalt Institute)

Summary of Presentation/Report:
Mike Anderson provided a copy of the Asphalt Institute Technical Advisory Committee document entitled "Guidance on the Use of the MSCR Test with the AASHTO M320 Specification." He reported that anyone may obtain this document at the Asphalt Institute (AI) web site.

Anderson gave an update and overview of the task force involved in use of the MSCR test with the AASHTO M320 Specification. This document was approved by the AI technical committee. The focus of this document is to provide guidance on eliminating the elastic recovery or PG plus specifications. Anderson reported that you should not expect a strong correlation between the master test and PG plus values. He overviewed the LTPPBind 3.1 at 98 percent reliability requirement and reported this is what AI recommends to be used.

ACTION ITEM #1: Multiple Stress Creep Recovery (MSCR) Task Group; Mike Anderson will update the precision and bias statement for the MSCR test.

4. **MSCR Repeatability/Relationship to Mix Rutting**—Hussain Bahia (University of Wisconsin at Madison)

Presentation Title: ***Multiple Stress Creep and Recovery (MSCR) – Reproducibility, Repeatability, and Relationship to FN (Part of ARC (E1b-1) work plan)***

Presentation Summary:
Hussain Bahia acknowledged the sponsors and other individuals that are doing the work under this study and that the work is supported by the ARC-WRI-FHWA.

Bahia overviewed the MSCR and how the Jnr is determined for asphalt. His opinion is that there is an issue with averaging the first and second set of 10 loading cycles in the test. He also noted the MSCR percent recovery can be added to validate polymer modification. Bahia showed examples correlations relating Jnr and minimum recovery values.

D'Angelo commented the percent recovery has nothing to do with rutting. He replied that the states wanted something other than the elastic recovery test to identify or determine whether they have some type of polymer in the asphalt. This comment resulted in a lot of debate and discussion between D'Angelo, Bahia, and others on the intent of the test and how it is being used.

Bahia reported on some items related to his evaluation of the test procedure, equipment, and variability from the MSCR based on statistical analysis of 8 binders. The analysis in his evaluation concluded high variability for parameters reported in the MSCR test. As part of his report, Bahia showed results from four binders in terms of the inter-variability analysis after modifying the reporting format. This listing included the PG and number of labs reporting their results. The parameters reported included Jnr at 0.1 and 3.2 kPa and percent recovery values.

Bahia included a listing of the MSCR and DSR equipment used in the study. He noted that there are outliers in the data and they eliminated all outliers in the data analyses. Next were the results for the PG76-22 and again there were a number of outliers that were removed. The second PG76-22 was much better and no outliers were observed in the data. Bahia reported that they observed stress sensitivity in the data for the PG76-28. Stress sensitivity was not observed in the data presented for the previous asphalt binders.

Bahia reported the acceptable variability in terms of G* - sin δ; difference in inter-laboratory PG testing. He started with the MSCR reproducibility analysis without the outliers – this is the coefficient of variation for different Jnr values at 0.1 kPa and 3.2 kPa. Gerald Reinke asked; what was the test temperature for this data? Bahia replied; 64 C. There was debate or concern that was not the case. Bahia noted that he will come back to that question later. Bahia reported many labs he believes are not calculating percent difference in Jnr between 0.1 and 3.2 kPA correctly.

Bahia reported all tests passed the normal distribution criteria, so they moved on to the ANOVA on the MSCR reproducibility. He showed the p-values for various samples. He also reported the test data does indicate there is some issue, but not whether it is equipment related.

Bahia identified some of the challenges in implementing the MSCR test method – specifically the variability between testing equipment and number of cycles. He demonstrated some of the challenges through examples of using the MSCR for a neat binder at 46^{o}C (Jnr versus number of cycles for three different types of equipment; Bohlin, TA, and Paar Physica). Bahia also presented and discussed test results for a modified binder at 70^{o}C. He noted one can reduce the variability of the test by eliminating the first few cycles or extending the number of load cycles. He also concluded some devices are not accurately capturing the first few loading cycles.

Bahia showed some results of his analysis completed on ignoring the first five cycles as compared to the last 5 cycles and adding more number of cycles. He commented the test was envisioned to go with 50 cycles, and his opinion getting the steady state within the first 5 cycles is asking too much. Bahia suggested a revision to be made because of this variability. He definitely recommends excluding an averaging of results and is of the opinion that averaging of the cycles is one reason for higher variability.

The second part of Bahia's presentation was on the use of the Jnr to estimate the elastic portion of a binder. He presented the Jnr and percent recovery values for a modified binder at 46^{o}C, and identified his concern with AASHTO TP70. The concern – the curve (Jnr versus percent recovery) is material based and not performance based. Bahia's question; what is the basis of the line – performance based or material based? Bahia's opinion is that we should be looking at a range of materials. Bahia included discussion for verifying by Flow Number results. He presented test results for 3 additives, 2 stress levels, and 2 gradations, and showed the resulting flow numbers for the different mixtures made in the lab at different stress levels. Bahia showed the two best materials in terms of Flow Number on the percent recovery chart. From that data, his conclusion is that he cannot support the Jnr versus percent recovery concept.

Bahia conclusion was to remove percent recovery and Jnr from the MSCR and develop new criteria. For rutting, Jnr is needed – not percent recovery. Run percent recovery at 25^{o}C, if it is to replace elastic recovery. Bahia recommends that the ETG design a study to verify and justify the limits; it is hard to find a reasonable PG grade that cannot meet the Jnr 4.0 at the pavement temperature. He believes that the 75% limit on Jnr 3.2 to 0.1 has no data to justify it in terms of mixture or pavement performance. Bahia also suggests the stress levels be revised. A few studies indicate that higher stress (10 to 25 kPa) correlate better to rutting.

ETG Discussion, Comments, and Questions:
D'Angelo agreed with Bahia's recommendation to eliminate the first 5 loading cycles. Concerning the temperatures that Bahia used are probably in the range that should not be used. We know the variability is high at those temperatures because the asphalt is soft. Bahia disagreed with that comment that he used test temperature outside the range of normal practice. D'Angelo countered that he has lots of data about the temperature effects. Most of the values used should be 0.3 and not 0.08. D'Angelo requested that Bahia take this into account when he does his analysis. There was a lot of debate on the meaning and use of the data. D'Angelo's position is that how you process the materials makes a difference. The numbers in the table were based on many binders, and he emphasized all of that data has been presented to the ETG. The line (Jnr versus percent recovery) was drawn below all of that data, because of cross linking of the polymers. D'Angelo stated percent recovery has nothing to do with rutting. The Jnr is the parameter related to rutting. D'Angelo noted why percent recovery is included has to do with the cracking potential and not rutting. At the request of highway agencies, the percent recovery was used to ensure that the polymer was added and is well blended.

Gerald Reinke commented that before we start eliminating the first 5 cycles, shouldn't we make sure that those cycles have no useful information or if they are telling us something. Bahia agreed with Reinke's comment, but the issue is that we are averaging the 5 cycles. That is the

problem or issue. Reinke's follow up comment; you mentioned steady state, but maybe we are looking at something different. Bahia replied; if we assume a linear material, we take the last 5 cycles, the averaging process does not tell us anything. Bahia agreed with Reinke's comments; we need to test at more samples and conditions.

Ludo Zanzotto believes that the stress level should be higher. He also agrees about the first couple of loading cycles. However, he stated that elasticity in one condition is different than in another condition. In addition, Jnr in one application is different than a Jnr in a different application. Zanzotto used an example of SBS for comparing binders and mixtures with and without SBS and it worked well.

TP70 contains both Jnr and Percent Recovery. Is this implied that agencies must use both? Bahia commented that agencies do not understand the difference between Jnr and percent recovery, and wrongly believe that they are related. D'Angelo stated that percent recovery is measured, so it is reported but it is not a part of the specification. D'Angelo noted that they are not trying to predict cracking from the higher test temperatures –only to check for polymer in the asphalt. He also reported that because of inertia there is a limit on the high temperature side. His recommendation; you should not want to change the specification. D'Angelo agreed that there were compromises made at the beginning, but everyone understood that when the specification was first developed.

Mihai Marasteanu noted two important points made by Bahia; how do we look at the binder from simple tests and do we know if we will see differences which can create problems with equipment manufacturers. The other important point is related to predicting of rutting as a performance based properties. You are not going to predict rutting simply from the binder tests – you need a mixture test to predict rutting.

Matt Corrigan asked where are the details of the flow number test? Bahia replied that the details are in the ARC quarterly progress report from last year. If you need the detail data, Bahia requested that he be e-mailed and he will send the excel spreadsheet.

ACTION ITEM #2: D'Angelo and Bahia will meet, along with Task Group and combine DSR data with recommendations on how to proceed with MSCR specification. Potentially, design a study for conducting a mixture test program to verify and justify the MSCR limits of the Jnr and Percent Recovery relationship.

5. **Linear Amplitude Sweep Task Group Report**—Hussain Bahia (University of Wisconsin at Madison) and Gerald Reinke (Mathy Construction)

Report/Presentation Title: *Fatigue Characterization of Asphalt Binders with the Linear Amplitude Sweep (LAS)*

Presentation Summary:

The webinar included 10 to 15 participants. Bahia listed the webinar contents which consisted of 4 parts: (1) Binder Fatigue Testing, (2) LAS: Theoretical Base, (3) Performing the LAS Test, and (4) Analysis of LAS Results.

Part 1 – Binder Fatigue Testing
Bahia overviewed the Superpave PG tests and noted what is missing: traffic loading and pavement structure. The assumption is that the asphalt is a linear viscoelastic material. The original approach was the time sweep test under NCHRP 9-10, which turned out to be very complicated and took a lot of time so it was not a practical approach. Thus, another approach was needed. Bahia referred to the MEPDG fatigue relationship and noted a simplified solution for the binder in terms of determining parameters through a simplified fatigue equation.

Bahia also summarized the background behind the Viscoelastic Continuum Damage (VECD) analysis and presented the damage function that is computed by a spreadsheet for the VECD. Bahia presented a summary of the focus and challenge related to binder fatigue testing. Specifically: (1) Asphalt concrete has been shown to have a well-defined relationship between loading input and fatigue life, (2) VECD analysis can be an effective tool to determine damage characteristics, (3) Conventional binder fatigue procedure (time sweep) is problematic, and (4) binder fatigue testing needs an efficient procedure that can do more than rank relative performance for a single condition.

Part 2 – Linear Amplitude Sweep (LAS) Test: Theoretical Basis
Bahia gave a summary of the presentation. The LAS test is a DSR procedure consisting of a frequency sweep and strain amplitude sweep; the goal is to derive the fatigue law, with parameters A and B which are binder properties: A is from the amplitude sweep test, while B is from the frequency sweep test.

The new test method being proposed can be run through the DSR as strain controlled test. The new test method for the binder consists of two tests – the frequency sweep which takes about a half an hour, and a strain amplitude sweep test that also takes about a half an hour. Bahia overviewed the fatigue law parameters A and B. Both parameters are calculated in the spreadsheet. The damage curve comes from the relationship that was developed by Yong Rak Kim from the University of Nebraska. The Linear Damage Curve was shown by Bahia and briefly discussed in determining fatigue parameters A and B.

Part 3 - Performing the LAS Test
Bahia overviewed the three pieces of equipment that can be used for LAS testing and showed a video for using each piece of equipment. These include: (1) the Anton-Paar Rheometers, (2) TA Rheometers, and (3) Bohlin Rheometers. Bahia reported they have used their own rheometers for the test. His presentation, however, was focused on use of the other three rheometers. For the Anton-Paar rheometer, at the smaller strain levels the DSR can be used but at the higher strain values the DSR cannot catch up with the feedback. Bahia stated you need to have the DSR under that condition. Darin Hunter clarified; the anomalous data shown by Bahia was not an artifact of the rheometer but a response from the binder. Bahia thanked Hunter for the clarification. He

agreed, it is not a rheometer problem but can be a material response. Bahia's point; you have to be careful what we are measuring and how we use the data.

Bahia overviewed and presented a video of each piece of equipment.

Part 4 – Analysis of LAS Results
Bahia overviewed the analysis of the LAS test results. This included an analysis that can be performed using repeated load tests. In summary, the linear amplitude sweep is proposed to address concerns over the current binder specification. It uses existing equipment and testing geometry. The VECD analysis can be employed to account of traffic and pavement structure. It is being proposed as an AASHTO format draft standard for the test procedure.

ETG Discussion, Comments, and Questions:
Bob Kluttz asked what is the appropriate test temperature for this test? Bahia replied that it should be the average climate temperature, rather than the grade temperature. Kluttz asked if it can be performed at the equivalent temperature. Bahia replied that you could, but noted that it would take more time to run for these added test temperatures.

Kevin VanFrank asked if it make sense to fix the test temperature around the fatigue test? Bahia replied that using this test, it allows us to focus the test around the strain level that is high enough to define A and B. Bahia noted that Carl Johnson tried to test at these lower test temperatures, but the binders were so hard that they did not get reasonable results.

John D'Angelo noted one item that needs to be looked at is that the MEPDG shows more fatigue damage at the higher test temperatures and not at the cooler test temperatures. Bahai noted a different test temperature can be used with the LAS test if that is what the user wants to do. But you can also shift these curves and estimate the values. Then go to higher damage criteria for defining failure.

Bob Kluttz recommended that Bahia combine his data with Dave Timm at NCAT to see how both sets of data fit together. Bahia agreed and had planned to contact Timm.

Ron Glaser commented that this is a very attractive test to get some idea about the binder's resistance to cracking. WRI has been struggling with this issue, and would like to keep temperature constant to reduce the aging difference in the test results. He asked Bahia for guidance or a suggestion towards this application – how does aging affect the resistance to fatigue cracking? Bahia replied; there are two AAPT papers related to that topic. Bahia's opinion is that we know how to analyze or consider the effect of aging. They have tested limited samples but are still investigating.

Bahia asked for guidance from the ETG on what else needs to be done beyond the webinar and the draft standard. This standard has not yet been forwarded to AASHTO, awaiting recommendations from this ETG. It was recommended that others need to start using the standard in order to be able to provide input. Concern remains whether other labs will have similar results and repeatable data with the procedure. Baumgardner left it to Bahia whether to

submit now to AASHTO as a provisional standard. Others in the ETG also suggested that this should be submitted to AASHTO as a provisional standard and that will give time for others to use the procedure and to determine variability. Eventually, procedural ruggedness will be needed before it becomes a full standard.

Gerald Reinke opinion is that he has been using the test and believes it is a good test. When you get to hard or stiff binders you cannot run this test at a low temperature because you do not get much strain.

Bahia requested the names of volunteers for performing additional tests using the standard so that it can be moved forward. Volunteers include; Kraton (Kluttz), Utah DOT (Kevin VanFrank), Louisiana DOT (Chris Abadie), Mathy Construction (Gerald Rienke), WRI (Mike Farrar), FHWA (Audrey Copeland), University of Nevada at Reno (Ellie Hajj), Paragon (Gaylon Baumgardner), Asphalt Institute (Mike Anderson), Blackwitch Emulsions (Codrin Dakanga), US Oil (Shauna Tecle Marian), and Stark Asphalt (Carl Johnson). A total of 12 labs volunteered to further examine this procedure.

It was also recommended that a ruggedness study be also investigated. Bukowksi suggested that Bahia look into the ruggedness standard from ASTM and outline what he would like to do and report back to the ETG at the next meeting.

ACTION ITEM #3: Linear Amplitude Sweep Task Group; Bahia will forward this test as a provisional standard, with the agreement from the ETG.

ACTION ITEM #4: Bahia will prepare a preliminary plan for the ruggedness test parameters to be considered for the Linear Amplitude Sweep test and potential participants.

Chairperson Baumgardner adjourned the meeting for the day at 4:45 PM.

Wednesday, 16 March 2011

Call to Order – Chairman Baumgardner called the meeting to order at 8:00 AM. He asked the participants to sign the attendance sheet that did not sign it yesterday. The sign-up sheet was again distributed.

Tom Scarpas asked Baumgardner to announce the Rilem 7th International Conference for Cracking in Pavements. Abstracts are due in the near future. Baumgardner noted conference brochures are available.

6. Wording for Asphalt Additives/Modifiers—John D'Angelo (D'Angelo Consulting)

Report/Presentation Title #1: *AASHTO M320 Proposed Changes, 1-24-2011*

Presentation/Report Summary:

While D'Angelo presented this topic, he noted that Steve Burhans had assembled the report and also acknowledged others that were involved in this effort.

The document that was presented reflected the track changes so all attendees could see exactly what had been recommended for change. The changes relate to the definitions regarding particulates. D'Angelo went through all of the changes that had been made to the document and explained reasons for the change. He reported some of the biosynthetic fuels that are not naturally occurring were excluded from the proposed changes.

A controversial item was related to solubility. Many of the polymers used are not soluable. He noted that the changes did not receive consensus, and there is still debate or controversy among the participants. He also reported this is still in draft form.

ETG Discussion, Comments, and Questions:
Gerald Reinke stated that he was part of some of the wording revision and initial development. He commented that if you do not run the right test; you must further investigate to ensure that the binder meets the specification, but still there is no guarantee. Abadie asked if this is not true for any asphalt? Reinke agreed. Abadie thought the mix may need to be part of the wording.

Bob Kluttz noted M320 is a material guide not a test standard. If we are going to put Note 4 in M320, should that note go into the aggregate specification as well as in other specifications? D'Angelo understands, but noted the direction from Chairman Baumgardner on the rewording of M320. Kluttz referred to crack seals, emulsion, etc. D'Angelo agreed with him – everything is up for revision. Kluttz suggested this be done for all materials. Baumgardner – binders are being modified with the goal that the modifiers are being used to improve performance. Baumgardner suggested adding the word mixture. Kluttz suggested moving Note 4 under 5.2. D'Angelo requested recommendations to the rewording of M320 be sent to him because we are still not ready with a final document.

D'Angelo noted that while still not ready to send to the SOM, we are getting closer. There are still some issues that need to be resolved – like solubility. His opinion is that the next version could be ready within a couple of weeks for distribution for review and comment through the ETG. Frank Fee requested the document be distributed to friends of the ETG. It was agreed to also distribute the document to the friends of the ETG. Bukowski commented; if there is any controversial items remaining, he would hesitate moving it forward to the SOM prior to further ETG discussions and D'Angelo agreed.

ACTION ITEM #5: D'Angelo will forward the next version of M320 to Bukowski to provide to the ETG and friends for additional comments. Any comments and discussion should be then sent to D'Angelo.

7. **Ground Tire Rubber Task Group Report—**Gaylon Baumgardner (Paragon Technical Services) and Matthew Corrigan (FHWA)

Presentation/Report Title #1: ***Development of a CRM Binder Performance Specification***

John D'Angelo gave the report for the task group.

Presentation/Report Summary:
D'Angelo presented the objective of the study; to identify suitable testing methods for GTR under the Superpave procedures/equipment. Some of the concerns include: large gap requirements due to large particle size, trimming of parallel plates, sedimentation of particulates, and deformation of asphalt at geometry surface, rather than entire volume of GTR sample.

D'Angelo gave an overview of the objective and purpose of this effort. He reported the issue is most of the rubber used in the U.S. is larger than the gap size in the DSRs. The question then is how can we test binders that have particulate that is near or greater than 1 mm? He showed some test results comparing G*/Sinδ for 1 and 2 mm gap sizes. How to test larger CRM sizes? Part of the study was to try up to a 4 mm gap, but still which did not work very well. So they had to go to an alternate approach.

D'Angelo identified and discussed the different geometries that were used: parallel plate, Couette Set (Cup and Bob), and vane 14 mm set (Cup and Vane). He first overviewed some of the sample preparation and testing issues with the parallel plates and how that can affect the test results. The next part of the presentation was the "Cup and Bob". D'Angelo mentioned it is the distance from the centroid or center of the sample that controls the results. He also showed photos of the test/sample set up using the Malvern instruments. With this system you can obtain a 5 mm gap. D'Angelo summarized some of the validation testing that was done to confirm the results for the Cup and Bob and Vane tests. For various materials, the G* master curves were generated for the PG64-22 binder with different geometries. D'Angelo reported they did see differences between the geometries.

D'Angelo then overviewed a new geometry and the rubber grading experiment for the Cup and Bob system. He listed the binders included and the testing that was planned for each condition. D'Angelo showed a comparison of the DSR geometries for PG64-22 neat, PG70-22, and PG64-22+PPA. Comparisons were made of the continuous grade with the different asphalts. He reported that some were just outside of what is considered good interlaboratory variability, and questioned whether the 1 mm variability is really valid in this effort. D'Angelo noted that there was an improvement of 4^{o}C on one of the samples which is significant.

Bob McGennis asked if the RTFOT was used. D'Angelo answered that it was and then McGennis asked if any unusual binder behavior was observed. D'Angelo repelled that none was observed, but that the efforts in this regard were limited. McGennis reported that they have seen some unusual results – it appears they are not getting the same air exposure and asked what did you attribute the improvement in low temperature properties? D'Angelo replied; he did not know; all he can say is that when it is soaking, asphalt is being absorbed into the rubber.

D'Angelo then showed some of the results from the PG continuous grading for blends using different geometries. He also showed results from the BBR on the effect of CRM on the low temperature grade. He reported there is a difference between the s and m values of the different geometries. Rowe asked if this is m-controlled. D'Angelo answered; yes, all were m-controlled.

D'Angelo noted this has been in debate in the ETG for years. Both s and m values were improved, but more so on the m values. It is up for debate on what actually caused the improvement.

D'Angelo showed test results for the MSCR in terms of Jnr at 0.1 and 3.2 kPa versus binder blend. He also summarized some of the observations from changes in Jnr versus percent recovery at 0.1 to 3.2 kPa stress level. A difference in the test results between the shear rates was observed, so they looked at the nonlinear effect for the creep and recovery cycle for the PG64-22 using the 3.2 kPa neat asphalt. D'Angelo presented some of the creep and recovery results for the PG64-22, 15% 60 mesh, and 3.2 kPa. He reported all samples have the peak strain which means they all saw the same shear strain. The differences are in the recovery part of the test. That same observation was present in other test specimens included in the experiment. He also presented the creep and recovery results for the PG64-22, 10% 30 mesh, and 3.2 kPa. D'Angelo reported that for the same peak strain there was a difference in the recovery part of the relationship.

Reinke asked; did you do the same testing for the other materials or look at the individual curves for the PG76-22? D'Angelo answered; yes they did. Reinke commented; the issue is partially a function of the fill materials. D'Angelo agreed with that comment and referred to the Cub and Bob issues summarized in the presentation. He reported there are significant stress sensitivity issues in the test, and stated this might be an artifact of the test itself. They are trying to verify what they are seeing from the test results. D'Angelo discussed one of the Cub and Bob issues: the creep portion of the test should be different but isn't (the recovery should be similar but isn't). This brings up a question – is it a particulate binder issue? To answer that question D'Angelo suggested testing the binders that have stress sensitivity but no particulates, waxes and extender oils to determine if there are different recoveries. In addition, try some creep testing at extended times and extended recoveries to evaluate the differences. Other issues noted by D'Angelo included solubility and MSCR percent recovery – rubber and polymers are not the same.

In summary, D'Angelo reported the following from the test results and comparisons:

- Control for all parallel plate and Cup and Bob geometries showed similar results for T-315 and TP-70 at 2 different temperatures. Trimming of the samples is not needed when using the Cup and Bob geometries.
- GTR at 64C exhibited differences between the Bob and Vane geometries.
- Accurate measurements can be generated if sedimentation of particulates occurs during the test when using the Bob geometry.
- CRM binder is sensitive to crude source.
- Rubber size does affect the test results and particles should be ¼ gap size or less.
- Careful formulation is needed to meet all Jnr specifications, but it can be done successfully. In addition, CRM binders can be produced to meet PMA specifications.
- There may be some differences for CRM binder and PMA specifications – solubility for CRM binder may be different, stress sensitivity may be different, while most other properties will be the same.

ETG Discussion, Comments, and Questions:
Gaylon Baumgardner made one comment related to this topic; there is a second task group on this item which is looking into the precision and bias for the 2 mm gap size. This second task group is on hold and will begin their plans based on the results from this task group. Matt Corrigan is the task leader and is waiting on the samples to be used.

Jean Planche asked if D'Angelo checked the storage or separation of the binders in storage? D'Angelo answered; no, that has yet to be done. Planche commented; sometimes you have a big change in the s and m values that is related to storage or separation which might explain an improvement or difference in the BBR results. He also noted there could be a difference in orientation of the molecules using the Cup and Bob. D'Angelo agreed that settlement could have occurred in the beam samples and agreed with the effect of the molecule orientation. Baumgardner stated; separation tests have been done and the difference was between 2 to 3 degrees of temperature. Planche replied to Baumgardner's comment; you can have a minor difference in temperature but a huge difference in the m and s values.

Frank Fee comment; the existing solubility is a critical parameter and recommended that someone start looking into this. D'Angelo agreed with that comment.

Baumgardner asked when this can be sent to 2nd Task Group lead by Corrigan; and D'Angelo hoped that this could happen in the next several months.

ACTION ITEM #6: John D'Angelo will continue work on GTR testing with parallel plates, Cup and Bob, and add the DSR using 4 gap mm parallel plate. He will forward the proposed specification and guidelines for preparing samples to the second task group being lead by Matt Corrigan for the precision and bias work. This information and data will be forwarded to Matt Corrigan within several months.

Report/Presentation Title #2: *Best Practice for Using Recycled Rubber*
Hussain Bahia gave the second presentation, an overview of results from a study completed by the University of Wisconsin at Madison in collaboration with the Recycled Materials Resource Center (RMRC).

Presentation/Report Summary:
The objectives of this study is to determine if recycled rubber can be used to deliver the same or better performance than virgin polymers, and what is the best method to do this; full or partial digestion? Bahia reviewed some initial results for answering these questions. He noted this information is included in a report entitled "The Effects of Digesting Crumb Rubber in Modified Binders" dated February 2011.

Bahia reviewed some of the literature and previous studies related to digestion. His opinion is that the digestion of rubber is critical. He summarized the effects of digesting crumb rubber in modified binders, and noted rubber is not soluable. Bahia started with solubility which is greater than 97.5% as required in the California specification. His presentation and work focused on determining if it is economical for using these materials in RAP and other materials. A California

DOT representative pointed out that the California specification for 97.5 percent refers to blended materials; it drops to 93 percent for field materials.

Bahia overviewed the literature review related to the effect of digestion to satisfy solubility. Bahia commented that some of the literature suggests that full digestion may not result in an improvement. Digesting it at high temperatures for longer periods of time is better. He showed similar effects related to the PG grading from the Glover report (Texas Transportation Institute).

Bahia summarized findings from the literature review and reports. Studies reviewed clearly show it is possible to cure rubber for too long a period at high temperatures. Materials produced at the highest level of curing indicate severe rubber degradation. This high level of curing can widen the PG span only incrementally and does not always yield improvements on specification basis required for a specified traffic condition. In addition, Bahia reported; it is very clear from the literature there is no problem with the grading, the real problem is related to meeting the solubility requirement. His opinion; this point should be considered in future specifications. If we are introducing a new specification for rubber, the solubility really needs to be considered and understood. He included an example showing the effect of partially digested rubber compared to other binders. There was a large improvement in the PG grade, but as you start to increase the digestion you start to lose the benefit.

ETG Discussion, Comments, and Questions:
Henry Romagosa asked what happens on the low temperature side? Bahia replied; he was unsure, but referred to Glover's work.

Kevin VanFrank asked if you can improve the high PG grade by adding filler? Bahia answered that you can. There is an improvement in elastic recovery. Gaylon Baumgardner commented; he has done similar work with seven different binders using four different particle sizes over four different temperatures. The longer time degraded the material, but for the shorter time you have more rubber. Over time you achieve a better specification.

Bob McGennis commented; he is trying to harmonize the results from Bahia and D'Angelo in terms of the softening oils to give it an improvement on the low temperature side but not on the hot temperature side. This comment resulted in a lot of discussion. McGennis is of the opinion that digestion needs to be studied in much greater detail.

Ludo Zanzotto overviewed some of the work and tests they have completed. In summary, he reported when using recycled rubber need to use high temperatures and times which were impractical and concluded that was not the way to go. He also mentioned that they abandoned the approach and went to a simple technology for measuring digestion at different times. Zanzotto concluded that when they used high stresses, the crumb rubber showed poor performance in relation to SBS modification.

Gayle King stated the solubility needs to stay in the specification or we are going to get all sorts of things added to asphalt to increase the high temperature grade. He also stated you must understand that if we break the chains, you will eliminate the elasticity of the materials. So how

we digest the materials and how the bonds are broken down is important and must be understood. He commented that we can see other materials that will fully digest the rubber and still retain the elasticity of the material.

Gaylon Baumgardner commented that CRM is in our market and will continue to be in the market, so we will need to deal with it, but not penalize the producers. His opinion; we need to do a study on SBR and recommend a solubility method that can be used in a future specification. He suggested we establish a task group for looking into solubility where GTR is the main focus. He also recommended that the particulates that do not break down should be considered a mix item and not a binder item. Bahia stated; there are procedures where the particulates can be separated, so we will know how much is there and how it impacts the properties.

Gale Page referred to the Florida research report that is available from Rey Roque on this topic. The report and specific results are on the Florida DOT website.

Frank Fee commented it is critical to identify solubility, but it must be understood. Chris Abadie commented that filler can improve performance but not always. Here we have a combination of the two – the challenge is to quantify the binder effect related to the mix effect.

ACTION ITEM #7: Bahia will prepare a proposal to look into solubility for GTR modified binders procedures and limits for the next ETG meeting (ASTM D 7353). Individuals that volunteered for this action item or committee include: Gerald Reinkie, Bob McGennis, Frank Fee, Codrin Durango, George Way, Carl Johnson, Ioan Negulescu, Gaylon Baumgarnder, Gayle King, Sam Huddelston, John D'Angelo, and Jean-Pascal Planche.

8. Procedure Mixing/Compaction Temperature Update—Mike Anderson (Asphalt Institute)

Presentation/Report Title: ***Laboratory Mixing and Compaction Temperature for Asphalt Binders.***

Presentation Summary:
Mike Anderson acknowledged that much of this presentation was extracted from Bahia's research project, NCHRP 9-10 for determining the zero shear viscosity (ZSV). He also acknowledged that Randy West presented some of this work on the draft of NCHRP 9-39 at the last ETG meeting. This presentation is a summary including the more recent data and results.

Anderson overviewed some of the previous studies that have been completed to determine the mixing and compaction temperatures. Mixing and compaction temperatures can be significantly different depending on the procedure used. A summary of the results from the NCHRP 9-39 study were presented, and noted there is a draft test method available in the NCHRP 9-39 report. Anderson demonstrated how this method is used to determine the mixing and compaction temperatures, an empirical procedure. He summarized some of the key findings from the NCHRP 9-39 report.

The NCHRP 9-39 Phase Angle method was used to calculate temperatures. Anderson reported he also evaluated the NCHRP 9-39 binders to determine the standard mixing and compaction temperatures to make comparisons between the NCHRP 9-39 procedures and the standard rotational viscometer procedure. For neat asphalt the results are similar, but for modified binders they start to deviate. He summarized the NCHRP 9-39 procedure, the Holley procedure and the ASTM D2493 or the rotational viscosity procedure and provided a comparison using all three methods. The NCHRP 9-10 binders were used as an additional comparison of materials with these methods. Anderson reported that it appeared that the NCHRP 9-39 and 9-10 have similar results, while the Holly procedure only somewhat matches up with NCHRP 9-39. One finding was that may need to truncate data for the master curve which requires some judgment and 80^{o}C may be too high for unmodified PG64 or softer asphalt. It was noted that other ETG members are also currently evaluating these results.

ETG Discussion, Comments, and Questions:
Frank Fee noted that there are 7 states currently evaluating the flow number test experiment under the Mixture ETG, and possibly these States could include the evaluation of the mixing and compaction temperature procedures in this effort. He suggested getting together with Mike Anderson and determining the compaction and mixing temperature for those mixtures included in the flow number experiment. Some members disagreed with this suggestion about assigning this to the flow number Task Group. Concern within the Binder ETG that this could delay adoption of the 9-39 results. Some believe that gyratory compaction process may be insensitive to slight temperature variations (<20^{o}C) and so better to start the design/laboratory compaction process with a reasonable temperature calculated value.

Chairman Baumgardner commented that this a binder issue and not a mix issue and suggested that the Binder ETG still needs to review these procedures to determine if we need to do more testing (maybe not) and then decide what goes forward as a proposed standard to AASHTO SOM. Currently, now it this is not an AASHTO standard, rotational viscosity is used. However, regardless of what is decided need to move away from the equiviscous procedure, because of modified binders. Some ETG members believe the supporting data for these changes need to be evaluated by a larger community and then, eventually move away from using the equiviscous temperature. Regardless, Mike Anderson maintains that this new procedure (9-39) does a much better job than the current one (equiviscous temperature), so we need to move forward on this. Decided to distribute the new 9-39 procedure to all the Binder ETG members and then decide what should be done related to a recommendation to the SOM. Anyone wanting to see or review the whole report can go to the NCHRP website to get the reports.

ACTION ITEM #8: Mike Anderson will forward a draft standard on Phase Angle and Steady Shear Flow Tests to ETG members for review and comment prior to the next ETG meeting, after which it will be decided at the next Binder ETG meeting to forward an opinion to the AASHTO Subcommittee on Materials (SOM).

9. RAP ETG Activities—Audrey Copeland (FHWA)

Two presentations were given under this topic and both presentations were given by Audrey Copeland.

Presentation/Report #1 Title: ***FHWA Study RAP Blending Reclaimed Asphalt Pavement Expert Task group Activities***

Summary of Report:
The first part of the report was on the background and overview of the RAP ETG. Audrey Copeland overviewed the objective of the ETG and acknowledged efforts of the members of the RAP ETG. Information on the RAP ETG is available at www.moreRAP.us. She reported activities of the ETG that included targeting low RAP usage State standards, coordinating development of research needs statements, RAP usage survey, high RAP performance, and the RAP ETG website.

Copeland overviewed and listed some of the accomplishments. These include; Designing HMA Mixtures with High RAP Content, A Practical Guide, NAPA Publication QIP-124; TRB Webinar entitled "Design and Production of High Reclaimed Asphalt Pavement Mixes;" methods to increase RAP usage while ensuring pavement performance, NAPA Publication PS 34; and the RAP FAQ Pamphlet.

Copeland also overviewed the proposed research needs statements from the group.

Copland briefly discussed some of the aspects of the RAP use survey. She acknowledged Jim Pappas (Delaware DOT) is conducting the survey this year and has taken over this effort. Other accomplishments include the high RAP performance study. Copeland overviewed the two accomplishments under this topic. These included the SPS-5 study completed by NCAT and a compilation of historical results from Demonstration Project 39 for the period 1978 and 1983.

Copeland discussed results from the NCAT survey on RAP management practices and RAP variability. She mentioned a webinar that is scheduled for April 25, 2011 that is being hosted by NCAT (http://www.morerap.us/RAP%20Resources/reports.html) The Reclaimed Asphalt Pavement Management Best Practices is currently under review by the ETG as is the RAP State-of-Practice – Publication No. FHWA-HRT-11-021. The next accomplishment listed was from the North Central Superpave Center on "Investigation of Properties of Plant Produced RAP Mixtures."

Also mentioned were efforts by the Asphalt Research Consortium (ARC). One effort, being lead by Hussian Bahia and Ellie Hajj, as well as the field study being lead by Mike Harnsberger on monitoring the field performance of RAP mixtures.

Finally, the RAP ETG has recommended a alternative procedure to be added in M323 as a procedure for evaluating binder replacement due to RAP and RAS. The task force is lead by Lee Gallivan.

Presentation/Report #2 Title: ***FHWA RAP Study***

Summary of Report:
The second part of the report was focused on the FHWA RAP study. Copeland gave a brief update on this binder blending study. Copeland identified the premise for this effort, which included: RAP binder may have less of an impact than assumed and complete blending of virgin and RAP binder within reasonable time and temperature may not necessary due to composite effects. These theories are supported by previous studies (specifically, the Huang 2005 and NCSC Plant study of 2008 to 2010). She reported one of the tests recommended by Mihai Marasteanu tests will be used to evaluate RAP mixtures. The reason this method is being used is because of the lower temperature side related to cracking resistance of the mixture. She included an example on using one binder for the 35% RAP where the low temperature is borderline, and explained why they went to the test recommended for use by Marasteanu.

Copeland overviewed the experiment design and testing plan for the RAP study. A question proposed, as part of the original plan, was to determine the long term aging of the samples. The debate was whether the samples need to be long term aged in finalizing the experimental design. John D'Angelo added; there is debate on long term aging, what it represents, and how valid it is. They know binders change with age, but the issue is how long to age material in a lab to represent what is on the roadway.

ETG Discussion, Comments, and Questions:
Gerald Reinke commented they have opted to look at short term aging and he agrees with D'Angelo about the value and specific time and temperature to be used. His other thought is related to the low temperature properties and their importance – on high RAP mixtures, they have seen cracking problems. So if you are going to evaluate the mix we must include some way to evaluate fatigue cracking.

Kevin VanFrank comment; you have pavement sections that are 20+ years old, he suggested milling them to see what the properties are relative to the comments about premature fatigue cracking for high RAP mixtures. Utah has used 40% RAP on some mixtures and thus far all have exhibited some premature cracking. His opinion; fatigue properties of the mixture are important as part of the evaluation.

Gayle King commented on a FAA cracking study and will be presented at AAPT later this month. The other part of the lab study has yet to be published or completed using Marasteanu's test method. King will share that information with the RAP ETG, and mentioned an issue that has been seen in the BBR test. For aged mixtures, they start seeing damage in the mix through micro-cracks without confinement that is softening the mix at the lower temperatures; the m-value is getting softer.

10. Bending Beam Rhoemeter Creep Compliance Study—Geoff Rowe (Abatech, Inc.)

Gaylon Baumgardner reported test specimens are not being stored for 16 days in the BBR. The purpose of this report is to try and identify the cause for some of the issues with this test. He

emphasized the effort is not to change any test method or specification, but to try and figure out what is happening. The work plan for this effort is attached to the meeting minutes as Attachment D and the following presentation.

Presentation/Report Title: *Assessment of Binder and Mixture Properties following Extended Periods of Isothermal Storage*

Presentation /Report Summary:
Geoff Rowe started summary of the study. He reported there is a lot of data in his report. He defined isothermal storage time in days; this is what Baumgardner referred to as the introduction to this report. Rowe started with showing example binder data. The key is the decrease or softening of the binder after about 4 days – a drop in stiffness. Looking at the mix stiffness test results no softening is exhibited in the data. He showed the bending beam rheometer data, and reported there is much more scatter in the data for the colder test temperature. Rowe mentioned that the m-value is about what you would expect but the stiffness dropped significantly which was unexpected after aging. Rowe reported; they tested the mix after a annealing to 64 C and ran the BBR test at -12 and -18 C. In this case the test results were ordered properly and they could develop a master curve from the test results.

Rowe overviewed some of the older work that has been done. He referred to some of Marasteanu's and Bahia's work, and showed some of the results reported by Dave Anderson. He questioned whether there is some sort of test artifact or something else to try and understand what is going on in terms on increasing modulus at the higher temperatures. Rowe explained the work plan that was prepared to examine that anomaly in the data.

Rowe discussed the experimental work plan that was distributed to all ETG members for review and comment. The initial focus was on the same binder but was expanded to several crude sources, wax modified, and polymer modified (SPS) binders. Phase 3 in the plan is to look at other binders. Rowe acknowledged the participants that are involved in this effort and the individuals that will do the analysis. These participants include: Paragon Technical Services, MTE, University of Minnesota, University of Wisconsin, and WRI. The individual doing the analysis include: Rowe, Anderson, and D'Angelo, in addition to the designated laboratories.

Rowe briefly overviewed the steps for each lab related to testing the binder. Each lab will be sent sufficient binder to manufacture three sets of three BBR test specimens. These specimens will be tested at three temperatures: PG-low minus 2C, PG-low plus 4C, and PG-low plus 10C. A total of 45 beams will be manufactured and will be tested at temperature soaking times corresponding to 0, 2, 4, 8, and 16 days. The 32 day time in the original study was removed since all these effects occurred before that time.

Rowe overviewed steps for the mix testing. A parallel data set will be obtained from testing of mixtures. To avoid manufacturing differences, all beams will be prepared by Paragon Technical Services. This involves the preparation of about 300 beams for BBR testing. Rowe reported on the additional testing items included in the experiment; which include: University of Wisconsin will measure the glass transition temperature and perform a single edge notch beam experiment

for each of the binders; MTE and Paragon Technical Services will develop a master curve for each binder and mix sample; MTE will do the testing in air and using storage in air and normal force evaluation; the University of Minnesota will attach acoustic emission sensors to the beams in an attempt to measure events during the isothermal conditioning; Dongre labs will look at DTT testing; and WRI will do the AFM testing or imagery.

Gerald Reinke sent Rowe the information on the MTE normal force related to the torsion bar in the ARES rheometer and condition it to -28^{o}C. Reinke overviewed the process that was used in the procedure. He explained the data and emphasized the change in normal force which was over a 25% increase which eventually decreased. He reported you do get large swings in the normal force but is unsure what is causing this to occur. Rowe then showed the time line for the 3 stages of the effort. He believes that some results would be ready to present at the ETG meeting in the fall of this year.

ETG Discussion, Comments, and Questions:
Reinke was asked to comment on the normal force diagram that was presented during the report. Suggested putting a nonasphalt sample in the equipment to see the results, and Reinke agreed with that suggestion.

Jean Planche opinion is that some of this is related to waxes and crystallization. Baumgardner and Ioan Negulescu both felt it was important to take samples at different times and test them. Negulescu referred to work done by Bahia to measure the glass transitions. Negulescu did similar testing and got very good results for comparing glass transition and DMA work. Negulescu volunteered to participate in the group.

ACTION ITEM #9: *Bending Beam Rheometer Creep Compliance Study* – The proposal for the assessment of binder & mixture properties for extended periods of isothermal storage was submitted for attachment to the meeting minutes. Those participating in this work plan include: Geoff Rowe, Gaylon Baumgardner, Dave Anderson, Gerald Reinke, Mihai Marasteanu, Hussain Bahia, Fred Turner, John D'Angelo, and Ioan Negulescu. Stage 1 of the work plan will be completed and reported on by the next ETG, Stage 2 will be completed by the fall of 2011, and stage 3 will be completed by the spring of 2012.

11. Thermal Equilibrium in the DSR—Dave Anderson (Consultant), John Casola (Malvern), and Darin Hunter (Anton Paar USA)

Presentation/Report Title: *Protocol for Determining Thermal Equilibrium in the DSR*
The report was given by Darin Hunter.

Presentation /Report Summary:
Darin Hunter overviewed the findings to date. These findings include that thermal equilibrium in the test specimen occurs some time after the DSR equipment indicates that the test specimen has been reached. This extended period of time is dependent on the rheometer design, test

temperature, and operator technique. Hunter reported that a protocol is needed for determining when the test specimen is at thermal equilibrium so that a reliable wait time can be determined.

Hunter reviewed the history behind this issue; specifically – is 10 minutes sufficient? He used a graphical representation of the idea. As part of this report, Hunter provided some definitions regarding gradients and equilibrium. Gradients are the temperature difference between different points in the test specimen, fixtures, and apparatus. Equilibrium is a point in time when temperature at different points is constant. He pointed out that thermal gradients are still present even when thermal equilibrium has been achieved. Hunter reported they have added a 5 minutes addition to the equilibrium time.

Hunter reviewed the procedure being used to determine when the specimen is in thermal equilibrium – the use the absolute deviation of the change in G* average slope over time. This is a moving average of the slope and when it becomes equal. Hunter discussed the recommended protocol for this effort to determine the equilibrium time to ensure thermal equilibrium has been achieved. His study approach consists of a multiple process, which was identified as follows:

1. Mount reference fluid or asphalt binder in DSR and trim in the usual manner.
2. Create a bulge and bring to test temperature.
3. Once test temperature is reached, initiate loading and continue for 30 seconds.
4. Record G* and DSR temperature at 30 second intervals.
5. If testing is done a multiple temperatures, set the DSR to the next temperature and repeat steps 3 and 4.
6. Determine the average absolute deviation and the time when two consecutive values of this deviation are less than 1.00 percent.
7. Determine the equilibrium time as defined.
8. Determine the wait time as the equilibrium plus 5 minutes.

Hunter explained the results from a recent study to answer the question whether we can use the reference fluid? Hunter provided the answer to that question - Yes if the limiting value of delta G* is adjusted to 0.5%. The binder source is not an issue because we are looking for a change in the data and not an absolute value. Hunter identified the remaining issue: the protocol identifies the temperature effect, not the long term drift observed in earlier studies. The reference fluid offers a good means for isolating this effect or observation. Future plans include testing selected binders and reference fluid in 2 hour steps and include multiple rheometer designs.

ETG Discussion, Comments, and Questions:

John D'Angelo commented that we have been talking about this issue for some time and asked if there was an AASHTO method written up that can be forwarded to the SOM. Anderson indicated that he would like this to be done before the next meeting.

Asked if the wait time is important as G* changes. Hunter answered that this is something that he has observed but is unsure how important or what impact it has on the results.

John Casola reported in response to D'Angelo's question; the actual protocol for doing the analysis is finalized, so it should be put together before the next meeting. Gaylon Baumgardner

asked; when you are getting acceptable results how often do you do the protocol? Casola answered; getting reproducibility in the data is not the issue. The real issue is to understand the equipment. You do it once, and once you know the time you are done. Baumgardner commented he has 3 pieces of equipment and all three are from different manufacturers. His question; do I need three different values? Casola answered; select the most conservative one. Hunter also commented that this is not applicable for GTR material.

It was asked if this is an AAHTO procedure? Casola answered not yet; but it is in a step by step procedure that can be written into an AASHTO standard. Corrigan commented that time is getting critical to do this. Baumgardner suggested that the ETG look at the procedure first and then take action whether to forward to the SOM. Casola again stated not yet in AASHTO format but is a step by step procedure. Baumgardner requested John Casola into an AASHTO format..

McGennis asked if there is a spreadsheet that has the step by step procedure that can be followed and used and are we looking for individuals to try this procedure out on real asphalt samples. Casola replied; yes, they are looking for individuals to implement and try the procedure.

ACTION ITEM #10: *Thermal Equilibrium in the DSR* – John Casola and Darrin Hunter will convert the DSR temperature equilibrium procedure into AASHTO format and forward it to Baumgardner. Baumgardner will send it to the ETG for review and comment with eventual submission to the SOM.

12. BBR Low Temperature Fracture Testing—Mihai Marasteanu (University of Minnesota)

Presentation #1 Title: ***Low Temperature Strength Testing of BBR Binder Beams***

Summary of Presentation:
Mihai Marasteanu overviewed the presentation. He started with a review of the NCHRP idea study to develop detailed loading procedure that allows testing mixture beams with minimal software modifications and no changes to the current BBR equipment. He followed the opening comments with a discussion and overview of the sample preparation procedure for tall and normal gyratory compacted cylinders and field cores and how the BBR test specimens were manufactured.

Marasteanu summarized the specimen geometry effect study and reported that the IDT and BBR differences are most likely due to specimen geometry effects between the two tests. He also showed the medium cooling effect for different materials.

Marasteanu reported they had drafted the BBR creep mixture test method and presented that method to the ETG about a year ago, but it has yet to be submitted to AASHTO. A question they are pursuing to answer is to determine if they can back calculate the BBR binder properties from the measured mix properties. Marasteanu stated you cannot convert mix properties to binder properties using the 2S2P1D model relationship because of its complexity. He reported they found out the alpha coefficients in the model is similar to mix design and they developed a

relationship between the shear stress of the mix and binder that uses the alpha parameter. The Alpha coefficient is a regression constant that is supposed to be related to mix design. Marasteanu commented the Hirsch model has some benefits in that it allows some transformation of mix to binder properties and vice-versa that the ENTP does not include. The experimental and back calculation data compare very well.

Marasteanu presented the concept of a new NCHRP idea study using Cannon Instruments to measure the BBR strength of binders and mixtures. The new system is capable of performing strength tests on mix and binder beams. Marasteanu reported on some of the previous work that has been accomplished relative to this topic. He showed some comparisons between BBR, IDT, and DT strength results which included a comparison of the data that takes size effects into consideration. The size effects were first investigated as a statistical problem. Marasteanu stated the size effect or analytical determination of the mean strength requires an integration process.

Marasteanu overviewed the current limited work relative to the binder and mix strength values. The asphalt mixture strength test was analyzed using two types of simulations, Weibull and Gaussian distributions. He reported they expect to have a problem comparing the results to traditional strength methods. As of now, there is no size effect correction that can be used – no unique trend was found. Marasteanu opinion is you cannot transform results from the IDT to large scale mixtures for testing at low temperatures. This becomes a controversial and debatable issue.

Relative to the asphalt strength tests, the 3 percent per minute for the DTT was originally selected, but he is unsure why it was selected. They are seeing a large difference that cannot be explained by the geometry effects. The question that needs to be answered is; which one is the right one in terms of the loading rate for the test? Marasteanu stated they may need to increase the thickness of the beam which should not be a problem. They have an experimental plan for testing different beam sizes to determine the size effects.

ETG Discussion, Comments, and Questions:
Mike Mamluck (ASU) commented on the issue with testing thin beams and asked; why do you not use thicker specimens or is this work trying to use a specific device? Marasteanu answered; we are trying to use these thin beams so that the equipment does not need to be changed. He agreed it is device specific, but testing thin beams will make it easier for users in making these measurements. This is a practicality issue and he does understand that it may not prove correct.

Gayle King commented that they have used this test on fog seals, where the specimens are thin and in other studies trying to understand the aging issue in thin layers. He noted there are areas or conditions where thin layers must be used. King agrees with the approach to answer some of the questions and issues.

Ron Glaser – If you start making corrections for size effects for getting mix properties, this will be useful for field cores and it would be nice to get a handle on this for making the jump between the aged binders and mix properties. His opinion; this is a good work effort or study that should be pursued but acknowledges that the thin layers are a challenge. Marasteanu agreed and would

have preferred to use a thicker sample. Ron Glaser commented; as you start to decrease beam thickness you are probably going to need a lot of replicates because of variability.

13. Cleanup of AASHTO Test Standards—Dave Anderson (Consultant) and John Bukowski (FHWA)

This presentation was given by John Bukowski in Dave Anderson's absence.

Presentation/Report Title: ***AASHTO Asphalt Binder Test Methods and Practice Updates***

Summary of Presentation:

Bukowski reported that Dave Anderson has been pursuing the need to review some of the procedures or test standards for editing to current practices. Dave Anderson reported he has a number of standards that have been edited and wants to get them to the SOM in the near future.

Dave Anderson visited ARML last week to identify and discuss what needs to be corrected for the test standards. Anderson identified the reasons for doing this as simplify AMRL's mission, increase clarity, eliminate redundant material, correct errors, update details to reflect current best practice, and coexist with ASTM where appropriate. The concept for this effort was similar to what Anderson is working with the Asphalt Institute (AI) for updating information in the AI MS-25 manual.

Bukowski showed the schedule planned for updating the test standards, and commented this schedule will be shared with the ETG. However, the last bullet of being forwarded to AASHTO for consideration at the summer 2011 meeting was probably too ambitious. ETG members agreed that they wanted to see all the proposed edits from Dave Anderson, before sending to the SOM.

The last item of the report included examples of some issues on standardization and verification terms that are used interchangeably and incorrectly. Also issues on RTFOT, leveling is required and the technique for leveling not specified. In the BBR, daily verification versus standardization in terms of what constitutes appropriate daily practice. And leveling of PAV pans, the requirement is unrealistic and no technique is provided.

ACTION ITEM #11: *Review and Cleanup of AASHTO Test Standards* – Mike Anderson will obtain the red-lined changes to multiple binder test standards from Dave Anderson. The listing of test standards with revisions/changes will then be forwarded to the ETG.

14. Asphalt Research Consortium (ARC) Database: Overview and Update—Elie Hajj (University of Nevada at Reno)

Presentation Title: ***ARC Database: Overview and Updates***

Elie Hajj explained the reason for this database. He identified the work elements under the ARC TT1d and TT1e tasks. These include development of a materials and research database. The

purpose is to store information related to sources and properties of materials used in various consortium research activities.

Hajj identified some of the challenges for the database. The database will be web-based. Challenges included, no software installation, flexibility to include new test procedures, a central database, multiple users to the database, different user roles, common materials use, and ability to relate materials to validation sections.

Hajj identified the key design goals of the database: create the most flexible system possible eliminating "hard-coded" data types; create a role-based infrastructure granting privileges to categories of users; and create an entirely web-based system because no software would be installed on client computers. The technologies used in developing the database are SQL Server 2008. ASP.NET was selected as the web development platform. Hajj provide a flow diagram of the database which is a general users diagram.

Hajj overviewed how to get into the data from the database. All materials have a type and a supplier. Materials can be created from other materials and all materials are associated with the different work tasks, validation sections, and/or other component materials. Hajj overviewed each one in particular.

- Starting with the Material Types – there are master categories. Under the master categories there are sub-material types. There are property groups and attributes for each property group.
- Validation sites for the software models; there are support files that are uploaded to a user-defined hierarchical file system. The support files can include report files reports, scanned document, picture, etc.
- Reports included in the database will follow the FHWA research report format and the website is: http://www.fhwa.dot.gov/publications/research/general/03074/index.cfm. These reports will be compliant with Section 508 and owned by FHWA.
- Selection and filtering feature of the software – materials can be selected and filtered by material type, material category, supplier, work tasks, validation sections, and component materials.

Hajj briefly overviewed deployment of the ARC database to other servers. The current status or work in progress includes; update final Help System items to reflect changes, continue to fix bugs resulting from broad users, develop read-only user interface for non-consortium users, and a plan for deployment to other servers.

15. Western Research Institute (WRI) Update—Mike Farrar (WRI)

Presentation Title: ***Laboratory – Asphalt Binder Short and Long-Term Aging***

Summary of Presentation:
Mike Farrar acknowledged individuals that are involved in this study. He started his report by first defining and introducing the challenge – lowering the mixing temperature to produce WMA

may reduce the amount of binder oxidation during mixing and compaction and may affect long-term oxidation.

Farrar commented we probably do not want to turn the temperature down for the RTFO for WMA aging during the analysis. This was in answer to the question – can we simulate WMA binder aging by lowering the temperature and/or time in the RTFO? Farrar overviewed the different items that need to be considered: at lower temperature the amount of rolling is reduced; at lower temperature does the amount of volatiles lost simulate a warm plant; polymer modified asphalt does not roll or rolls less; and some polymer modified asphalts creep out of the bottle.

Farrar discussed the different alternatives that have been suggested based on different objectives – produce large amounts of aged binder and thin film aging. He also discussed the 4 mm diameter parallel plate DSR. He listed the advantages, the published reports, and the draft modified ASTM method that has been prepared. One paper was published last year at TRB to determine equipment compliance, and the second paper shows the correlation between different plate sizes.

Farrar then showed the simple aging test (SAT) device/mold. The sample size is 300 micro-mils film or 1gram per slot and there are three slots on the device. D'Angelo asked; where did the 120^{o} and 140^{o}C come from for WMA and HMA mixes? Farrar answered; these were overall averages. D'Angelo commented; they looked low for mixing temperatures, but appear to be close to the compaction temperatures. Farrar listed the features and advantages of the SAT. Farrar also noted that the device was designed so that it could be used with the DSR in measuring long term aging.

Farrar overviewed and showed the aging scheme and rheology in terms of a flow diagram. He showed some typical data that was from the Manitoba WMA binder site. This included a comparison of the SAT and RTFO data. He also showed some test results of Log G* versus frequency and how that changes with time of aging. He overviewed the work done by Glover – 50 minutes at 160^{o}C. He could age a 500 micro thick film and get the same viscosity as compared to the RTFO.

Farrar discussed and addressed the variation in film thickness and its effect on diffusion using the RTIR, DSR, and GPC. He overviewed the future work being planned on the SAT to finalize details on sample preparation and oven temperature and time; FTIR (functional group changes & degradation of polymer), thermo-gravimetric analysis (evaluate percent mass change), Rheology change with aging time in the over, diffusion and effect of variable thickness (300 to 1200 micro- mils), and compare the SAT to RTFO and extracted HMA and WMA binders.

ETG Discussion, Comments, and Questions:
Gerald Reinke commented that Glover did the work that was summarized in terms of aging time and temperature. His opinion is Farrar needs to build on the Glover work and this needs to be a specification test. He suggests changing the target temperature. Reinke commented; he likes the approach. Farrar agrees with the specification comment.

Geoff Rowe referred back with the UK work but it was the modification to the device that came from Switzerland in terms of getting a cheaper version of the test. Farrar agreed with the Teflon suggestion. Rowe suggested getting some feedback on what was done on the UK work.

ACTION ITEM #12: *DSR 4 mm Plates Test Procedure* – Mike Farrar will put the 4 mm plate DSR procedure into an AASHTO type format by the next ETG meeting.

16. Meeting Summary/Action Items/Next Meeting—Gaylon Baumgardner (Paragon Technical Services) and John Bukowski (FHWA)

John Bukowski summarized the action items that were identified from this meeting, which are:

Multiple Stress Creep Recovery (MSCR) Task Group:

1. Mike Anderson will update the precision and bias statement for the MSCR test.
2. D'Angelo and Bahia will meet, along with Task Group and combine DSR data with recommendations on how to proceed with MSCR specification. Potentially, design a study for conducting a mixture test program to verify and justify the MSCR limits of the Jnr and Percent Recovery relationship.

Linear Amplitude Sweep Task Group:

3. Bahia will forward this test as a provisional standard for the Linear Amplitude Sweep test with the agreement from the ETG.
4. Bahia will prepare a preliminary plan for the ruggedness test parameters to be considered for the Linear Amplitude Sweep test and potential participants.

5. *DSR* – D'Angelo will forward the next version of M320 to Bukowski to provide to the ETG and friends for additional comments. Any comments and discussion should be then sent to D'Angelo.

6. John D'Angelo will continue work on GTR testing with parallel plates, Cup and Bob, and add the DSR using 4 gap mm parallel plate. He will forward the proposed specification and guidelines for preparing samples to the second task group being lead by Matt Corrigan for the precision and bias work. This information and data will be forwarded to Matt Corrigan within several months.

7. Bahia will prepare a proposal to look into solubility for GTR modified binders procedures and limits for the next ETG meeting (ASTM D 7353). Individuals that volunteered for this action item or committee include: Gerald Reinkie, Bob McGennis, Frank Fee, Codrin Durango, George Way, Carl Johnson, Ioan Negulescu, Gaylon Baumgarnder, Gayle King, Sam Huddelston, John D'Angelo, and Jean-Pascal Planche.

8. *Laboratory Mixing and Compaction Temperature for Asphalt Binders* – Mike Anderson will forward a draft standard on Phase Angle and Steady Shear Flow Tests to ETG members for review and comment prior to the next ETG meeting, after which it will be decided at the next

Binder ETG meeting to forward an opinion to the AASHTO Subcommittee on Materials (SOM).

9. *Bending Beam Rheometer Creep Compliance Study* – The proposal for the assessment of binder & mixture properties for extended periods of isothermal storage was submitted for attachment to the meeting minutes. Those participating in this work plan include: Geoff Rowe, Gaylon Baumgardner, Dave Anderson, Gerald Reinke, Mihai Marasteanu, Hussain Bahia, Fred Turner, John D'Angelo, and Ioan Negulescu. Stage 1 of the work plan will be completed and reported on by the next ETG, Stage 2 will be completed by the fall of 2011, and stage 3 will be completed by the spring of 2012.

10. *Thermal Equilibrium in the DSR* – John Casola and Darrin Hunter will convert the DSR temperature equilibrium procedure into AASHTO format and forward it to Baumgardner. Baumgardner will send it to the ETG for review and comment with eventual submission to the SOM.

11. *Review and Cleanup of AASHTO Test Standards* – Mike Anderson will obtain the red-lined changes to multiple binder test standards developed by Dave Anderson. The listing of test standards with revisions or changes will be forwarded to the ETG.

12. *DSR 4 mm Plates Test Procedure* – Mike Farrar will put the 4 mm plate DSR procedure into the AASHTO format by the next ETG meeting.

Gaylon Baumgardner and John Bukowski reported that the next date for the ETG meetings will be the week of September 19, 2011. The location or place of the next meeting has yet to be determined but will probably be somewhere along the east coast. The order of the ETG meetings for the next round will be: the Models, Mixture, and the Binder ETGs.

17. Meeting Adjournment

Baumgardner thanked everyone for attending and participating in the meeting. The meeting was adjourned by Chairman Gaylon Baumgardner at 3:45 PM.

ATTACHMENT A

Asphalt Binder Expert Task Group

Phoenix, Arizona
March15 & 16, 2011

Meeting Agenda - Draft

Day 1 - March 15, 2011

1:00 p m	Welcome and Introductions	**Baumgardner**
1:15 pm	Review Agenda/Minutes Approval & Action Items September, 2010 Meeting	**Bukowski**
1:30 pm	MSCR Task Group Activities • Effect of Polymer Content Testing Procedure • Report of Group Lab Testing (Mix Bending Beam/Puss-Pull) • Implementation Update	 **Dongre** **M.Anderson**
3:00 pm	Break	
3:30 pm	MSCR Repeatability/Relationship to Mix Rutting	**Bahia**
4:00 pm	Linear Amplitude Sweep Task Group Report • Procedure Review/Comments • Update on Activities	**Bahia/Reinke**
5:00 pm	Adjourn for the Day	

Day 2 – March 16, 2011

8:00 am	Wording for Asphalt Additives/Modifiers	**D'Angelo**
8:30 am	GTR Task Group Report • Procedure for Performing P& B • Update on Activities	**Baumgardner** **Corrigan**
9:30 am	Procedure Mixing/Compaction Temperature Update	**M. Anderson**
10:00 am	Break	
10:30 am	RAP ETG Activities • FHWA Study RAP Blending	**Copeland**

- Modification to M323

11:30 am

Noon	Lunch	
1:00 pm	BBR Creep Compliance Study	**Rowe**
1:30 am	BBR Low Temperature Fracture Testing	**Marasteanu**
2:00 pm	TBD	
2:30 pm	ARC Database: Overview and Update	**Elie Haij**
3:00 pm	Break	
3:30	WRI Update	TBD
4:30 pm	Meeting Summary/Action Items/Next Meeting	**Baumgardner**
5:00 pm	Adjourn	

ATTACHMENT B

ASPHALT BINDER EXPERT TASK GROUP MEMBERS

Chairman: **Gaylon Baumgardner** Executive Vice President Paragon Technical Services, Inc. 2829 Lakeland Drive, Suite 2000 Jackson, MS 39232-7611 Phone: 601-933-3217 Cell: 601-842-3743 Fax: 601-933-3363 Gaylon.baumgardner@ptsilab.com	Co-chairman: **R. Michael Anderson** Director of Research & Lab Services Asphalt Institute 2696 Research Park Drive Lexington, KY 40511-8480 Phone: 859-288-4984 Fax: 859-288-4999 manderson@asphaltinstitute.org
Secretary: **John Bukowski** FHWA Deputy Director HIPT Federal Highway Administration 400 7th Street, SW. Washington, D.C. 20590 Phone: 202 366-1287 Fax 202-493-2070 John.Bukowski@dot.gov	
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ATTACHMENT C

ASPHALT BINDER ETG WORKING COMMITTEE MEMBERS

Aging Task Group: Gayle King Jim Barnett Laurand Lewandowski Jan Negulescu Gerald Reinke	**Moisture Damage Task Group:** Bob McGennis Chris Abadie Ken Gryzbowski Dean Weitzel
Low Temperature Task Group: Mihai Marasteanu Jim Barnett Raj Dongre Bob Kluttz Gerald Reinke Sang-Soo Kim	**Modification Task Group:** Laurand Lewandowski Mark Buncher Carissa Mooney Mihai Marasteanu Henry Romagosa
Validation Task Group: Gerald Reinke Mark Buncher Gayle King Mihai Marasteanu Henry Romagosa	**PPA Best Practice Task Group:** John D'Angelo Terry Arnold Mike Anderson Gayle King Jean-Valery Martin Fran Miknis Olga Puzic Gerald Reinke Henry Romagosa
GTR Modified Asphalt Task Group: Gaylon Baumgardner, Lead Chris Abadie Audrey Copeland John D'Angelo Darin Hazlett	**GTR P& B Round Robin Precision & Bias Group:** Matt Corrigan, Lead Chris Abadie Gaylon Baumgardner Tom Bennert Bob McGennis Randy West

MSCR Task Group:	**Linear Strain Amplitude Test Group:**
John D'Angelo, Lead Haleh Azari Raj Dongre (laboratory participation) Edgard Hitti Karissa Mooney Ioan Negulesce (laboratory participation) Gerald Reinke (experimental plan) Geoff Rowe (experimental plan) Chris Williams (lab participation; experiment plan) Jack Youtcheff (laboratory participation)	Hussain Bahia, Co-Lead Gerald Reinke, Co-Lead Chris Abadie Haleh Azari Jim Barnet Audrey Copeland Mike Farrar Leonard Lewandowski Karissa Mooney Kevin VanFrank
Mixing & Compaction Temperatures Group: Mike Anderson, Lead Frank Fee Edgard Hitti Laurand Lewandowski Karissa Mooney	

ATTACHMENT D

WORK PLAN
ASSESSMENT OF BINDER AND MIXTURE PROPERTIES FOLLOWING EXTENDED PERIODS OF ISOTHERMAL STORAGE

Task group members: Geoffrey Rowe; Gaylon Baumgardner; David Anderson; Gerry Reinke; Mihai Marasteanu, Hussain Bahia; Fred Turner, John D'Angelo

Problem statement:
In recent work it has been noted that stiffness of asphalt binder and mixture specimens has decreased between the PG+10^{o}C temperature and the PG+4^{o}C temperature when stored under isotheral conditions. This decrease was observed when asphalt binder and asphalt concrete BBR specimens where held at a constant low temperature (-18^{o}C) for an extended period of time. Previously in the literature only an increase in stiffness has been reported with time (for example Bahia et al., 2002).

The cause of this observed reduction in stiffness is not known but may be the result of a testing artifact such as the influence of normal stresses or it may indeed reflect damage to the test specimen. It has been postulated that this reduction in stiffness is associated with micro-cracking in the binder and mixture specimens.

The data obtained from this recent study shows that this drop in stiffness occurs more significantly after 2 to 4-days, typically followed by an increase in stiffness which continues beyond the initial stiffness for the binder samples. The mix samples did not regain significant stiffness. This drop in stiffness occurred in samples made with a control PG64-22 binder and wax modified specimens.

In the PG specification low temperature testing is performed at the lower grading temperature +10°C but the pavement may well experience the low grading temperature. Thus, during specification testing the asphalt binder may never be subjected to temperatures that are encountered during service. If the decrease in stiffness is prevalent in the range of temperatures from the lower grading temperature to 10° above the lower grading temperature the current BBR test protocol may not properly reflect the behavior of the asphalt binder in the pavement. This importance of this effect may be further accentuated if the pavement remains close to the lower grading temperature for a number of days. If a change occurs in a BBR specimen (mix and/or binder) above the grade temperature due to micro-cracking then it is possible that damage can occur in pavement structures when they are held in a similar condition – i.e. if pavements are held at a temperature above the critical cracking temperature for an extended period of time. Indeed these pavements might crack at a higher temperature.

Understanding the phenomena will help determine if this issue is significant and if adjustments should be made with regard to the use of the BBR test. It is possible that improvements could be realized in the accuracy of the prediction of low temperature cracking.

Objectives:
The objectives of the work plan outlined herein are to conduct an initial evaluation with 4 binders in order to provide insight into the nature of the observed changes and to provide some insight as to the it's probable cause. Testing will be conducted by several laboratories with regard to these binders as both mixes and binder specimens. The results of this testing will be used to determine if a wider comprehensive study should be conducted by an organization such as NCHRP/ FHWA/ AASHTO etc.

Materials:
Four binders have been initially selected for this investigation. The binders include a standard PG64-22 which was used for the earlier work plus others that will be anticipated to have some alternate chemistry. Details on the proposed materials are provided below.

A mix design will be used using a granite aggregate from a source in Georgia. Sufficient materials will be used to compact gyratory specimens from which small beams will be sawn for rheological testing (BBR dimensions). Sufficient quantities of material will be kept by Paragon technical Services to enable repeat testing if necessary.

Potential materials for the study include:

Binders	Source
Phase 1	
PG64-22	Lion Oil
Phase 2	
PG64-10	West Texas
PG64-22	Wax Modified – 3% Sasobit
PG58-28	Canadian crude
PG 76-22	SBS Modified - North Sea/Brazilian, Ergon, Vicksburg or Conoco Phillips Woodriver
Stage 2	
AC20	China crude (Table 1 AASHTO spec)
PG64-22	NuStar
PG62-22	Mayan

Laboratories:
Laboratories involved in study are as follows:

Materials preparations and mix beam fabrication
- Paragon Technical Services

Testing
- Paragon Technical Services

- MTE
- University of Minnesota
- University of Wisconsin
- Dongre Testing Lab
- WRI

Testing/experimental:
Work will be conducted in stages to check if the observed phenomenon is re-occurring in the orginal materials evaluated. This will then roll into a stage two with further materials and some additional materials have been identified for a stage three testing.

Binder
Each laboratory will be sent sufficient binder to manufacture three sets of three BBR test specimen. These will be tested at three temperatures PG_{low}-2, PG_{low}+4 and PG_{low}+10^{o}C. Consequently each laboratory will manufacture 9 BBR beams for each binder – a total of 45 beams. These beams will be tested at temperature soaking times corresponding to 0, 2, 4, 8 and16.[1]

Mixture
An identical data set will be obtained from testing of mixtures. To avoid differences in manufacture all beams will be prepared by Paragon Technical services and shipped to each participating test laboratory. This will involve the production of 270 beams for BBR testing – with a few additional beams being produced for items such as acoustic emission testing.

In addition to the above:
- University of Wisconsin will measure the glass transition temperature (T_g) and perform a single edge notch beam experiment (SENB) for each of the binders.
- MTE and Paragon will develop a master curve for each binder and mix sample (range +60 to PG_{low} – 10^{o}C approx).[2]
- MTE will do the testing in air and using storage in air and normal force evaluation..
- University of Minnesota will attach acoustic emission sensors to the beams in an attempt to measure events during the isothermal conditioning.
- Dongre Testing Labs – will look at DTT testing.
- AFM - WRI

Analysis:
Rowe, Anderson and D'Angelo will collate data from the various test laboratories and produce an analysis report with input from each of the researchers.

Time-line:
Stage 1 - Samples sent out by end of June, Data end of September

[1] The 32-day time in the orginal study has been removed since all these effects occurred significantly before this time.
[2] By going to -10^{o}C lower than the PG grade temperature the peak in the G" can be used to estimate the TG. This will be on samples in the 0-day condition.

Stage 2 and 3 will follow an initial report to ETG in fall of 2011.

Stage 2 reported March 2012.

Supplementary information

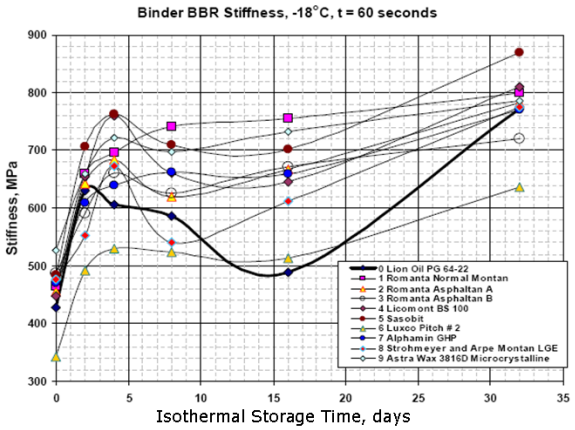

Figure 1: Binder test data at -18°C (Sasobit) – typical example from recent work

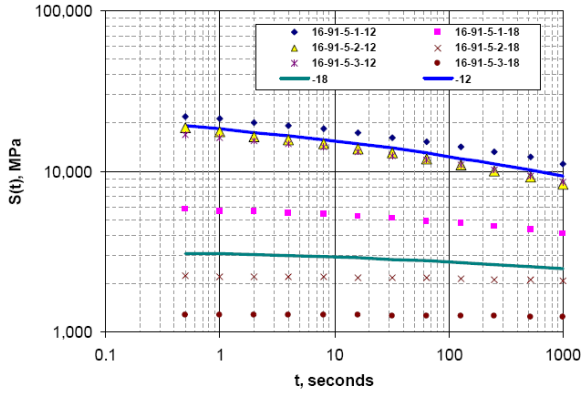

Figure 2: Mix data - Material 5 - day 16– typical example from recent work

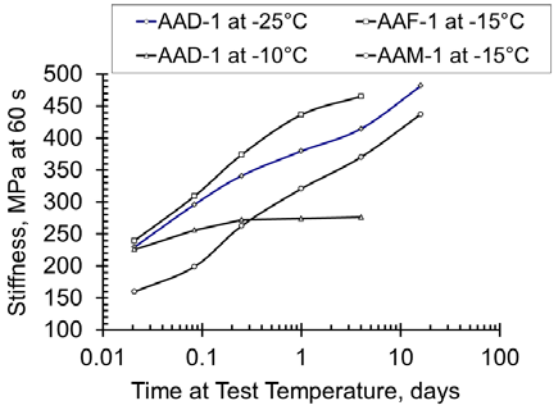

Figure 3: Test results conducted in 1990's by DAA and others - show no evidence of stiffness reduction (ref: DAA to provide) these data were obtained by placing beams in the BBR bath and holding them there for extended periods of time. Replicate measurements were made. The beams were tested repeatedly by turning them over from one isothermal storage time to the other. By the way, isothermal storage or isothermal conditioning is a better way to describe the conditioning than some of the other terms that I have heard used such as "soaking".