FHWA Asphalt Binder Expert Task Group Meeting

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 77 individuals attended the meeting (19 members, 2 contract personnel, and 56 visitors, excluding attendees via the Webinar). The meeting was held at the Double Tree Hotel, Minneapolis, MN.

ETG Members in Attendance:
Gaylon Baumgardner, Paragon Technical Services (Chairman)
Mike Anderson, Asphalt Institute (Co-Chairman)
John Bukowski, Federal Highway Administration (Secretary)
Chris Abadie, Louisiana Department of Transportation
Dave Anderson, Consultant
Mark Buncher (Liaison), Asphalt Institute
Audrey Copeland (Liaison), National Asphalt Pavement Association
John D'Angelo, Consultant
Darren Hazlett, Texas DOT
Gayle King, GHK, Inc.
Mihai Marasteanu, University of Minnesota
Bob McGennis, HollyFrontier Refining & Marketing
Bruce Morgenstern, Wyoming Department of Transportation
Ioan Negulescu, LSU
Jean-Pascal Planche, Western Research Institute
Gerald Reinke, Mathy Construction
Henry Romagosa, ICL Performance Products LP
Geoff Rowe, ABATECH
Kevin Van Frank, Utah Department of Transportation

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

ETG Members Not in Attendance:
Edward Harrigan (Liaison), TRB
Eileen Sheehy, New Jersey DOT

Friends in Attendance:
Haleh Azari, AAPRL (AMRL)
Hussain Bahia, Univ. of Wisconsin-Madison
Satish Belagutti, FHWA
Sandy Brown, Asphalt Institute
Matthew Corrigan, FHWA
Brian Cox, Flint Hills Resources
Bill Criqui, Road Science
Codrin Daranga, Blacklidge Emulsions
Mike Farrar, WRI
Frank Fee, NuStar Asphalt
Jean Paul Fort, COLAS
Lee Gallivan, FHWA
Nelson Gibson, FHWA
Ron Glaser, WRI
Stacy Glidden, Mathy Construction
Beth Griffin, DuPont Company
Tom Harman, FHWA
Mike Harnsberger, WRI
Rick Holmgreen, Phillips 66
Darin Hunter, Anton Paar, USA
David Jacobson, TA Instruments
Carl Johnson, Northwest Asphalt/Stark
Greg Kamykowski, TA Instruments
Sang-Soo Kim, Ohio University
Robert Kluttz, Kraton Polymers
JV Martin, INNOPLOS
Maria Knake, AASHTO
Pavel Kriz, Imperial Oil Co.
Susan Kistberger, Cargill
Chuck Maggi, Cannon Instruments Co.
Marissa Mooney, NuStar Asphalt
Dennis Muncy, Road Science
Kevin Nelson, Seneca Petroleum
Chuck Paugh, ESC Inc./FHWA
Jean-Pascal Planche, WRI
Mark Pooler, WRI
Todd Porter, Cargill
Geoff Rowe, Abatech
Judie Ryan, Wisconsin DOT
Olga Shulga, ICL Performance Products
Guy Sisler, Flint Hills Resources
Tom Snyder, Marathon Petroleum Co.
Suzanne Stauduhar, Cargill
Chris Strack, Sonneborn
Hassan Tabatabaee, Univ. Wisconsin-Mad.
Shaune Tecle Marian, U.S. Oil
Jill Thomas, MN Asphalt Pav't. Assoc.
Laci Tiarks-Martin, PRI Asphalt Tech.
Fred Turner, Western Research Institute
Russell Ulbrich, TA Instruments
Scott Veglahn, Mathy Construction
Raul Velasquez, Univ. Wisconsin-Madison
George Way, RAF
Eric Weaver, FHWA
Haifang Wen, Washington State Univ.
Ludo Zanzotto, Université of Calgary

[Attachment A is the meeting agenda, Attachment B includes a listing of the ETG members, and Attachment C includes a listing of the Binder ETG Task Group members].

DAY 1: Monday, 24 September 2012

1. Call to Order – Gaylon Baumgardner (Paragon Technical Services)
Chairman Baumgardner called the meeting to order at 1:00 PM.

Welcome and Introductions – Chairman Baumgardner welcomed all participants to the meeting. It was noted that two signup sheets are being distributed for logging in attendance; one signup sheet is for the members and the other for friends of the ETG. Also noted copies of the agendas are available. Baumgardner asked all participants making a presentation to give the electronic file to Satish Belagutti prior to their scheduled time so there is no lost time in loading the files. He asked Mike Anderson (Co-Chairman) for additional comments and

then asked for all attendees to introduce themselves. Mike Anderson welcomed everyone to the meeting and thanked all in attendance.

John Bukowski also welcomed all to the meeting, and reported the minutes and agenda were distributed to the members via e-mail prior to the meeting.

2. **Review Agenda/Minutes and Action Items from March 2011 Meeting** – John Bukowski (FHWA); Secretary

Review Agenda – Bukowski reviewed the meeting agenda.

Approval of March 2012 Meeting Minutes – Bukowski noted there were no suggested changes or revisions to the minutes as submitted via e-mail to the members.

Review Action Items – Secretary Bukowski summarized the action items from the March 2012 Asphalt Binder ETG meeting. He stated any member not receiving the minutes from the last meeting to contact him during the meeting. The following is a listing and status of the action items from the March 2012 ETG meeting.

1. **ACTION ITEM #1:** Before the next ETG meeting, Mike Anderson will direct a review of Jnr at 3.2 kPa on neat asphalt binders to determine if and how much the maximum Jnr value should be adjusted. Additional review participants are: John D'Angelo, Gerald Reinke, Geoff Rowe, Gaylon Baumgardner, Chris Abadie and Matt Corrigan.
   UPDATE: Action item is on the agenda.

2. **ACTION ITEM #2:** John D'Angelo will rewrite the wording in TP70 to use 10 cycle conditioning at 0.1 kPa, 10 cycle testing at 0.1 kPa and 10 cycle testing at 3.2 kPa. Report test results for each of the last 10 test cycles and the average of the 10 test cycles at both 0.1 and 3.2 kPa.
   UPDATE: Bukowski summarized this item; specifically related to the number of cycles and mentioned the revised wording that went to the AASHTO SOM 2b technical section.

3. **ACTION ITEM #3:** Mike Anderson and the mixing and compaction task group will continue to work on this issue regarding the two different methods for calculating laboratory mixing and compaction temperatures and report their progress/findings at the next ETG meeting.
   UPDATE: Action item is on the agenda.

4. **ACTION ITEM #4:** Geoff Rowe will report the findings and recommendations on Isothermal Storage of BBR Specimens at the next ETG meeting.
   UPDATE: Action item is on the agenda.

5. **ACTION ITEM #5:** John D'Angelo will edit both M320 and MP19 and submit to Bukowski and Baumgardner. Bukowski will forward to the Subcommittee on Materials, Eileen Sheehy, Technical Section 2b chair.
   UPDATE: Action item is on the agenda, information was sent to the SOM 2b technical section.

6. **ACTION ITEM #6:** Hussain Bahia will edit T 44 (solubility) agreed in the previous ETG meeting. He will submit the edited copy to the SOM 2b technical section. (Bahia will add a statement on the use of filter aid, as described in ASTM D4.)
   UPDATE: Bukowski acknowledged many worked on this item. He reported that the 2b technical section chair, Eileen Sheehy believes that T 44 needed further consideration, so it was not forwarded to the full SOM for ballot. The 2b technical section wanted more information/rationale on this topic to persuade state DOTs this change is warranted.

7. **ACTION ITEM #7:** John D'Angelo will provide a commentary on this topic of using the DSR to grade GTR modified binders and advise the SOM as to the rationale for the recommended changes.
   UPDATE: Action item is on the agenda.

8. **ACTION ITEM #8:** Haifang Wen task group will review the Binder Thermal Cracking Test and make recommendations to the ETG by the next meeting as to the use as a possible alternate test. The task group includes: Haifang Wen, Dave Anderson, Mike Anderson, Geoff Rowe, Ioan Negulescu, Gayle King, and Jean-Pascal Planche.
   UPDATE: Action item is on the agenda.

9. **ACTION ITEM #9:** Bahia will continue with the Linear Amplitude Sweep test (LAST) and DSR ruggedness testing with Anton-Paar, Malvern Instruments, and TA Instruments. All tests are to be performed on samples and procedure provided by Hussain Bahia. The task group includes: Hussain Bahia (UW-Madison), Nelson Gibson (FHWA-Turner Fairbanks), Gerald Reinke (MTE), and Kevin VanFrank (Utah DOT).
   UPDATE: Action item is on the agenda. Bukowski stated everyone should have already received the revised procedure for this test.

10. **ACTION ITEM #10:** Dave Anderson will submit the temperature equilibrium criteria and the excel spreadsheet to Bukowski for distribution to the ETG members. He requested members who have data to submit the requested data to him (one reference fluid and a binder). The analysis of this data will be presented at the next ETG meeting.
    UPDATE: Action item is on the agenda. Bukowski noted a spreadsheet is available for discussion which is on Tuesday's agenda.

11. **ACTION ITEM #11:** Mike Anderson will report on the Intermediate Test Temperature Criteria at the next meeting. Dave Anderson, Geoff Rowe, and Jean-Pascal Planche will prepare a white paper on the testing rational and with Mike Anderson report on the status of this white paper effort.
    UPDATE: Action item is on the agenda.

12. **ACTION ITEM #12:** Gerald Reinke, Mike Anderson, and Gaylon Baumgardner will evaluate the BBR cracking medium effects using air and solvents to investigate the findings reported by Mihai Marasteanu and report those findings to the group at the next ETG meeting.
    UPDATE: Action item is on the agenda.

13. **ACTION ITEM #13:** DSR 4-mm plate rheological testing protocol will be prepared and evaluated by the 4 mm plate DSR task group. The task group will report on their progress at the next ETG meeting. The task group includes: Mike Farrar, Gerald Reinke, Jean-Pascal Planche, Geoff Rowe, Mike Anderson, Steve Salmons, and Dave Anderson.
    UPDATE: Action item is on the agenda.

14. **ACTION ITEM #14:** Dave Anderson will submit a prioritized red line pdf version of the edits from updated test standards to Baumgardner and Bukowski by the end of March for distribution to the ETG members for review and comment. Dave Anderson would like the reviews and any comments to be returned as soon as possible to prepare for submittal to the subcommittee on materials.
    UPDATE: Action item is on the agenda.

John Bukowski asked for questions related to the SOM meeting. Reinke asked what was the problem for the substitution of tolulene in the T44 test. Bukowski thought that item had not been scheduled on the agenda for the 2b tech section. Chris Abadie commented everything passed except for T 44, because the subcommittee assigned to review the changes to AASHTO T 44 did not see the changes prior to the meeting and decided not to act on it. Maria Knake commented that the committee opinion was it would result in a lot of comments and negatives that would have to be resolved.

ACTION ITEM #1: The TP 44 task group will prepare written support and background for the recommended changes to the standard. This includes the rationale for those changes. Bukowski asked Hussain Bahia to put together some additional information on the substitution on the use of toluene.

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

Presentation #1: *Evaluation of Jnr Criteria for Unmodified Asphalt Binder;* Mike Anderson (Asphalt Institute)

Summary of Presentation:

Mike Anderson commented on their cooperative agreement with FHWA that includes this area. He acknowledged the individuals and organizations for helping with these studies. Anderson reported he will discuss two studies in his presentation.

Anderson started by reviewing the evaluation of straight run binders. He thanked John D'Angelo for providing the information on straight run binders. He pointed out the average is slightly higher than the criterion. This was not believed to be an issue until they started their detailed analysis. Anderson showed a summary of the data on results from source A unmodified binders. He identified two items from this data: (1) the difference in the G*/sin delta; and (2) showed some of the Asphalt Institute (AI) MSCR data from the database and identified some small differences.

The data set showed there to be a bias between the two data groups. Anderson then commented on the differences in results between the DSRs. D'Angelo noted; when looking

at this data, you usually do not look at the linear Jnr but use log Jnr. He was unsure what effect that would make. Anderson agreed he needs to go back and re-analyze this data.

Anderson then overviewed the TAC evaluation of SHRP MRL asphalt binders. The task group included seven labs; PRI Asphalt Technologies, Asphalt Technologies Group (Meigs), Jebro, Flint-Hills Resources, MTE, FHWA, and the Asphalt Institute. The labs used different DSR devices. They ended up with 11 DSRs and identified the different types of DSRs. Anderson then showed the PG for the different SHRP binder designations used in the study. He then overviewed the test temperatures and test procedures that were used and explained the process used in this study.

Anderson showed a comparison of the critical temperature determined by TP 70 and T 315 using asphalt "AAA." He noted one data point appears to be an outlier and explained it could be a reporting error. His point was that the critical temperature identified by TP 70 is generally lower than the critical temperature defined by T 315.

The bar charts included in his presentation showed the difference in the DSR devices in terms of the Jnr at 3.2 for the asphalt AAA at the critical temperature. They also determined the G*/sin delta with the same asphalt and pointed out some potential recording errors. He reported they took all of this data including the one data point that might be a recording error and included this in the analysis of comparing G*/sin delta and Jnr.

In summary, Anderson reported their evaluation showed consistently lower than critical temperatures from G*/sin delta. In general, they believe this confirmed the earlier findings. They did not see any evident bias between the different DSR devices, but noted they did not do a statistical analysis of the data – this was just based on his visual comparisons of the data from different DSRs/different manufacturers. He reported that this supports the round robin comparisons that were previously done and this data confirms the similarity of results between the different devices.

Anderson then reported on the different steps that will be considered in the future regarding what their TAC recommended. The Asphalt Institute TAC recommended the MP 19 criterion for Jnr for "S" graded asphalt binders be changed from 4.0 kPa-1 to 4.5 kPa-1. Anderson also noted, however, the TAC does not intend to recommend changes to AASHTO, but rather prefers the recommendation come from the ETG.

He pointed out this is a mathematical exercise so that one becomes equivalent to the other in terms of MP 19 and M 320. This does not affect the binder stiffness of currently produced unmodified asphalt binders. Anderson stated this topic has been discussed in different meetings, and he plans to provide the ETG a report on this study.

ETG Comments, Questions, and Discussion:
Kevin VanFrank asked if the concept is to mathematically adjust the results to match the existing specification or rather suggest changes to the specification. Anderson replied that the idea is to revise M 320 and MP 19.

Bob McGennis asked what the consequence if we remain at 4.0 in MP-19. Mike Anderson replied that you will need slightly stiffer asphalt.

Baumgardner asked Anderson about the differences they saw in Jnr values between the different asphalts. Anderson replied that he would have to look at the spread in data from the MRL binders. Baumgardner said the reason he asked this question is that producing asphalt at the low end seemed to have rutting problems and this is a rutting issue. Anderson commented if we change the criteria, we are not asking for a harder or softer binder. Their interest is seeing MP 19 and M 320 come together. D'Angelo referred back to Baumgardner's question; it is not a matter of softer or harder asphalt but the source of the asphalt. He noted you may see less of a difference for some of the asphalts and believes Anderson will not see the shift difference in his data because it is going to fall a little above or below the line. He notes when you get to the neat asphalt on the extremes you will start to see differences.

Hussain Bahia noted if you look on the area related to modified binders, Wisconsin uses a lot of modified binders to look at the equivalencies. He believes that Jnr was proposed to solve the issue with modified binders. Baumgardner noted we are not talking about modified binders, rather the unmodified binders. He noted this is a binder purchase requirement. Bahia recommended you still need to look at the modified binder to ensure the purchase specification does not change.

Anderson made a comment on the overall premise behind the creation of the MSCR specification – modified binder properties were not being captured properly in the PG specification. The PG system was good for neat asphalt, but for modified asphalts the concept fell apart and that was the reason for going to Jnr. That is also why there was a proliferation of PG+ specifications. Now with MSCR, the Jnr is doing much better for evaluating rutting potential.

Anderson believes they have sufficient data to show that you can connect directly between PG and MSCR by going to 4.5 criteria.

Baumgardner requested Anderson write up the concept and results from this work for the ETG to review which will ultimately go to the SOM for review

ACTION ITEM #2: Mike Anderson will prepare a document on the rationale for changing Jnr to get "S" grade binders. This document will summarize what has been done and what is recommended, which will be submitted to the full ETG for review and comment before the next ETG meeting and possible submission to the SOM for review. Anderson will write up the rationale as a stand-alone procedure for distribution to the ETG for review and comment. This item will be included on the agenda for the next ETG meeting prior to sending it to the SOM.

Presentation #2: *MSCR Recovery: Proposed AASHTO Procedures;* Mike Anderson (Asphalt Institute)

Summary of Presentation:
Mike Anderson distributed information on a procedure to evaluate the delayed elastic behavior of asphalt binders related to the AASHTO standard on the MSCR test. He referred to a table in the proposed standard that provides guidance on selecting test temperature.

The analysis is to determine the Jnr 3.2, and to plot the test data. If the test value is above the line you have a delayed elastic response. He also noted there is an equation for calculating a minimum level of recovery using the equation. He emphasized that these are different ways to obtain the elastic delayed response. Baumgardner added that this effort was done at the request of the SOM. Anderson reported the procedure contains a target value, but there is no quantified evidence this parameter is related to performance. He noted the performance issues really need to be quantified through mixture testing. This is just a way to measure whether there is an elastic delay in the response. He emphasized this is a draft and he is requesting comments from the group.

Anderson noted a copy was distributed to the group but he will send an electronic version to the ETG. The ETG will make comments which will be discussed at the next meeting and whether the final results should be forwarded to the SOM.

ETG Comments, Questions, and Discussion:
Bob Kluttz made a suggestion on cleaning up the intent/purpose for the procedure. Mike Anderson asked Kluttz to participate in the review.

Matt Corrigan asked Anderson to provide some background on how details in the draft were selected for table 1. Anderson replied; the guidance using table 1 was developed based on the climate and materials, and selection of a test temperature. Corrigan commented that even though you are clarifying the selection of test temperature, some users may still try to use an incorrect temperature due to not understanding LTPPBind. Anderson agreed with Corrigan's comment on the confusion, so that is the reason they included table 1 in the draft standard.

D'Angelo reviewed the document and noted that need more emphasis on temperature based on different climates where the binders are used. Some individuals are trying to use the same asphalt in totally different climates – for example trying to use the same binder PG grade in both Chicago and Miami. Anderson agreed with D'Angelo's comment but reiterated; this was to serve as guidance for individuals. He believes there needs to be guidance provided. Sandy Brown asked if the temperature recommendations could be placed on a map. Anderson replied; they do have the map in their guidance document. Karissa Mooney asked; do we want to include something more in the standard to avoid making an error in using the wrong temperature and Anderson agreed.

Beth Griffin asked the source of data and how the actual curve was plotted in the report. Anderson noted that they looked at the available binders in defining an elastic response and a line was drawn just below them. He also referred to some of the modified binders that fell below the line which did not meet the Jnr value. He stated this does not mean that you have a polymer in the asphalt. He asked D'Angelo how does he believe this would apply to GTR modified binder since they are located below the line and suggested adding a caution statement based on elastic polymers and users not be concerned that GTR's may not pass this

criteria. D'Angelo agreed some GTRs have a little less recovery. He also noted you can meet the criteria with higher rubber contents – with lower amounts you might not meet the criteria.

Baumgardner noted that there are three volunteers for this effort to make revisions to the standard – Bob Kluttz, Matt Corrigan and Gerald Reinke. It will be submitted prior to the next meeting.

ACTION ITEM #3: Mike Anderson will submit to the ETG a pdf version of the MSCR recovery standard for evaluating the delayed elastic behavior of asphalt binders. All comments from the ETG will be discussed at the next meeting. Mike Anderson, Bob Kluttz, Gerald Reinke and Matt Corrigan will review the revisions prior to its submittal to the ETG.

4. **Task Group Recommendations; Binder Thermal Cracking Test**—Haifang Wen (Washington State University)

Presentation Title: *Updates on DSR Thermal Cracking Test*

Summary of Report/Presentation:
Haifang Wen acknowledged the task group members: Mike Anderson, Dave Anderson, Gayle King, Ioan Negulescu, Jean-Pascal Planche, and Geoff Rowe. Wen then provided some background on the topic. He overviewed the laboratory characterization and the test protocol used to evaluate selected binder properties. He explained why the 5^{o}C was selected. He stated below 5^{o}C, the DSR will probably not be able to break the specimen.

Wen showed some results for the original binders used in terms of failure strains versus transverse cracking. He then overviewed the development of the draft test protocol and explained the test. He noted the break was not always a fracture in the specimen but a failure with the bond between the specimen and plate. To eliminate this effect an epoxy was placed on the plate and then zeroed out the gap on the plate. He noted there is never a zero gap but close to zero. The rod is lifted to place the specimen on the plate, so they are using the epoxy to bond the specimen to the plate. There were no bond failures after this change. Wen then described the draft protocol, which has yet to be submitted to the ETG.

Wen reported they changed the diameter to 4 mm so that the specimen would fail under loading. He described the process for mounting the sample, for placing the epoxy, zeroing the gap and lifting the rod for placing the specimen on the plate. Set the temperature to 5^{o}C and give the epoxy time to cure prior to testing. The other issue was related to compliance and this was one item they did not address. He reported the failure strains are relatively high, so the compliance is much less than the failure strain so it might not be a problem. He asked Mike Farrar about the compliance issue or error from the equipment. Farrar noted below 0^{o}C the equipment can have a significant effect on the results. Wen again noted that the machine compliance is relatively small compared to the failure strain.

Wen then discussed the impact of the epoxy on the results between the frequency and shear modulus of the material. He noted there was no impact on the test results. Wen then asked

Ioan Negulescu to discuss the samples tested at LSU. Negulescu replied they did the analysis and reported the correlations were very good between the failure strains or stiffness and asphalt properties. He noted he was unaware of the addition of polymers in one of the samples but the chemical analysis identified the one with the polymers and it correlated well with the failure strains and stiffness.

Wen then referred to the potential use of this test to evaluate block cracking and referred to Geoff Rowe's work.

ETG Comments, Questions, and Discussion:
Gayle King asked about using epoxy and not being able to reuse the plates. Wen noted it is difficult to remove the epoxy but it can be done so the plates can be reused. Mihai Marasteanu asked about using the DSR for fracture. He noted there may be some limitations on using the DSR to define fracture of the specimens, so he would like to see more background on other materials where the DSR has been used to define failure or fracture. Wen replied they have some information, but it is not extensive.

Ron Glaser asked if he understands that this is a method to define the failure strain at lower temperatures but was wondering once you obtain the results at 5^{o}C and get the failure point at different temperatures, how do you shift the data to get the failure point at -20^{o}C. Wen acknowledged that would not be possible. At extremely low temperatures you cannot use the DSR. Glaser realized you cannot do the testing at really low temperatures, but you can use the procedure at two temperatures and estimate the shift function to determine the critical cracking temperatures at somewhat lower values. He suggested using a slightly warmer temperature and extrapolate to moderately lower temperatures. Geoff Rowe noted this was discussed at the last meeting and referred to his work on roofing asphalt. He went through the process he used at the last meeting to minimize the error and isotherms and how to do a conversion to calculate the relaxation stress.

Dave Anderson, referring to fracture mechanics, noted that the results of this test are only valid for the one loading rate and one temperature. Once you go beyond those values it is invalid. Ludo Zanzotto commented that they did work many years ago and this approach simply will not work when you are extrapolating beyond 20 degrees.

ACTION ITEM #4: The binder thermal cracking task group will review the testing protocol presented by Haifang Wen. Wen will submit it to the task group for review, which will be discussed at the next meeting.

5. **Update of Cooling Medium Effects on BBR Results**—Mihai Marasteanu (University of Minnesota)

Presentation Title: *Cooling Medium Effect on Asphalt Materials Bending Strength at Low Temperature*

Summary of Presentation:

Mihai Marasteanu acknowledged the individuals involved in this work and noted this is part of an NCHRP IDEA study. He thanked the ETG for giving him time to present this topic on low temperature cracking. He reported the main idea was to derive simple test equipment to measure the creep stiffness and strength of the binder in one protocol. He noted they have done considerable binder testing, and realized that some idea of the mix strength is also needed when you start talking about stiffness values. Marasteanu reported they have worked with Cannon Instruments in building a device to measure with different loading patterns – both creep and recovery. However emphasized they have not yet used different loading patterns.

Marasteanu then overviewed the new testing device; the "BBR Pro". This is a strain controlled test because of how the machine was designed. He overviewed some of their preliminary work on binder strengths, the concept and calculations.

Marasteanu reported they started seeing differences between the BBR and DDT in terms of strength values. There can be many reasons for these differences (i.e.; specimen geometry and state of stress in the specimen) causing failure differences between the BBR and DDT. They used different equations to account for this and converted the BBR strength into a DDT strength. He noted the conversion did not yield the expected results and in fact showed greater differences rather than smaller differences between the two test methods specimen geometries.

Marasteanu reported they measured the BBR strength in potassium acetate and in ethanol and found the differences were reduced. He referred to D'Angelo and Dongre's work in this area related to Jnr and other properties. Based on that work, they started testing in three media including air, potassium acetate, and ethanol. He reported testing in air requires the use of a small fan for efficiency. Marasteanu showed test results from all three media in terms of strain versus stress. They have performed considerable testing and completed a statistical analysis of the data. They found the cooling medium does make a difference, and cooling in air also takes a lot more time.

The next item reviewed was the BBR size effect analysis and the cooling medium effect on the creep properties. From the analysis, Marasteanu noted there is a clear dominance in terms of strength with ethanol use the largest difference. For the creep differences, however, they saw much less affect and more work is needed to determine what impact the cooling medium makes on the results.

The next item discussed was related to using the BBR to estimate the mixture strength. Marasteanu reported they did not see the dramatic differences observed for the binder.

Marasteanu overviewed the conclusions from the work obtained thus far:

- A new testing method to determine the flexural strength of asphalt binder using a new BBR device was developed.
- The BBR strength values were compared with the strength values measured in the DTT.
- DTT binder strength much higher than BBR binder strength.

- Cooling medium has a significant influence on asphalt binder strength.
- BBR tests performed in ethanol result in lower strength values.
- BBR strength results in potassium acetate and air are comparable.
- Asphalt mixture strength measurements are also cooling medium dependent, but the effect is less severe.
- Asphalt binder creep tests are affected by cooling medium resulting in higher stiffness when air is used.
- Asphalt mixture creep results are not affected by cooling medium.

Conditioning and testing specimens in air appears to be the most convenient solution since it is more representative of field conditions. Asphalt binders, however, are highly temperature susceptible materials and rigorous temperature control is needed. Therefore a very good cooling system in air is required.

ETG Comments, Questions, and Discussion:
John D'Angelo commented that ethanol was probably setting up in the boundary conditions of the specimen for measuring strength. He noted they compared the air and potassium acetate and got good results so they moved away from the ethanol. The relationship between "s" and "m" are not always reliable indicators, but when using the tensile strength test at lower temperatures we see large differences. For some reason, however, it is not reflected in results from the BBR device and we need to try different approaches.

Bob Kluttz asked Marasteanu to refer back to the strength curves and noted there appears to be a lot of scatter in the data and attributed the scatter to the specimen or sample preparation rather than from the air. Kluttz noted this is getting closer to what the Europeans are doing in terms of strain control.

Reinke asked why run at a temperature of -24^{o}C and -18^{o}C rather than at the standard temperatures. Marasteanu replied; they did run at the standard temperatures as well as the other temperatures. Reinke asked about these test results. Marasteanu replied they were very similar to what was shown in his presentation. He agreed to send Reinke the results. Reinke asked that the report be sent to the entire ETG. Baumgardner asked if Marasteanu was ready to distribute to the ETG the results for further recommendations. Marasteanu would first like to look in more detail at the creep results, but still believes the medium is the main cause for test result differences.

Baumgardner asked for a report back at the next meeting and report on the analysis done from these different tests.

6. Update on Isothermal Storage of BBR Specimens—Geofff Rowe (Abatech)

There was a brief verbal report given by Geoff Rowe. He reported they have not done as much as they should have by this time, and will continue with the analyses for the next meeting.

7. Lab Mixing and Compaction Temperatures Task Group Activities—Mike Anderson (Asphalt Institute)

Presentation Title: *Laboratory Mixing and Compaction Temperatures for Asphalt Binders*

Summary of Presentation:
Mike Anderson acknowledged the task group members: Andrew Hanz, Hussain Bahia, Gerald Reinke, Karissa Mooney, Edgard Hitti, and Frank Fee. He reported that while he had been the task group lead, Andrew Hanz will be taking the lead in the future. Anderson will continue to serve as a member.

Anderson overviewed the task group objective: to review the procedures available for determining laboratory mixing and compaction temperatures and recommend appropriate wording to be used in Note 4 and Sections 8.2.1 and 8.7.1 of AASHTO T312, *Preparing and Determining the Density of Hot-Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor*. He reported on activities under this task group. This included a meeting at UW-Madison on May 23, 2012. The attendees included: Gerald Reinke, Hussain Bahia, and Andrew Hanz. The discussion was on efforts in determining lab mixing and compaction temperatures for modified asphalt binders. The other activity was on preparing the Asphalt Institute guidance document on *Determination of Laboratory Mixing and Compaction Temperatures for HMA*. Anderson reviewed the guidance document is terms of the equiviscous ranges using the rotational viscosity at two temperatures (135^{o} and 165^{o}C) or rotational viscosity at one temperature (135^{o}C) and the original G*/sin delta at one temperature. The guidance document for modified binders follows the NCHRP project 9-39 procedure.

Anderson then overviewed the other lab mixing and compaction temperature procedures that are currently available, including: the NCHRP project 9-10, thin film rheology, and mixture workability procedures. He also mentioned Raj Dongre has used a procedure based on this technique.

Anderson questioned how significant really are the effects based on the selection of lab mixing and compaction temperature under these procedures. How accurate do we really need to be in selecting lab mixing and compaction temperatures.

Anderson overviewed their expected results from this study. Mixing and compaction temperatures determined from the equiviscous procedure will be significantly higher than the temperatures determined from the NCHRP project 9-39 procedures. This will result in significant changes to the physical properties of the binder and mixture. The finding can be used to recommend to user agencies that the NCHRP project 9-39 procedure be used for determining the mixing and compaction temperatures of modified asphalt mixtures.

However, Anderson noted this was a limited study and there were parameters like absorption that were not included in the experiment. He reviewed details and the parameters included in the experiment, and defined very broad ranges of each parameter to just fill in the

experiment. He presented the sampling template used for the experiment. He also reviewed the variables considered for the compaction temperature which included three items: no aging, immediate compaction after sample preparation, and 2 hours of aging at a lower mixing temperature. The measured responses included the maximum specific gravity, volumetric properties, and dynamic modulus measured at 20^{o}C. The recovered binder included a continuous grading at the high and low temperatures, as well as running the Linear Amplitude Sweep test at 20^{o}C and MSCR test at 64^{o}C.

Anderson reported the testing has been completed for all of the cells presented, but the data analysis has yet to be completed. He will report on some of the data analysis completed to date. He started with the effect of aging time on G*/sin delta. The results in terms of aging and of no aging did not result in anything unexpected. Then looked at the effect of mixing temperature on G*/sin delta. An effect was noted, but not as large as from the aging time. Anderson showed results from the high temperature grade first and then on the low temperature side using the BBR stiffness for a PG64-22. Anderson showed some of the results for the mixture using air voids and dynamic modulus. He reported mixing temperature did not matter as much as some other parameters that are more important. Anderson noted the amount of conditioning over powered any difference in mixture temperature.

Anderson provided a summary of the overall results: air voids are not significantly affected by mixing and compaction temperatures but are affected by the conditioning; the dynamic modulus at 20^{o}C is affected by the 2 hours of the conditioning temperature. When specimens are conditioned for 4 hours E* was not significantly affected for two of the three asphalt binders. They are continuing the effort in terms of evaluating binder properties of two asphalts using the LAS test and reported that a paper was submitted for the 2013 AAPT meeting.

ETG Questions, Comments, and Discussion:
John D'Angelo commented that there are two things that you must look at: (1) a PG76 -22 is not necessarily a PG76-22 from all crude sources, and (2) you need to consider the properties you are looking at which do not include E* but rather the Semi-Circular Bend test and others. These will tell you more differences in fracture properties in terms of the aging. Anderson agreed and commented they want to look at other properties, but their main focus was on what happens to the binder using the volumetric properties.

Frank Fee asked about the absorption for the aggregates and type of mixer used in the effort. Anderson noted absorption was less than 1.5 percent and a large Hobart mixer was used. Reinke commented that 0.5 percent voids is significant when doing mix design and selecting a target asphalt content. Anderson agreed with the comment.

Marasteanu asked if these mixtures included RAP. Anderson replied none of the mixes contained RAP.

Anderson summarized that this is an effort to quantify how much difference can exist in terms of the volumetric properties between the various approaches.

Frank Fee noted aging matter greatly and will make a difference, so he questions when is there an effect due to aging, as related to the other properties and when will it be absorption dependent. He suggests the study needs to define the volumetric properties. McGennis noted however that original scope was only asphalt content, but now we are looking at other properties.

Gayle King noted that we are still trying to get at the right mixing and compaction temperatures and there is a difference between the lab and field for polymer modified mixtures. His opinion is we need to get the temperatures right and they need to be close to those to be used in the field. How do we do that? Reinke suggested set the lab temperature at 165^{o}C which should work, but we have to provide that temperature to the mixing plant and we still need to give the rational for selecting a temperature for the field in comparison to what is done in the lab. Fee suggested using the information published by NAPA. Anderson noted there is a procedure in T 312 but is not correct for modified asphalt. Bahia commented that a high enough mixing temperature is needed to coat the aggregate. This data, temperature for coating the aggregate, exists and is important in terms of the bond strength and moisture damage potential.

Bukowski summarized the issues and noted we have to define some range of temperatures. He believes we still need to provide guidance even if we cannot get it down to one unique number. Anderson agreed with Bukowski's comment and believes that the task group can eventually provide that information.

Baumgardner adjourned the meeting for day 1 at 5:00 pm.

DAY 2: Tuesday, 25 September 2012

Call to Order – Chairman Baumgardner called the meeting to order at 8:00 am.

8. **Overview of Rheological Models for Asphalt Binders—**Dave Anderson (Consultant) and Geoff Rowe (Abatech)

Presentation Title #1: *Overview of Models that Describe the Rheological Behavior of Asphalt Binders* – White Paper Status

Presentation Summary:
Dave Anderson started his presentation with the origin of rheology and defined rheology as the science of the deformation and flow of matter and describes the interrelation between force, deformation and time. The mathematical process/model can take many different forms for different types of materials. He also noted you can talk about empirical rheology or fundamental rheology, and defined a rheological model – an explicit mathematical expression that relates stress-strain behavior to time and temperature. There are three important parameters included in the model – time, temperature, and deformation (or the interrelationship between force and deformation and time), which is a three dimensional model and not a two dimensional model. He also emphasized we are talking about liquids. Anderson then identified the basic assumption of the model: the material has a linear stress-

strain response or is linear viscoelastic. In other words, behavior must be linear viscoelastic to generate a model to describe time-temperature functionality. Boltzmann superposition principle is valid and the material is thermorheologically simple. He noted results should have a good relationship between G* and phase angle, and if there is a lot of scatter, then the material is not thermorheologically simple.

The next item discussed was the definition of model parameters, which are coefficients that define the model. He noted we need to distinguish between modeled and derived parameters. He stated the master curve properties are based on fundamental properties which are point properties. Anderson noted we do not measure stress – we measure load or force and area and calculate stress. The same point is true for strain – we measure length and deformation. There is no such thing as a measured stress or strain.

Anderson pointed out we need rheological models to help relate binder properties to the pavement. He cautioned about extrapolating with rheological models – they should only be used for interpolations and to describe the type/shape of the behavior. Anderson then summarized his comments, in that master curve parameters provide a bridge to chemical composition and a tie between rheology and pavement performance; provide interpolation/extrapolation to time-temperature where testing is not performed; and models are used to describe the shape of the master curve and its temperature dependency.

Anderson noted that the application of rheology to asphalt cement specifications is not new. Some rheological measurements were used in historical specifications. Anderson then overviewed some of the earlier simple rheological models and their benefits. He discussed the Fraass test, which is an example of an empirical rheology model.

He reviewed the eight models based on fundamental properties: Jongepier and Kuilman's model; Dobson's model; Dickinson and Witt's model; Christensen and Anderson's (CA) model; Fractional model; Christensen-Anderson-Marasteanu (CAM) model; Polynomial model; and the Power law model. Other models are sigmoidal in shape and apply to mixtures. He only wanted to address the parabolic models, and he then focused on selected models.

Anderson explained the CA model is a result of an evolution process. It was originally envisioned as a basis for specification development and recognizes the long-term consideration by others of the importance of "temperature susceptibility." The CA model gave an explicit description of time dependency and the temperature dependency is explained the Arrhenius function. Anderson then showed the pen-vis relationship and acknowledged Vyt Puzinauskas work and understanding of the master curve. Anderson reported the master curve was built into the pen-vis relationship – although it is very simple. Anderson then overviewed the derivation of the CA model or the basis of the derivation. Anderson noted you need to describe the relaxation modulus and noted all of these models are based on statistics. He described and illustrated the relaxation modulus in terms of probability. He noted and defined a few quick measurements that can be used to describe the CA model.

Anderson then moved onto the time-temperature superposition principle and noted the shift function changes over time because of physical hardening which changes the shift functions.

He stated one needs to measure above and below the glass-transition temperature. Anderson also noted the rheological concept was too radical for specification use during the SHRP work. Consequently work was directed to relate each specification criteria to a failure mode. The net result was morphed into the G*/sin delta which was related to rutting at high temperatures, G* times sin delta which was related to fatigue cracking, and the S related to a single event thermal cracking.

Anderson then explained the post-SHRP work related to the extension of the CA model. He noted the CA model works well from 40^{o} to 70^{o}C but does not work well as the phase angle approaches 90^{o}C. To improve on the accuracy, the CA model was modified by the introduction of a fourth term which extends the model to longer loading times. The modified model is referred to as the CAM model (Christensen-Anderson-Marasteanu). The CAM model works well with non-modified binders over a wide range of temperatures.

Anderson then discussed some of the model specifics based on mechanical analogues relaxation spectra/prony series. This model uses a series of springs and dashpots to describe the shape of the master curve. As with CA-CAM model, it is a "fitting exercise." However, it yields data that can be used in powerful computational techniques.

In summary, rheological behavior has been a part of asphalt binder technology for more than 100 years. In addition, rheology models may be empirical or fundamental. Empirical models are limited in their value and prior to the 1980's, the test and analytical devices were based on limited measurement and analyses. Rheological models are confined to linear behavior based on measurements of point properties that are based on calculated stresses and strains. Careful attention to measurement techniques is essential for robust model development. Point measurements characterize the behavior at a characteristic time and temperature. The model is needed to interpolate to intermediate times and temperatures.

ETG Comments, Questions, and Discussion:
Baumgardner asked if Anderson needed help on preparing and finalizing the paper on this subject. Anderson replied he is committed to preparing the white paper and sending it to Delmar Salomon for further comment. He believes it is progressing. Rowe, Mike Anderson, and Marasteanu offered assistance as needed in preparing the white paper.

Bob Kluttz believes this will be a much need document. There was some debate on using higher strains levels in terms of transforming creep data into viscoelastic behavior.

9. Intermediate Temperature Task Group Activities—Mike Anderson (Asphalt Institute)

Presentation Title: *Intermediate Temperature Parameter for PG Asphalt Binders*

Summary of Presentation:
Mike Anderson acknowledged the task group members that are working on this topic: Dave Anderson, Hussain Bahia, Gaylon Baumgardner, Gayle King, Bob McGennis, Jean-Pascal Planche, Gerald Reinke, and Geoff Rowe.

Mike Anderson stated the purpose of the task group to evaluate the existing intermediate temperature parameter and criterion in AASHTO M 320 and MP 19, and if necessary, revise and/or develop one or more parameters that do not require significantly more testing than the current intermediate temperature parameter determined using T 315, have reproducibility at least comparable to but preferably better than the d2s% values for the current intermediate temperature parameter, and are related to the rheological and failure properties of the asphalt binder at intermediate temperature.

He noted they are not suggesting G* sin delta be replaced or changed, they are looking into if it only needs to be changed for the intermediate temperatures. He emphasized they are not going to replace a test that takes 20 minutes to run with 2 to 3 tests that take a day and a half to run.

It has been suggested that the asphalt binders being produced today may be different enough from the SHRP binders that the G*sin delta parameter and/or criterion for intermediate temperature may not be applicable. Anderson noted they have separated these materials into three groups: (1) old conventional binders or the SHRP MRL binders, (2) new conventional binders that represent current production, and (3) new unconventional binders formulated by Bob McGennis to represent unusual intermediate temperature responses compared to new conventional binders.

Anderson overviewed each of the categories starting with the old conventional binders that were used in developing the current PAV-DSR parameter.

The next review was on new conventional binders that represent current production. Anderson mentioned doing some screening tests but those have yet to be determined. He showed the testing matrix that is being used to fill all of the cells in the matrix. He also noted Bob McGennis is blending many of these for the screening tests, and if selected, he will blend much larger quantities for the sampling matrix. Anderson reiterated the intent of the new unconventional binders was to see if they have unusual responses. When this matrix was put together, a requirement was the binder needs to represent commercially available binders.

Anderson then went through the new unconventional binder testing that is planned: targeting 1.2kPa at 64^{o}C and testing as PG 64-22, and the MSCR. He reiterated, the purpose is to evaluate “new unconventional” binders and to determine which to include in the complete testing program. Anderson reported the planned testing is not an all inclusive program. He noted they might eliminate some of these and add others over time. Right now the testing program includes: aging with PAV and possible PAV40, chemical analysis, DSC (Planche will do the testing), and BBR (continuous grade determination by AI). DSR testing uses a series of test and equipment and loading shapes. He noted; the intent is to look at the spectrum of tests and select the ones that we will be going forward.

Anderson then reviewed the next steps, which include: analyze and collate data on “old conventional” binders using new proposed tests; obtain remainder of “new conventional” binders using split samples and conduct aging prior to shipping to labs for testing; and complete testing on “new unconventional” binders and select subset of binders for complete evaluation. Ioan Negulescu volunteered to do some of the aging and testing of the binders.

ETG Comments, Questions, and Discussion:
Bob Kluttz recommended some hard asphalt be considered.

Marasteanu asked about the shape of the master curve and temperature dependency of the relationship. Dave Anderson commented if one only controls the high and low temperature stiffness and not the intermediate temperature, this would be a mistake. Dave Anderson believes we may need two parameters at the intermediate temperature. Dave Anderson noted when the m-value was introduced in the specification; he was encouraged because it controlled the shape. Rowe commented there will be an extensive data set to do a lot of analysis and understand where all of this fits together. Reinke noted that we need a parameter to anchor the master curve in the middle and does not understand why we do not check the mixture tests to understand the fatigue properties.

10. Low Temperature Ductility of Polymer Modified Asphalt—Beth Griffin (DuPont Company) and Hussain Bahia (University of Wisconsin at Madison)

This presentation/report on this topic was not included on the agenda.

Presentation #1: *Introduction—Low Temperature Ductility and Performance—* Beth Griffin (DuPont Company)

Summary of Presentation:
Beth Griffin gave the background on this topic, and defined low temperature ductility in terms of getting a better understanding of it as it relates to Evaloy. She reported from the AAPT Tampa meeting; there is little to no valid information relating low temperature ductility to performance of polymer modified asphalt.

Griffin reported the results from the ductility test do not rank the polymer modified asphalts as they do for other asphalts. She reviewed some of the literature on this topic, and noted polymer property measurements depend on the test conditions. She reported the request was made to research the low temperature ductility test for better understanding of properties measured versus other fatigue and rutting properties for polymer modified binders; with the objective – explain the relevance of the test for PMA. Griffin then turned the presentation over to Hussain Bahia to explain the data collected.

Presentation #2: *Evaluation of Ductility as a Performance Indicator—*Hussain Bahia (University of Wisconsin at Madison)

Summary of Presentation:
Bahia summarized the literature reviewed on ductility and acknowledged the individuals that have worked on this topic: Cristian Clopotel, Amir Arshadi, and Hassan Tabatabaee. A summary from the literature review showed that in a number of older studies some correlation was seen between ductility and performance and ductility and aging, but there are conflicting results in that there is no clear analysis of the fundamental meaning of ductility. More importantly, most studies have focused on neat asphalt, and the loading and sample geometry of the ductility test lead to significant shortcomings.

Bahia noted they started with a simple analytical and numerical analysis of the test, but also used finite element analysis to simulate the test and determine what is going on in the specimen in terms of non-uniform stress-strain values. He explained the results from this analysis by looking at the elongation versus strain values to show it is very non-uniform. He identified the time component in the test in terms of changing the strain rate of the test over time. Specifically, at constant crosshead speed engineering strain rate is constant but true strain rate varies significantly.

He reported they tried to control the strain rate because the viscoelastic material properties are strain-rate dependent. Bahia showed the results from the finite element study on the effect of the strain rate. The stress rate in the ductility bath varies non-linearity with elongation in the ductility bath. He also emphasized; there is an affect from the geometry of the test specimen. He then presented some correlations with other performance tests but none of the correlations were good. Bahia then reported on previous work using the DSR-ductility test. Using the DSR you can see the difference in the effect of modified asphalts and the polymers have superior performance to neat asphalt. Bahia suggested ductility be used, but it needs to be measured in the right way, using the DSR.

Bahia then showed more of their data using the DSR in comparison to the ductility bath test. He reported some materials failed in the ductility bath test but were found to be good using the DSR. The strain-rate needs to be consistent and not vary throughout the tests. Bahia summarized that for neat asphalts the results from both tests are in agreement, but the ductility bath test can result in bias.

Bahia conclusions; the current ductility bath test has major mechanical and fundamental shortcomings; the ductility results do not correlate with proven binder performance tests; and the DSR ductility simulation results show very different results from conventional ductility. The bottom line is the current ductility test cannot reliably reflect binder performance in pavement, there are more fundamental properties for assessment of binder performance than the ductility, and if ductility is needed, the DSR method is preferred.

Bahia stated this is not a new topic, and reported there already is an AASHTO standard for this test – named Yield Energy of Asphalt Binders Using the Dynamic Shear Rheometer. This standard was proposed in 2009. The issue is very simple – the ductility bath test does not provide fundamental properties but the DSR can provide those properties.

<u>ETG Comments, Questions, and Discussion:</u>
Bob McGennis asked about section 1.1 as a specification material or parameter – would this apply to emulsions. Bahia referred to a prior NCHRP project. Reinke noted that he looked at Jnr for emulsions and one can get percent recovery using the Jnr but you are not dealing with RTFO aging, however you get the same answer. Reinke also noted they are trying to get Jnr in terms of percent recovery to more forward and adopt Jnr. If we now try to move this concept forward, his concern is that we will lose the focus in getting the Jnr test adopted. Bahia replied that he does not want to distract from getting Jnr accepted, but his opinion is the ductility bath test is not controlling the strain rate and is the wrong test. Reinke agreed with Bahia's opinion but stated we have not convinced individuals the current test is not

related to performance, so the test still remains in use. Bahia commented that there is sufficient evidence the existing ductility approach is wrong. He believes relating the ductility test to performance is wrong.

Ludo Zanzotto commented that he found ductility does not describe performance. He would not put ductility in the specification but believes that users will still want to keep the test. Bahia commented that he is not asking for the ductility to be thrown out, but be run correctly using the DSR.

Gayle King noted we need to teach the Jnr but the elastic recovery cannot be separated out at the low temperatures. He supports Bahia's recommendation. He discussed the two parameters relating to fatigue and aging. Ductility and LAS results do not agree and are not related to one another – they are two different tests and we need both. Bahia acknowledged many states are using ductility but that does not mean it is a good test. In his opinion we need to move away from these type ductility tests.

Reinke referred to the elasticity part in terms of Jnr, and noted you can run the test at any temperature you want, so we have a test that will give us a surrogate of elastic recovery.

Reinke asked Chris Abadie about their using the forced ductility test. Abadie replied they use it on original asphalt as well as modified asphalt. He replied he believes it has potential and could be used for the original asphalt as well as for emulsions. He does not believe they would use it for modified asphalt.

D'Angelo asked what limits are envisioned for the specification. Bahia answered that the agencies will have to set the limits based on comparing asphalts that perform well to those that do not. He does not yet have the recommended values.

Karissa Mooney asked if cure time or the networking of the molecules have been used to show how the material gains strength over time. Bahia noted that is in report from the ARC study and agreed with her comment that you can see the networking of molecules.

Baumgardner suggested an action item from this discussion, but it is unclear how this will be used. Bahia suggested a protocol for running the test for agencies that want to use it is needed.

ACTION ITEM #5: Hussain Bahia will prepare a test protocol for the DSR yield energy test for submittal to the intermediate temperature task group for evaluation.

11. Linear Amplitude Sweep Test Task Group

Presentation Title #1: *Review of ALF Binder Fatigue Data using the Linear Amplitude Sweep Tests* – Hussain Bahia (University of Wisconsin at Madison)

Summary of Presentation:

Hussain Bahia discussed two tests, one for frequency sweep and the other for the damage resistance using the amplitude sweep test. The first test on the frequency sweep (rheology) provides the slope or B-value and the second one or damage test provides the VECD – the A parameter. Bahia acknowledged the data were provided by Nelson Gibson at FHWA.

Bahia showed data to define the issue, and presented examples of good and poor quality data. Bahia reported his team looked at the sample preparation procedure to explain the reason for the poor and good quality data. He reported the difference is not related to the hardness or aging of the binder but is related to sample preparation. His opinion is that sample preparation and conditioning are two items that need to be improved to get more consistent data.

Bahia described the damage mechanism in terms of what is happening in the specimen. They used an image analysis to determine crack length which is not debonding or delamination as reported by some for this test. Bahia noted this is a legitimate failure of the material.

He explained, some of the binder samples showed unreasonable results in the amplitude sweep test because of delamination. Bahia noted they looked at a solution for the delamination issue. This has to do with reheating or going to a higher temperature, resulting in more repeatable data. He overviewed the procedure that has been used to eliminate this issue. In accordance with AASHTO T 315 provisions, it is suggested that spindle and plate temperature be raised to 64^{o}C or higher before insertion of the asphalt sample to ensure sufficient adhesion is achieved. In addition, a simpler strain ramping method could minimize the delamination problem.

The next item reviewed was the effect of aging on fatigue life. Bahia noted the relationship to the mix, aging, and where used in the pavement structure. For thicker pavement structures, aging can help you, but for thin structures with more deformation, aging can be detrimental. This has to do with the slope of the relationship due to aging. Bahia referred to a visiting professor from Brazil, Thais Pamplona, who is doing fatigue work to confirm this observation from the ALF sections that have a constant thickness. In summary, aging appears to improve binder fatigue resistance at low strain levels but deteriorates fatigue resistance at high strain levels. These changes in resistance to fatigue are highly asphalt specific; for some binders the changes are less than for others. Bahia acknowledged all of the members involved in the study and work: ARC, FHWA, and WRI.

Presentation Title #2: *Review of LAS Ruggedness Testing Changes* – Hassan Tabatabaee (University of Wisconsin at Madison)

Summary of Presentation:
Hassan Tabatabaee discussed the LAS testing ruggedness results and identified the issues and proposed changes to the draft practice. ETG members were sent the revised test standard for this test prior to the meeting. Tabatabaee then overviewed the ruggedness test program and listed the factors included in the study: test temperature (two levels), sample placement method (two procedures), number of frequencies used in the frequency sweep, range of frequencies, strain during frequency sweep, strain sequence during amplitude sweep, and number of loading cycles per strain step.

Tabatabaee summarized the ruggedness test results and listed the p-value for parameters A and B, and identified the factors found to be significant: sample placement, range of frequencies, frequency strain sweep, and strain sequence. He also discussed the issues identified from previous use of the test. He noted, based on results from the ruggedness test and feedback from ETG users, the following issues were identified: delamination of stiff binders from the spindle plates; difficulty for achieving target step strain sequence for some standard rheometers; edge fracture, and the definition of failure criteria. Tabatabaee discussed each issue and summarized the results for each issue.

- Delamination - The cause is insufficient adhesion between the asphalt and metal plate for highly stiff binders. The usual application temperature of 40^{o}C is too low for severely aged materials or highly modified binders. The solution for this issue was to increase the plate temperature during application to achieve adhesion. A note should be added to the AASHTO TP 101 procedure for allowing the temperature to be increased to 64^{o}C and higher.
- Achieving the target strain - The cause is that some standard rheometers have difficulty handling sudden strain amplitude jumps in the test. He presented examples of the target value and the value imposed by the rheometers. He mentioned the research grade rheometers get very close to the target load, but for other rheometers the results applied can be significantly different from the target value. The solution was to use continuous ramping of strain amplitude. This results in the same total test time of 310 seconds, the same number of total loading cycles, and same strain rate. He showed that the simpler method results in the same responses or measurements.
- Edge fracture - The edge fracture is due to fatigue which is the purpose of the test. Asphalt edge fracture is similar to observations in other materials under cyclic fatigue loading. Tabatabaee explained the binders were evaluated using rotation controlled time sweeps. The reductions in torque were compared with the measured crack lengths that were defined by using paint around the specimen using an imaging process. The image analysis was used to determine crack length and propagation through the specimen. The drop in the modulus during the test was proportional to the reduction in area of the specimen as caused by crack propagation.
- Failure criteria - Tabatabaee noted that they are keeping the A and B parameters but adding a failure index. The failure index is the rate of crack propagation versus crack length. Initially the rate of crack propagation was very slow but there is a point in the test that the crack propagation significantly increases and that point is defined as failure. This is being proposed as an optional value from the test. Tabatabaee reported similar rankings using N_f or the parameter A and the failure index.

He then reported on the repeatability of the test. Tabatabaee showed the coefficient of variation (COV) for different asphalts and compared the COV from the continuous and step methods. The continuous method results in better repeatability or lower COV values. Tabatabaee summarized the results from the ruggedness study. The issues were identified by ruggedness testing and user feedback and those were addressed through modification of the procedure. The proposed modifications to the LAS test included continuous rather than step oscillatory strain sweep, and use of fracture based index for ranking relative “damage

tolerance" of asphalt binders. Tabatabaee ended his report by acknowledging the sponsors for this work (ARC, FHWA, and WRI), and thanked others that were involved in the study: Raul Velasquez, Amir Arshadi, and Thais Pamplona.

ETG Comments, Questions, and Discussion:
Gaylon Baumgardner asked the ETG to review the changes and provide comments prior to the next meeting. This will be included on the agenda for review at the next meeting.

D'Angelo asked about the differences related to aging and whether the test should be run on PAV or other aged materials. He noted that from the data it appears as if you have to go to PAV aging. Tabatabaee replied that more work will be done to describe the procedure and how this will be done. Baumgardner asked D'Angelo to put his comments in writing during his review of the document.

ACTION ITEM #6: The ETG will review the recent TP 101 revisions and considerations given to forward to SOM after the spring ETG meeting.

12. Update on the Double Edge Notched Tension Test (DENT)

Presentation Title #1: *Fall 2012 DENT Updates*—Nelson Gibson (FHWA)

Presentation Summary:
Nelson Gibson explained the testing process of the DENT. The important point of the test is that it uses notched samples and the notches get more severe under load. He again presented the results from the DENT evaluated in the FHWA accelerated load facility (ALF) report. The report is available at: http://www.pooledfund.org/Document/Downloaded/3065.

The MTO inter-laboratory study was just completed so he does not have any results to report at this time. He again showed the ranking of different binders included in the study using DENT. He explained that the test is run at one temperature and one elongation rate. He also showed a tabular matrix of all binders tested and pointed out one binder does not always fail at the low or high levels. D'Angelo noted that without equiviscous temperature you cannot tell which one is better. Gibson reported that they have the equiviscous temperature data.

The next area covered in Gibson's report was on testing with crumb rubber - wet process. He showed the results from the different temperatures and asked if the results looked reasonable. If a higher extension rate or low temperature is used in the brittle area, the test is invalid. If a low extension rate or high temperature the test results are questionable. So his point is, what is the preferred region to perform the test. For the most part, however, the binders ranked as observed in performance in the field (ALF).

Presentation Title #2: *Ontario 2011 Experience*—Sandy Brown (Asphalt Institute)

Presentation Summary:

Sandy Brown gave a summary of the Canadian TAC meeting focused on a binder purchase specification. He started with the 2011 Ontario experience and described the process, which included: a trial purchase specification that was used on 33 projects; multiple samples from 25 contracts were collected; initially the DENT and MSCR Recovery were used as a purchase specification. All testing was for owner acceptance from 6 to 8 MTO qualified consultant laboratories. He presented these results from the MTOs and the contractors, on the results for the DENT and MSCR tests. He noted that the DENT test is their PG+ test. All results passed the DENT test. His point was when you ask for the DENT or MSCR you get results that generally pass both. Brown then provided a summary of the MTO enhanced correlation program in 2011.

ETG Comments, Questions, and Discussion:
Gibson noted that while LAS can be run in the DSR, he believes the DENT gives you stress concentration in fracture and those stress concentrations mobilize the polymers which can show the benefit of polymers. Marasteanu noted there are issues with DENT sample preparation in getting the notches correct. Gibson agreed with that comment.

D'Angelo commented the DENT is still just still a ductility test, you just changed the geometry. Gibson replied while this is an empirical test he believes it differs from previous ductility tests.

Dave Anderson commented that the problem with DENT is you only get binder behavior at one strain or elongation rate and at one temperature. What happens at different time and temperatures? Gibson replied he had reported those results for other test conditions.

13. ABCD Test Specimen Preparation—Sang Soo Kim (Ohio University)

Presentation Title: *Asphalt Binder Cracking Device*

Summary of Presentation:
Sang Soo Kim reported on the low temperature thermal cracking and noted the importance of stiffness from the BBR, strength from the DTT, modified BBR, and the coefficient of thermal (CTE) expansion. He used examples of no CTE then no cracking, or infinite strength then no cracks, or low stiffness then no cracks. He then covered considerations for the ABCD grading temperature: PG grading is based on mixture thermal cracking. The ABCD measures binder thermal cracking but needs correction. As a starting point, a correlation between the ABCD and the TSRST is needed.

Kim showed a comparison between the ABCD and TSRST data from a test road, FHWA polymer, and SHRP binder studies. He showed the relationship between BBR-PG grade temperature and TSRST cracking temperature and noted that the correlation is reasonable. When he compared the TSRST to the ABCD, reasonable correlations were observed, but significant difference between the projects. Kim presented the relationship to adjust the ABCD to match the TSRST temperature and found it to be reasonable. Kim reported that they are going to take a closer look at the results between the BBR and ABCD grade temperatures. Kim explained the difference is that the polymer is not adequately accounted

for in the current specification. He also noted physical hardening may be playing a role in the differences between the two methods.

Kim proposed a regression equation for comparing the ABCD and TSRST grade temperatures. Some unmodified binders lose a full grade in comparison with the BBR grade; while other polymer modified binders gain a full grade. There are some exceptions and that is the reason they need to continue to supplement with field data.

He continued with the second part of his presentation on the ABCD inter-laboratory study. Kim reported some of the rings and molds had been damaged and he had to remove those data from the group. Another problem reported was related to the pouring device and ABCD ring, as well as breaking off the pins. The pouring device is small and difficult to handle, so they created another pouring device that can be highly controlled in the amount of material placed in the ring. Kim explained changes made to the ABCD test procedure included in TP 92. These changes included: eliminating the silicone mold and trimming of the sample. Kim presented the results from no trimming and no lubed mold: the ABCD cracking temperature was not affected significantly, repeatability of ABCD strain jump at fracture was improved, and the preparation time was reduced. Kim identified and reviewed some of their current work that includes: measuring the CTE of the mix and binder; performing binder creep in compression loading, and improving on the asphalt concrete cracking device.

ETG Comments, Questions, and Discussion:
Bukowski noted there were comments from the last SOM technical section ballot that need to be addressed before it moves forward as a provisional standard in AASHTO. Bukowski asked if there were any comments that still need to be resolved. Kim replied he has addressed the trimming issue. Gibson added that additional comments will be sent to Kim.

An additional issue is how to deal with air void deviation. Gibson asked Kim to comment on the pouring process and eliminating some data related to the protrusions. Kim acknowledged these and identified some other issues and why changes were made.

Ludo Zanzotto asked if different cooling rates were used and would the different cooling rates change the ranking. Kim replied they have tried different cooling rates with no change in the ranking. The only difference was that at higher cooling rates, the dispersion in the data increased.

Marasteanu asked if the thermal stress at fracture is obtained during the test. Kim noted, with the new rings, thermal stress could be calculated.

ACTION ITEM #7: Bukowski will forward any comments on AASHTO TP 92 ABCD to the ETG for review and information prior to the spring meeting to decide whether the ABCD should go forward to the SOM based on questions from the SOM regarding the last ballot.

14. DSR Temperature Equilibrium Spreadsheet—Dave Anderson (Consultant)
Presentation Title: *Thermal Equilibrium Spreadsheet*

Summary of Presentation:
Dave Anderson reported this has been an on-going effort, and asked if the current test method give sufficient time to allow temperature of test specimen to attain equilibrium and can we shorten the equilibrium time by making it rheometer specific?

Anderson presented some of the earlier data collected regarding G* versus time. He mentioned G* is a good estimate to determine when we have thermal equilibrium; when G* becomes constant. He mentioned some of the rheometers for concern were the older models that are no longer being used. Anderson reviewed some of the observations made from the data analysis and showed for some rheometers you do not have to wait as long as the test procedure requires. He noted the equilibrium time depends on the rheometer design thus he believes the equilibrium time should be rheometer specific. In addition, the current time is excessive for many rheometers, but too short for others. However, shortening the time will facilitate improved productivity.

Anderson covered the relevant information which indicated testing should be initiated only after thermal gradients in the binder have stabilized. Stabilization is defined as when G* is constant. He gave the starting assumptions they used and provided definitions of selected terms or parameters. He also noted some of the definitions will change as they proceed forward with changes to the standard.

Anderson identified the factors that affect the time to equilibrium that need to be determined for a specific DSR. He also noted all temperature control systems are not the same. He noted there are three issues to address in determining the time which include: how do we determine the equilibrium time, is the current wait time universally acceptable, and can a reference fluid be used for determining the equilibrium time.

Dave Anderson explained the recommended protocol and went through each step in the process: mount unmodified binder sample in the DSR and trim in the usual manner; create a bulge and initiate loading at 10 rad/sec as described in AASHTO T 315. But continue the loading for 30 minutes; move to the second temperature if testing to an unknown grade is anticipated; and conduct analysis to determine the time. He also overviewed the proposed test method changes, retain current 10 minute wait time as default procedure; allow user to use new proposed procedure as an option; and determine the tse value as device-specific value to be established as part of yearly standardization procedure. Anderson stated they are proposing this be included in the current ASTM version, as an option.

Anderson discussed his spreadsheet that aids in the calculation. He asked for additional data to use in the spreadsheet. He explained the inputs to the spreadsheet and the data that needs to be generated which includes modulus, phase angle, and time and tabulated the answers from the spreadsheet.

Anderson then presented some typical plots of data in terms of G* changes with time, as well as the rheological index, R. Anderson emphasized, he needs additional binder data from samples run at different temperatures and reference fluid. He requested that this data be provided as soon as possible.

ETG Comments, Questions, and Discussion:
Reinke noted testing a single sample on one DSR does not take a long time or effort and encouraged individuals to provide additional data to Dave Anderson.

Baumgardner noted Dave Anderson, John Casola, and Darin Hunter are part of this effort. Baumgardner volunteered his lab and was believes Reinke would also provide his additional data. Anderson noted it is not the number of labs, but number of rheometers needed.

ACTION ITEM #8: Dave Anderson will suggest a list of binders and test fluid to be used in the evaluation of the DSR temperature equilibrium. Potential test labs are from NEAUPG, SEAUPG, and WSTC. Frank Fee was an additional volunteer as well as the western states. It was suggested to get the other user producer groups to comment on the spreadsheet use.

15. "Redlines" AASHTO Binder Procedure Standards—Dave Anderson (Consultant)

Summary of Presentation/Report:
Dave Anderson noted the purpose of this effort is to homogenize the binder procedures and standards and to update them for approving labs. He noted unfortunately the ASTM and AASHTO version are not always the same so you cannot replace one with the other. The BBR is an issue, but they are not rewriting the standards only ensuring they represent current practice. He reported the intention is to have the ETG review the red-lined version of proposed changes and provide comments to Anderson so this can eventually be sent to AASHTO for ballot.

Anderson suggests the DSR standard not go forward until the equilibrium information is added. He asked Maria Knake for her opinion on that topic. Knake suggested the DSR go out right away so that they can get comments back. The equilibrium time can be added later.

Anderson made reference to some of the changes being made to the standards. These include calibration versus standardization, thermometer versus temperature measuring device, editorial changes, reorganization to improve clarity, changing aged to conditioned, referenced documents, etc. He noted the difference in terminology needs to be improved; for example you do not measure stiffness, you calculate stiffness. Anderson defined buttering the specimen prior to trimming and why it is done for the DTT.

Anderson stated an important change would eliminate many ethylene glycol mixtures. He then covered many of the sample preparation issues in his report. Anderson noted not adjust the contact load while the specimen is in the mold. In going through the revisions, Anderson noted he has some minor revisions to make and will send Baumgardner and Bukowski the updated version shortly after the meeting. He also noted the annex has been corrected to reflect standardization, rather than calibration. Anderson requested comments back within two weeks.

ETG Comments, Questions, and Discussion:
Geoff Rowe asked if the s-value is reported at the same time you report the m-value and calculated stiffness. Anderson replied you do not except for selected rheometers. He noted maybe it should be in the standard but he believes that is too tedious. Rowe noted that including a note on this should be adequate. Rowe noted in the Cannon DSR, you have two columns of data one is referred to as measured and the other as calculated.

Bob Kluttz suggested there should be a standard for definitions, rather than having the definitions in each standard. Maria Knake commented right now there is no standard only for definitions but they are working on that topic. Anderson noted the definitions are in TP 61 and not in ASTM. Kluttz asked if there is a difference between buttering and softening the surface. Dave Anderson commented that "buttering" is a fairly accepted term.

Chuck Paugh asked about the use of the word calibration and the number of changes that will be required. Knake replied we have been using the word calibration incorrectly for a long time and in many cases we do not need calibration – only standardization.

Baumgardner noted they have the DSR red-lined version but not have the BBR red-lined version. Dave Anderson will send Baumgardner both the red-lined versions. Baumgardner replied that after he gets these from Anderson, he will send the entire ETG. Anderson asked for comments back in two weeks so these can be forwarded to AASHTO. Anderson will provide the current red-lines for the revised standards to Baumgardner within a week.

ACTION ITEM #9: Dave Anderson will send the revised red-lines to Bukowski by October 6. Bukowski will forward them to the ETG for comment. Comments on the revised red-lines need to be sent back to Anderson by October 19.

16. Fundamental Properties Project III Progress and Products
Fred Turner noted three reports will be given on this topic; he will give the first report followed by a report by Mike Farrar, and then by Ron Glaser. He acknowledged the individuals involved in this work: Jack Youtcheff and Jean-Pascal Planche.

Presentation Title #1: *FPIII Introduction and Overview and Automated SARA Separation update*—Fred Turner (WRI)

Summary of Presentation:
Fred Turner gave an update on the Automated SARA Separation. Turner acknowledged the work under this topic is a product from FP-01. He also acknowledged the individuals working on this topic: Ryan Boysen, John Schabron, and Joseph Rovani. He reported; the system is operational and described the SARA separation fractions. He reported they are finding some interesting observations regarding aging and responses of binders.

Turner reported the asphaltene determinator for multiple uses has tracked very well and can produce a reasonable asphaltene index. Percent TPA tells you whether you have original or an air blown binder using the AD separation. The TPA is the total pre-condensed aromatic content. The automated SARA has been successfully coupled with the automated asphaltene

determinator to provide an integrated AD/SAR separation. The complete separation is expected to take about 4 hours and uses only a 2 mg sample. The system allows for successive separation of different samples.

Turner also reported repeat injections are possible without changing columns and the data are very repeatable. He showed the SHRP binder separations for some of the MRL asphalts, and reported the results will be different than reported previously for the MRL asphalt. There will be differences. Turner summarized the future work in terms of the current contract and future contracts. The current effort is to develop an understanding of the aging impact on the SARA fractions, and preliminary correlations between SARA fractions and physical properties. The future efforts will include an understanding of binder chemistry and physical performance link. He also reported the current contract ends in July 2013, but he does not believe this will be finished at the time.

Presentation Title #2: *Pavement Oxidation Considerations: Today and Tomorrow*—Ron Glaser (WRI)

Summary of Presentation:
Ron Glaser gave the next report related to pavement oxidation considerations. He reported they have had some success but still have a long way to go towards characterizing the binders. Some questions to be address in his report are; how can we design longer lasting pavements, what is the stress, and what is the failure stress?

He gave an illustration between a new and old/oxidized pavement in terms of thermal stress versus depth. He also showed an example of an HMA layer that is permeable and another one that is impermeable. He included an illustration that demonstrated the stress distributions will be different in the permeable pavement in terms of thermal stress versus depth.

Ron Glaser stated there is no one method to predict performance based upon a laboratory measured material property alone. Material properties change with time and with pavement depth and are required for predicting performance. These changes are caused by oxidation. FEM modeling for stress field and/or damage accumulation is essential for predicting rational performance. Glaser then reported on some items needed to be understood, such as: material properties changes in time and pavement depth are required, oxidation chemistry of the binder, climate, mix design, and traffic loading.

Glaser identified two questions that are important: how does the modulus and fracture toughness change with time, and can we determine this before construction or are we going to be field monitoring and curve fitting. He presented his view that we need to predict the rate of oxidation as a function of temperature and oxygen availability, must be able to predict the change in mechanical properties of the mix as a function of extent of oxidation, and an alternative approach in predicting mechanical properties changes directly during the material characterization testing.

Glaser discussed some specific issues; use carbonyl only to quantify the level of oxidation; temperature and pressure dependence appear to be different for different binder sources; oxidation testing for modeling gradients is time consuming, expensive, and not likely to be

accepted; PAV only ranks materials against some arbitrary oxidation conditions and does not provide information sufficient for modeling; and PAV is not really field validated.

Glaser then presented the WRI advances for unmodified binders: fundamentally derived rate equation; temperature and pressure dependence appear to be source independent; predicted aging of RAP blends based upon starting materials – one parameter fits at one temperature; oxidation testing for modeling gradients is greatly expedited requiring only two or three aging testing experiments; may exploit pressure acceleration; and can be adapted to mix testing. He overviewed the relationship between different binders and oxidation and reported most of the relationships can be adjusted based on one parameter.

Glaser then defined what is missing; understanding the pressure effect, field validation, considerations for modified binders, consideration of RAP and WMA, and verifying the effect fine mineral matter has on the rate. He explained with two parameters they have the information needed to create a finite element system for predicting pavement response and performance. He concluded with what can be done under the current Fundamental Properties III contract. He reported there is a lot of documentation that is needed to aid in the technology transfer area. He suggested the ETG could help by identifying priorities for the missing components.

Glaser acknowledged the cooperation with Reinke and Arizona Chemical. He noted the importance of needing and using field validation data and referred to some of the work Charles Glover is doing to shorten the validation process. He also stated this work needs to be extended to the engineered and modified materials. They are getting close for converting the reduction of oxidation kinetics studies into a practical AASHTO method, but it will not be within the remaining time for this project.

Glaser noted there is still a lot of work needed to improve an understanding of oxidation chemistry. They have some reasonable empirical correlations between aging and mechanical properties or changes with oxidation, but not a complete understanding of why they work.

Presentation Title #3: *DSR Modification for 4 mm Plate DSR, SAT and Micro-Sampling*—Mike Farrar (WRI)

Summary of Presentation:
Mike Farrar discussed three projects; the 4 mm DSR plates, SAT, and Micro-Sampling. He acknowledged the individuals involved, J.P. Planche, Steve Salmans, Fred Turner, and Will Grimes.

- For the 4mm DSR, Farrar reported they are trying to develop an alternative to the BBR. He reported; the task group is trying to start procedural ruggedness prior to moving on to the round robin testing.

- Farrar overviewed the simple aging test (SAT), the aging scheme and rheology and the long term and short term aging with the DSR for emulsion residue - both recovery and aging. You need to know the ratio of the water to asphalt to ensure that you have sufficient film thickness. For the SAT, they need some direction on important points

of this topic and requested input from ETG. He reviewed the need to develop an AASHTO method for short and long term aging and establish temperature and time to simulate WMA. For the emulsion residue recovery and oxidative long term aging, they need to develop an AASHTO method, and confirm 6 hours at 60^{o}C, and establish PAV time and temperature to simulate field aging. He suggested creating a task group for validation, ruggedness testing and round-robin testing.

- Farrar reported for micro-sampling a draft standard is needed with eventual forwarding to AASHTO. In addition, a study is needed on the method and extent of oxidation caused by drilling. He also would like to have a task group for micro-sampling validation, ruggedness testing and round-robin testing.

The last item discussed was a WMA/HMA project in Wyoming. Farrar briefly went over the project, and presented some slides provided by Dave Newcomb on plans for NCHRP 9-52. He listed four projects they are using for collecting samples at the paver which will be used to adjust the laboratory aging protocol.

ETG Comments, Questions, and Discussion:
Gayle King made a comment on the SAT for emulsion residue recovery. He noted Reinke is working with a vacuum oven to improve on the material recovery process. Reinke replied that 6 hours does not result in a comparable material, but the 3 hour does. Farrar noted that the vacuum oven has a lot of advantages.

Codrin Daranga asked a question to VanFrank and Reinke; did you use softer asphalt in your analysis. VanFrank commented they used a CRS-1h material and Reinke noted they have used a PG58-28 binder. Daranga replied that if you test a material with a high volatile content, the results may be indicate a harder asphalt than you really have.

ACTION ITEM #10: WRI asked for feedback from the ETG on information related to the DSR modification for the 4 mm plates in terms of emulsion recovery. Gerald Reinke and others asked that samples be provided to them for testing. Their results will be provided to WRI for review and discussion at the next ETG meeting.

17. Single-Edge Notched Bending Beam (BBR-SENB) – Strain Tolerance and Fracture Properties of Binders—Raul Velasquez (University of Wisconsin at Madison)

Summary of Presentation:
Raul Velasquez gave the presentation on the single edge notched bending beam test. He reviewed the PG testing methods for low temperature cracking from the bending beam rheometer and direct tension test. Velasquez went through the process of the test and identified what they are trying to measure with the test. He reported the SENB results in two important items: failure energy and deflection at fracture.

The motivation for the development of the BBR-SENB is create a flexural test that utilizes a fixture-free prismatic beam specimen consistent with the BBR standard procedure. The selection of the geometry and loading pattern was motivated by success of the BBR in

controlling temperature, loading, and displacement measurements and by the high repeatability of the test.

Velasquez reviewed the extensive research that has been completed using the SENB, and reported most of the past research has been completed without the BBR. He then overviewed the modifications made to the BBR for the BBR-SENB and gave the reasons for making the modifications. The modifications included using a BBR beam with a notch, using pins in the molds to ensure proper notch preparation, and the use of beam supports to ensure notch alignment. He then summarized the effect of the modification by showing some typical results with and without the modifications. These comparisons included: the effect of loading rate and cooling rate.

Velasquez reported the Fenix Test and the SCB were used for measuring the fracture properties of the mixtures and in comparing the binder and mixture fracture properties. Three different aggregates were used in the plan: Spanish aggregate (UPC), granite, and limestone.

The next part of Velasquez's report was on the field performance with using the BBR-SENB. The material was from LTPP test sections with amounts of cracking varying from significant to minimal, as reported in the LTPP database. Results from this testing in comparison to the amount of cracking on the LTPP test sections were: fracture properties of asphalt mixtures is highly influenced by the fracture properties of the binders; binders with high strain tolerance perform better in the field; and binders of same low grade can have significantly different failure energy and deflection at fracture values measured at the grade temperature.

Velasquez then summarized the proposed plan for the ruggedness test program for the BBR-SENB. He reported the draft procedure was submitted to the ETG. He described the factors that were identified for the test, which included: two materials (unmodified and modified binders), notch length, loading rate, test temperature, conditioning time, and conditioning media. He asked for volunteers to participate in the ruggedness program.

The final remarks were the BBR-SENB is a good compliment to the BBR as it can measure damage resistance behavior and strain tolerance of binders at low temperatures. In addition, the experimental studies using the BBR-SENB as part of the pooled fund study phase II on low temperature cracking and ARC showed that fracture deformation and failure energy are good indicators of low temperature performance of binders. The BBR-SENB test is also a relatively simple test that can be carried out in a time frame similar to current BBR test. The analysis of laboratory and field experiments indicates a need to compliment current practice of using stiffness and relaxation properties with fracture properties.

He ended his report by acknowledging the sponsor FHWA and Dr. Codrin Daranga for his efforts in design and manufacturing of the prototype.

<u>ETG Comments, Questions, and Discussion:</u>
Geoff Rowe asked if he had master curves for all of these binders. He replied they have the data and have started creating the master curves. Rowe suggested taking the master curve data to define the Gt plotted versus energy to normalize the data. This is the binder data without the notch.

Dave Anderson asked at what temperatures were these run. Velasquez replied the fracture tests were run at a single event temperature; the lowest temperature before cracking reported in the database of LTPP.

ACTION ITEM #11: Raul Velasquez will submit the SENB test to the ETG members for review. Members should review and provide input and comments on the procedure prior to the next meeting. Volunteers for ruggedness testing were requested and further action will be reported at the spring meeting.

18. Discussion of TP 70: Addition of Recording Time Variation (example; from a 1.0 seconds – 0.0 sec + 0.05 Sec)—Matthew Corrigan (FHWA)

Presentation Title: *AASHTO TP 70 - MSCR*

Summary of Presentation:
Matt Corrigan discussed results from the SOM technical section meeting on this item and what is now need by that technical section so these changes can move forward to a ballot. These changes are to note 2 and section 7.3 of AASHTO TP 70.

Corrigan started with the background of the MSCR data reporting. Three different DSR models were used. He went through each of the DSR devices in terms of the sampling rate and how the rates changed. He reported the one of the three DSRs had a problem and the resulting data needed to be extrapolated. They had problems meeting the range of values for the third DSR.

He listed five changes to TP 70 that were recommended by the Binder ETG. These included: (1) add 10 conditioning cycles to the test method; (2) add a tolerance for the timing of the cycles -0.00 and +0.05 to account for some software recording issues; (3) add note 2 in case of negative recovery for soft binders; (4) eliminate the calculation of percent recovery difference between 0.1 and 3.2 kPa; and (5) modify the reference to MP 19 for determining the temperature to run the test. Corrigan reported items #1, #4, and #5 were moved to the concurrent ballot, and items #2 and #3 were considered for the technical section ballot.

Corrigan overviewed the items that were presented to the SOM technical section 2b (2012) meeting. At the meeting, the change for the tolerance for the timing of the cycles -0.00 and +0.05 to account for some software recording issues was discussed. Chris Abadie, acting as the technical section chair asked if all manufacturers could meet the criteria. It was concluded at the technical section meeting that all the manufacturers could not meet this change. Corrigan noted the resulting decision was not to move forward with the time tolerance recommendation.

Corrigan proposed the ETG to provide clarifications/commentary to TP 70 on this issue for the technical sections consideration at the 2013 SOM meeting.

Corrigan then identified more clarification is needed why to require these tolerances, why extrapolation is permitted whenever tolerances are not met, are the tolerances only valid for DSRs that use Windows7, and all equipment manufacturers need to be contacted for input. He commented that it needs to be determined if all equipment manufacturers meet the sampling rate for data required to be recorded every 0.1 second and every 0.45 seconds, why does the accumulation of individual cycle time tolerance exceed the total time tolerance, and the requirement for data at 0.0 seconds plus 0.05 seconds explicitly recorded versus -0.05 second plus 0.0 seconds and -0.3 seconds plus 0.0 seconds required for extrapolation.

Corrigan then overviewed the clarifications that are needed for note 2 and the revised draft.

ETG Comments, Questions, and Discussion:
The equipment manufacturers were polled around the meeting room and their comments were their instruments are based on Windows7, so there would be only a minor delay in getting the data moved from one to another spreadsheet, even if 100 items were being processed. Gary Kamykowski and John Casola, noted they are satisfied with this approach and don't see any problem with the timing.

Corrigan again repeated that the SOM still wants to see more information/commentary on why the recommendations are being made related to the tolerances under section 7.3. D'Angelo suggested that 1 second is defined as anything from 0.5 to 1.0 second.

Bukowski asked D'Angelo to write up the explanation regarding the rationale. D'Angelo agreed will work with Corrigan to produce additional commentary and get further manufacturers input.

Reinke commented that maybe the issue is not to get new software but to get new rheometers. He is unsure how far out they are extrapolating and he noted extrapolation just does not seem to be an issue. Corrigan replied; he is not concerned with the extrapolation but not having the data or the location of where the last data point exists is of a concern.

Raul Velasquez commented that what is needed is a description of how the extrapolation will be done because of the nonlinearity of the material. If the extrapolation is being done differently, maybe an issue is lack of sufficient data points. However, he believes standardizing the extrapolation process is needed. Corrigan noted others have made some of the same comments, but does not know how the extrapolations are being made. He asked for manufacturer comments on this issue. Greg Kamykowski noted it is a valid point to keep extrapolation consistent but with nonlinear testing you are not going to have the same answer so you only get so close.

ACTION ITEM #12: John D'Angelo and Matt Corrigan will prepare the written rationale for the MSCR changes to be reviewed by the DSR manufacturers. After the DSR manufacturers review and comments, the revised document will then be sent to the entire ETG; specifically looking at the tolerances as currently set because they are perceived to be too tight.

19. Pacific Coast PG Round Robin Program—Shauna Tecle Marian (U.S. Oil)

Presentation Title: *PCCAS PG Round Robin Program*

Summary of Presentation:
Shauna Tecle Marian made a presentation on behalf of the Pacific Coast PG Round Robin program. The objectives of which was to look at the following issues; DSR – extended resting period; PAV – to degas or not to degas; and MSCR – continued evaluation of the test.

Tecle Marian reported on the discussions they had in starting the PG specification. She went through the protocol for testing the PG binders, as well as the other details of the testing under the round robin program. She acknowledged the individuals and agencies that were involved in the testing and analysis of the data. Tecle Marian thanked all of the agencies for providing the testing: AKDOT, APART, AZDOT, CALTRANS, McCall, NVDOT, ODOT, Paramount, U.S. Oil, WFLD, and WSDOT.

Tecle Marian summarized the statistical analysis of the data and showed different graphs of the data. She acknowledged and thanked Ray Pavlovich and Nadarajah Sivaneswaran for doing the statistical analysis.

The next part of her report was on the MSCR at 3.2 kPa. The statistical analysis of the DSR extended rest period time showed no significant effect on the original DSR results for any of the PG binders tested, as well as no significant effect on the RTFO DSR results for any of the PG binders tested.

She then presented the other recommendations from this data.

Degass or not degass is okay but they believe there was more consistency when degassed.

They continue to evaluate the MSCR and currently see no significant effect on percent recovery or Jnr results for two of the binders and a significant effect on percent recovery at 3.2 kPa results for the third binder – the data confirmed the large variability.

Gaylon Baumgardner asked whether she was aware that 4 hour total test time for the DSR has now been accepted in the specification by AASHTO. Tecle Marian was aware of the 4 hours, but they still would like to see the time extended. Kevin VanFrank overviewed the process they used in their round robin program and found there was no statistical difference in the results. He also noted; there was evidence presented to the ETG in that physical hardening does occur, so there was a lot of debate and the 4 hours represented a comprise. Some noted they would like to use 8 hours. Tecle Marian commented their wish is for 6 hours. Matt Corrigan clarified the setting the time at 4 hours was not a compromise, but rather a revision back to an earlier procedure on total time to test. He noted if you track through all of the changes in terms of storage media, they defaulted to what has been done previously in the Superpave standards, which is 4 hours testing time.

ETG Comments, Questions, and Discussion:

Gayle King; as long as the specimen has been heated, you are not going to notice a physical hardening issue because you are annealing the specimen. He thinks we should not put a limit on the time as long as it is less than a day. There was a lot of debate between Gayle King and Dave Anderson on the terminology – steric hardening versus physical hardening. Tecle Marian; there are other issues here regarding the efficiency of testing. Bukowski suggested we need to hear from a larger number of agencies and the SOM on this topic before it is re-examined by the ETG.

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

Next ETG Meeting: John Bukowski reported they are looking at April 22 for the next ETG meeting, after the AAPT meeting. The Mix ETG will be held first and the Binder ETG would follow. Bukowski asked if there were any for conflicts. D'Angelo noted the ASTM meeting that same week. He also noted Richard Kim has volunteered the location site. D'Angelo asked about the week of April 29 as an alternate,

[NOTE: After the Mixture ETG meeting, it was decided the Binder and Mixture ETG meetings would be held during the week of April 29. The planned meeting date for the Binder ETG is May 2 and 3, 2013.]

Action Items: Bukowski summarized the action items from this meeting, which included:

1. ACTION ITEM: The TP 44 task group will prepare written support and background for the recommended changes to the standard. This includes the rationale for those changes. Bukowski asked Hussain Bahia to put together some additional information on the substitution on the use of toluene.

2. ACTION ITEM: Mike Anderson will prepare a document on the rationale for changing Jnr to get "S" grade binders. This document will summarize what has been done and what is recommended, which will be submitted to the full ETG for review and comment before the next ETG meeting and possible submission to the SOM for review. Anderson will write up the rationale as a stand-alone procedure for distribution to the ETG for review and comment. This item will be included on the agenda for the next ETG meeting prior to sending it to the SOM.

3. ACTION ITEM: Mike Anderson will submit to the ETG a pdf version of the MSCR recovery standard for evaluating the delayed elastic behavior of asphalt binders. All comments from the ETG will be discussed at the next meeting. Mike Anderson, Bob Kluttz, Gerald Reinke and Matt Corrigan will review the revisions prior to its submittal to the ETG.

4. ACTION ITEM: The binder thermal cracking task group will review the testing protocol presented by Haifang Wen. Wen will submit it to the task group for review, which will be discussed at the next meeting.

5. ACTION ITEM: Hussain Bahia will prepare a test protocol for the DSR yield energy test for submittal to the intermediate temperature task group for evaluation.

6. ACTION ITEM: The ETG will review the recent TP 101 revisions and considerations given to forward to SOM after the spring ETG meeting.

7. ACTION ITEM: Bukowski will forward any comments on AASHTO TP 92 ABCD to the ETG for review and information prior to the spring meeting to decide whether the ABCD should go forward to the SOM based on questions from the SOM regarding the last ballot.

8. ACTION ITEM: Dave Anderson will suggest a list of binders and test fluid to be used in the evaluation of the DSR temperature equilibrium. Potential test labs are from NEAUPG, SEAUPG, and WSTC. Frank Fee was an additional volunteer as well as the western states. It was suggested to get the other user producer groups comment on the spreadsheet use.

9. ACTION ITEM: Dave Anderson will send the revised red-lines to Bukowski by Oct. 6. Bukowski will forward them to the ETG for comment. Comments on revised red-lines need to be sent back to Anderson by Oct. 19.

10. ACTION ITEM: WRI asked for feedback from the ETG on information related to the DSR modification for the 4 mm plates in terms of emulsion residue recovery. Gerald Reinke and others asked that samples be provided to them for testing. Their results will be provided to WRI for review and discussion at the next ETG meeting.

11. ACTION ITEM: Raul Velasquez will submit the SENB test to the ETG members for review. Members should review and provide input and comments on the procedure prior to the next meeting. Volunteers for ruggedness testing were requested and further action will be reported at the spring meeting.

12. ACTION ITEM: John D'Angelo and Matt Corrigan will prepare the written rationale for the MSCR changes to be reviewed by the DSR manufacturers. After the DSR manufacturers review and provide comments, the revised document will then be sent to the entire ETG; specifically looking at the tolerances as currently set because they are perceived to be too tight.

Bukowski asked all task group leaders to look at their membership list and send him back the members or individuals included on their task group. The listing of membership for each task group is attached to the minutes.

21. Wrap-Up and Meeting Adjournment

Gaylon Baumgardner thanked everyone for attending and participating in the meeting. The meeting was adjourned at 4:55 PM.

ATTACHMENT A

Asphalt Binder Expert Task Group

Minneapolis, Minnesota
September 24 & 25, 2012

Meeting Agenda

Day 1 – September 24, 2012

1:00 pm	Welcome and Introductions	**Baumgardner/M. Anderson**
1:15 pm	Review Agenda/Minutes Approval & Action Items March, 2012 Meeting and SOM Technical Section 2b Actions	**Bukowski**
1:45 pm	Review of Jnr Criteria for Unmodified Asphalt Binder	**M. Anderson**
2:15 pm	MSCR Recovery: Proposed AASHTO Procedure	**M. Anderson**
2:30 pm	Task Group Recommendations Binder Thermal Cracking Test	**Wen**
3:00 pm	Break	
3:30 pm	Update of Cooling Medium Effects on BBR Results	**Marasteanu**
4:00 pm	Update on Isothermal Storage of BBR Specimens	**Rowe**
4:30 pm	Lab Mixing & Compaction Temperature Task Group Activities	**M. Anderson**
5:00 pm	Adjourn for the Day	

Day 2 – September 25, 2012

8:00 am	Overview of Rheological Models for Asphalt Binders	**D. Anderson**
8:30 am	Intermediate Temperature Task Group Activities	**M. Anderson**
9:00 am	Break	
9:30 am	Linear Amplitude Sweep Test Ruggedness Update	**Bahia**
10:00 am	Linear Amplitude Sweep Test Ruggedness Changes	**Tabatabaee**

10:30 am	Single Edge Notched Beam Procedure	**Tabatabaee**
11:00 am	Update on the Double Edge Notched Tension Test (DENT)	**Gibson**
11:30 am	ABCD Test Specimen Preparation	**Sang Soo Kim**
Noon	Lunch	
1:00 pm	DSR Temperature Equilibrium Spreadsheet	**D. Anderson**
1:30 pm	"Redlines" AASHTO Binder Procedure Standards	**D. Anderson**
2:00 pm	DSR Modification for 4 mm plates	**Farrar**
2:30 pm	Fundamental Properties Project III Progress and Products	**Turner**
3:00 pm	Break	
3:30 pm	Discussion of TP70 addition of recording time variation (ex. from a 1.0 seconds value to 1.0 seconds -0.0s +0.05s)	**Corrigan**
4:00 pm	Summary of Task Groups and Objectives	**All**
5:00 pm	Wrap-Up/ 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: 859-422-1301 manderson@asphaltinstitute.org
Secretary: **John Bukowski** FHWA Deputy Director HIPT Federal Highway Administration 1200 New Jersey Avenue, SE Washington, D.C. 20590 Phone: 202 366-1287 Fax 202-493-2070 John.Bukowski@dot.gov	
Members :	
Christopher Abadie Materials Engineer Louisiana DOTD 5080 Florida Blvd. Baton Rouge, LA 70806 Phone: 225-248-4131 cabadie@dotd.louisiana.gov	**Dr. David A. Anderson** Professor Emeritus of Civil Engineering Penn State University Penn Transportation Institute 201 Transportation Research Board University Park, PA 16802-2321 Phone: 814-237-8585 daa@psu.edu or DA.SC@COMCAST.NET
John D'Angelo Consultant 8528 Canterbury Drive Annandale, Virginia 22003 Phone: 571-218-9733 Johndangelo@dangeloconsultingllc.com	**Darren G. Hazlett** Deputy Director Construction Division Texas Department of Transportation 125 E. 11th Street Austin, TX 78701-2483 Phone : 512-416-2456 Fax: 512-506-5825 darren.hazlett@txdot.gov

Gayle King GHK, Inc. 15 Quick Stream Pl. The Woodlands, TX 77381 Phone: 281-576-9534 Cell: 832 741-2815 gking@asphaltscience.com	**Mihai Marasteanu** Professor University of Minnesota 164 Civil Engineering Bldg. 500 Pillsbury Drive, S.E. Minneapolis, MN 55455 Phone: 612-625-5558 Fax: 612-626-7750 maras002@umn.edu
Bob McGennis Technical Manager Holly Frontier Companies 20860 N. Tatum Blvd, #150 Phoenix, Arizona 85050 Cell: 602-315-6904 Robert.McGennis@Hollyfrontier.com	**Bruce Morgenstern** Materials Lab Wyoming DOT 5300 Bishop Blvd Cheyenne, WY 82009-3340 Phone: 307-777-4271 Bruce.morgenstern@wyo.gov
Ioan I. Negulescu Professor, Human Ecology Louisiana State University 232 Human Ecology Baton Rouge, LA 70803 Phone: 225-578-1684 inegule@lsu.edu and ioannegulescua@yahoo.com	**Jean-Pascal Planche** Vice President Transportation Technology Western Research Institute 365 N. 9th Street Laramie, Wyoming 82672 Phone: 307-721-2325 jpkanch@uwyo.edu
Gerald Reinke Mathy Construction 915 Commercial Ct. P.O. Box 563 Onalaska, WI 54650 Phone: 608-779-6304 Fax: 608-781-4694 gerald.reinke@mteservices.com	**Henry Romagosa** ICL Performance Products LP P.O. Box 171167 Holladay, UT 84117 Phone: 801-274 0955 Cell: 801-245 0429 henry.romagosa@icl-pplp.com
Dr. Geoff Rowe Abatech, Inc. P.O. Box 356 Blooming Glen, Pennsylvania 18911 Phone: 215-258-3640 Fax: 267-261-8481 growe@abatech.com	**Eileen C. Sheehy** Manager, Bureau of Materials New Jersey DOT P.O. Box 607 Trenton, NJ 08625-0607 Phone: 609-530-2307 Eileen.sheehy@dot.state.nj.us

Kevin Van Frank Utah Central Labs Utah Department of Transportation P.O. Box 14590 4501 South 2700 West Salt Lake City, Utah 84119 Phone: 801-965-4426 Cell: 801-633-6264 Fax: 801-964-4417 kvanfrank@utah.gov	
Liaison Members:	
Mark S. Buncher Director of Technical Services Asphalt Institute 2696 Research Park Drive Lexington, KY 40511-8480 Phone: 859-288-4972 Fax: 288-4999 Mbuncher@asphaltinstitute.org	**Audrey Copeland** Vice President-Research and Technology National Asphalt Pavement Association 5100 Forbes Boulevard Lanham, MD 20706-4413 Phone: 301-731-4748 Fax: 301-731-4621 Audrey@asphaltpavement.org
Edward Harrigan Transportation Research Board 500 5TH Street, NW NA 487 Washington, D.C. 20001 Phone: 202-334-3232 Fax: 334-2006 eharrigan@nas.edu	

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: 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)	**Linear Strain Amplitude Test Group:** 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	**Intermediate Test Temperature Group:** Mike Anderson, Lead Dave Anderson Hussain Bahia Gaylon Baumgardner Audrey Copeland Gayle King Bob McGennis Jean-Pascal Planche Gerald Reinke
BTC Task Group: Haifang Wen, Lead Dave Anderson Mike Anderson Gayle King Ioan Negulescu Jean-Pascal Planche Geoff Rowe	**DSR Task Group:** Mike Farrar, Lead Dave Anderson Mike Anderson Jean-Pascal Planche Gerald Reinke Geoff Rowe Steve Salmans