# FHWA Asphalt Binder Expert Task Group

| Asphalt Binder ETG Purpose |
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| 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 52 individuals attended the meeting (15 members and 35 visitors and 2 contract individuals). The meeting was held in Oklahoma City, Oklahoma.

*Members of the FHWA Asphalt Binder ETG in attendance included:*

Mike Anderson (Co-Chairman) Asphalt Institute
Matthew Corrigan, FHWA (Secretary)
David Anderson, Penn State University
John D'Angelo, D'Angelo Consulting
Gayle King, GHK, Inc.
Bruce Morgenstern, Wyoming DOT
Tanya Nash, Florida DOT
Ioan Negulescu, Louisiana State University
Jean Pascal-Planche, Western Research Institute
Gerald Reinke, Mathy Construction
Karl Zipf, Delaware DOT
Mark Buncher, (Liaison) Asphalt Institute
Edward Harrigan, TRB
Evan Rothblatt, (Liaison) AASHTO
Pamela Marks, (Liaison) Ministry of Transportation

Meeting Coordinator: Lori Dalton (SME, Inc.)
Technical Report: Elie Y. Hajj, (University of Nevada, Reno)

*ETG Members Not in Attendance:*

Gaylon Baumgardner, Paragon Technical Services, Inc.
Lyndi Blackburn, Alabama DOT
Joseph DeVol, WA State DOT
Darren Hazlett, Texas DOT
Geoff Rowe, Abatech, Inc.
Audrey Copeland, (Liaison) NAPA

*Friends in Attendance:*

John Bukowski, FHWA
John Casola, Malvern
Bob Kluttz, Kraton Polymers
Amir Golalipour, FHWA
Gerry Huber, Heritage Research Group
Guy Sisler, Calumet Specialty Products
Pamela Turner, NCAT
Waseem Fazal, FHWA Oklahoma
Kenneth Hobson, ODOT
Roger Corbin, ODOT
Scott Seiter, ODOT
Danny Gierhart, Asphalt Institute
Alexander Brown, Asphalt Institute
Don Powell, San Joaquin Refining Co., Inc.
Shauna Teclemariam, US Oil & Refining Co.
Bharath Rajaram, TA Instruments
Andy Cascione, Flint Hills Resources
Giovanni Onnembo, Innophos, Inc.
Punith Shivaprasad, Shell Bitumen, US
Al Palmer, Safety-Kleen
Jim Barant, Road Science
Todd Thomas, Colas Solutions
Rick Holmgreen, Shell Oil Company
Bob McGennis, Holly Frontier Companies
Tien Dao, Cannon Instrument Corporation
Gina Paroline, Anton Paar
Andrew Hanz, MTE Services
Scott Veglahn, MTE Services
Don Christensen, Advanced Asphalt Tech.
Ramon Bonaquist, Advanced Asphalt Tech.
Adrian Andriescu, SES Group & Associates
Zia Alavi, UC-Davis
Howard Anderson, Utah DOT
David Anderson, Consultant
Stacey Glidden, Payne & Dolan
Randy West, NCAT

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## DAY 1: Tuesday, September 14, 2015

### 1. Call to Order

Mike Anderson (Asphalt Institute) called the meeting to order at 8:00 AM. He mentioned that Chairman Gaylon Baumgardner (Paragon Technical Services) could not attend the meeting.

### 2. Welcome and Introductions

Matthew Corrigan mentioned there was a change in the ETG memberships from the last meeting. He welcomed the participation of the new Binder ETG members.

### 3. Review Agenda/Minutes Approval & Action Items, April 2015 Meeting. [Matthew Corrigan, FHWA]

Corrigan announced that minutes were distributed last week and asked if there were any revisions or corrections to the technical report. No additional comments were noted. The meeting minutes and the presentations are being posted on the website (www.asphaltetgs.org).

Corrigan reviewed the Action Items from the April 2015 Binder ETG meeting. The following is a listing and status of the Action Items from the last meeting.

- Action Item #201504- 1: The REOB Task Force will summarize the work and information presented during the meeting and provide a recommendation to path forward at the next ETG meeting.
  ***Update: Item is on the agenda.***
- Action Item #201504- 2: David Anderson to edit the current 4 mm PP test in DSR standard (sample preparation protocol) in order to distribute to ETG members and friends for review and comments.
  ***Update: Item is on the agenda.***
- Action Item #201504- 3: The binder aging concern Task Force to provide a summary and a description of the issue and provide recommendations and path forward at next ETG meeting.
  ***Update: Item is on the agenda.***
- Action Item #201504- 4: Geoff Rowe and David Anderson to provide the next Rheology 101 Presentation on fracture thru stiffness properties at next ETG meeting.
  ***Update: Item is on the agenda.***

### 4. Update on Oklahoma's Work in the Binder Field. [Kenneth Ray Hobson, Oklahoma DOT]

Presentation Title: *Oklahoma Update, Kenneth R. Hobson, Oklahoma DOT*

Summary of Presentation:
Hobson mentioned that the presentation will cover MSCR implementation, PPA/REOB, GTR, RAP/RAS, and Tack Coats. Most of the presentation will be on tack coat.

*MSCR Implementation:* Hobson mentioned that the MSCR implementation started in 2012. At that time the minimum recovery Rec3.2 was 95%. In 2015, a partial implementation for two polymer asphalt binders was done with different minimum recovery Rec3.2 values. The full implementation is planned for 2016 for $J_{nr}$ but the Rec-difference is problematic and probably won't be implemented at this point.

*PPA/REOB:* TFHRC did testing for Oklahoma DOT. The University of Oklahoma is doing a PPA research project. Oklahoma DOT has also the asphalt binders which will be tested in-house for XRF once the equipment is setup.

*GTR:* The Oklahoma department of environmental quality is asking the DOT to use more scrap tire rubber. GTR is planned to be used on a County Road and University of Oklahoma will be helping with the research.

*RAP/RAS:* Oklahoma DOT used the percent binder replacement in some demo projects. RAS was 75-85% from chemical extraction as compared to what is obtained from the ignition oven extraction. Only 3% by mass of RAS is allowed currently versus 5% allowed when first started using RAS.

*Tack coats:* SS-1 is primarily used in Oklahoma at 0.15 gal/SY diluted 1:1 with water. Three different tack coats are used on the County Road near Spiro, OK. The first one consisted of removing the field dilution with water in the field to see what will happen. This resulted in a 0.08 gal/SY original emulsion. The problem is that it tracked 2 hour after it broke. The second tack coat consisted of SS-1 with 0.10 gal/SY. The residual on this one is lower than the first tack coat. They couldn't do the 0.15 gal/SY on the second tack coat since it was too fluid and ran off the road. The third product with the same application rate of 0.08 gal/SY, for comparison purposes. The third product seemed to be working very well. Hobson mentioned that overlapping the longitudinal joint with tack coat is important. Hobson also presented the investigation of an old project where SS-1 was used at 0.06 gal/SY 1:1 diluted and where plane slippage had occurred. He noted that the old specification called for 0.05 gal/SY residual whereas the actual application on the project resulted in a lower residual than the specification required. In another project the NTQS-1HH at 0.25 gal/SY was used which should have been 0.08 gal/SY which led to fat spots in the wheel paths.

ETG Comments, Questions, and Discussion:
Gayle King asked why dilution should not happen in the field. Hobson responded that sometimes the material end up being diluted twice. Better control of the material can be achieved if not field diluted. Hobson mentioned that a lot of the surrounding states are working toward not allowing task coat dilution in the field. King mentioned that the two reasons for dilution on site is long transportation (hauling distance) or need for on-site storage tank.

**5. Update: PAV Degassing Issues. [David Anderson, Consultant]**

Presentation Title: *Update: PAV Degassing Issues, Task Force on Vacuum Degassing, Dave Anderson, Consultant.*

Summary of Presentation:
David Anderson mentioned that the task force is looking whether vacuum degassing is necessary prior to conducting rheological measurements for the BBR and DSR testing. A task force was formed in 2015 to look into this matter. He listed and acknowledged the members of the task force. A summary of the work completed to date and the future activities was listed.

- Work to date
  - Investigated linearity of pressure release rate
  - Reviewed previous degassing experiments
  - Informal survey of RMAUPG workshop attendees
  - Develop in experiment design
  - Selected samples for testing
  - Expanded participants to provide more robust experiment
- Future activities
  - Perform experimentation
  - Analyze the data
  - Present recommendations to ETG spring 2016
  - Coordinate with ASTM activities

An experiment is envisioned with the following variables: rate of pressure release, laboratory elevation, binder source to include PMB's, manufacturer of PAV (degassing rate). It was decided to do some background work first in order to properly be able to address the problem. Based on the literature review there is an identified need to include both a continuous-linear release rate with a nonlinear release rate or short bursts. Hence, the release rate and uniformity of release rate may need to be addressed in test method.

Vacuum degassing was adopted to enhance repeatability of direct tension test data and a protocol was developed based on results of laboratory testing program. Based on the literature, he concluded that degassing did not affect material (BBR and DSR) properties but was essential for DT. Anderson followed with a summary of previous studies on Degassing (AI study in 2007 and WCTG study in 1997). The results of a survey of RMAUP workshop attendees contradicted previous findings. On the other hand, degassing was not found to affect BBR or DSR test results based on AMRL proficiency sampling (2010). Anderson noted that a careful look at the AMRL data is needed to evaluate the data from an engineering stand point rather than throwing out the statistical outliers. Anderson also presented a summary of the findings from the PCCAS PG round robin study. While no significant influence on PAV DSR results for any of the PG binders tested was found, a significant effect was noted on PAV BBR results for Material "S" PG64-34.

Anderson presented the possible effects for degassing and no degassing and questioned whether it is a good idea of having degassing as optional. Some of the task force findings and conclusions to date were presented:

- Pressure release rate non-linear for one device
  - No data to show does or does not contribute to "problem"
- Some labs use vacuum degassing as fallback for bubble removal whether needed or not
  - Is this good practice?
- Test methods are inconsistent
  - Requirement for degassing and linearity issue need to be clarified

- Anecdotal information contradicts previous findings
    - Practitioners question "no effect" conclusion
    - Significant number of agencies disagree with current specification

The variables considered in the experiment are as follows:

- Four asphalt binders supplied by Colorado DOT
    - Samples from 2015 production
    - Binder type – plain, modified, heavily modified
- Release rate
    - ATS (non-linear), Prentex (Burst), manual (linear)
- Laboratory elevation
- Measurements (Replicate)
    - DSR after RTFO and prior to degassing
    - BBR and DSR after degassing
- Careful monitoring of technique

ETG Comments, Questions, and Discussion:
Matthew Corrigan asked about the timeline to complete the study. Anderson responded that the task force should be able to wrap it up by the next ETG meeting as long as the data is provided by participants. He will be sending out the testing protocol to participating laboratories. Then, he is planning on personally contacting the participating laboratories to discuss the protocol. Anderson requested having one more laboratory with high elevation in addition to Wyoming and Colorado DOTs. Howard Anderson proposed having Utah DOT participate in the study.

**6. Update: 4 mm DSR Testing. [David Anderson, Consultant]**

Presentation Title: *Asphalt Binder Testing Protocol for Dynamic Shear Rheometer, Dave Anderson, Consultant.*

Summary of Presentation:
Dave Anderson started by acknowledging the group working on this topic. He noted that Alec Cookman from WRI is replacing Mike Farrar and Andrew Hanz is replacing Gerry Reinke from MTE. Anderson also appreciated the contributions and involvements of the Rheometer manufacturer.

Anderson started his first part of the presentation on the specimen thermal equilibrium for DSR. He noted that it is recognized that thermal gradients and thermal equilibrium can affect accuracy. He also noted that thermal equilibrium is considered in the current AASHTO and ASTM test methods by a finite wait time of 10 min but no time limit is given for the completion of data acquisition. Additionally, test procedure is built around specification measurements at 10 rad/s based on early generation DSR's (devices that were available in the 90s).

Based on extensive series of tests it was found that the thermal equilibrium is not controlled by the DSR thermometer rather it is the time necessary for the G* to reach a relatively constant value. It was further established that the 10 minutes wait time is impacted by the specific instrument and the specific material. Anderson mentioned that there is a procedure developed to

determine the thermal equilibrium and recommended its adoption by ASTM and AASHTO. The specimen thermal equilibrium is in the range of minutes which implies the specimen mechanical properties are constant. This does not mean the DSR equipment is in equilibrium unless assumed the transducer and motor properties components are stable, and binder properties are not changing with time.

When establishing specimen thermal equilibrium, time zero is the time when the DSR indicate the target test temperature is reached. The criteria for specimen equilibrium is $C_{SE}$ which is defined as the average absolute deviation for 5 data points as percent of the average of the 5 data points. Anderson noted that the calculation for CSE cannot be done for the first two and last two measurements which will result in negative time. Thermal equilibrium time $t_{SE}$ is obtained when $C_{SE}$ is less or equal to 1%. Anderson noted that this process is simple and can be included in the DSR script in a relatively easy manner.

Anderson continued with his second part of the presentation on 4mm plate. He noted that the torque levels are not changing but the strain level is changing. The 4 mm plate could not be done in the past because of the lack of strain sensitivity measurements. Anderson noted that the focus of the task group is to look at various protocols used and try to get some uniformity among them so the test can be consistently used by researcher. The future work beyond scope of task group must include ruggedness testing, technology transfer to ramp up the learning curve, recommendations for a round robin program, and extend the findings to the 8 mm plates.

Anderson noted a couple issues with the current standards that affect the 4mm measurements and test results: 1) the need for the verification of the torque transducer since the current reference fluid measurement is just a verification of the machine; and 2) the need for the verification of the temperature transducer since the temperature measurements between the sample is needed for low temperature which is different than the temperature indicated by the DSR.

Anderson mentioned that several procedures are available for the verification of the machine compliance. Method A (MTE) uses ice to bond top and bottom plates while Method B (WRI) uses “crazy glue” to bond top and bottom plates. The objective is to determine DSR response when plates are held rigid. An ASTM task force was established to refine and validate the equivalency of two methods/techniques. The two procedures are established and will be included in the minutes. The calibration factor is rheometer and plate specific and the process to determine the factor is critically delicate as you don’t want the normal force to be excessive because it will damage the DSR transducer.

Anderson explained and described the primary differences between the WRI and MTE protocols in terms of placement of test sample and bulge formation. Anderson noted that the thermal equilibrium procedure and criteria established for the 8 and 25 mm plate might not be valid for low temperature measurements with the 4 mm plate. He questioned whether physical hardening is a factor in establishing thermal equilibrium for the 4 mm plate. Therefore the task group is trying to address two issues, the specimen placement, bonding, and geometry; and the thermal equilibrium. Accordingly the task group experiment consistent of five laboratories representing three DSR manufacturers, two asphalt binders representing low and high degrees of physical hardening, two sample preparation protocols, and testing using the thermal equilibrium protocol.

The G*, phase angle and rheological index, R value, will be monitored. Anderson noted that the R value shows the relative proportion of the change coming from phase angle and stiffness. Example results were shown and better results were observed with G* in comparison with the phase angle. A larger variability with the phase angle is sometimes observed because the test is conducted at the low strain levels and the phase angle is not calculated. The quality of the G* data affects the phase angle calculation.

ETG Comments, Questions, and Discussion:
Amir Golalipour asked about which DSR components are not stable and causing the problem. Anderson responded that he doesn't know for sure which component and he noted that the DSR equipment changed and evolved over the years. John Casola commented across different products, time, and equipment, a drift is observed for G' value over time in a number of situations and in more than just one manufacturer. He also mentioned that a concern is it doesn't always reach an equilibrium with time which may be due to instrumentations, hardware, self-heating, etc. It is a confounded problem that is observed on a wide range of materials and instruments and the cause is not known. Casola noted the goal is to come up with an acceptable window for measurements that can be met by everyone. Dave Anderson commented that he has data that show, in some instances, significant variation in the rheological index R value over time; while it was supposed to be constant. He also noted that the change in R value follows a very nice smooth curve indicating that something is coming to equilibrium.

Matthew Corrigan suggested that a warning be included in the test protocols about who should be doing the compliance checks and indicate the risks involved to avoid damaging the DSR equipment. Casola noted that it has been observed at WRI over the last four years that the variability in measurements when checking for compliance is very small when done properly. Hence, if somebody observing large deviation in the compliance measurements it indicates either the compliance verification is not being done correctly or the equipment is damaged. Casola commented that this also might need to be included in the document.

Golalipour asked whether the results from the two methods will be influenced by the different gap size for each method due to potentially different temperature gradient in the sample. Anderson responded that this is something that the group will be looking at. Casola noted that with a reasonable conductor material which conducts temperature evenly you will have a much better gradient across the surface. He mentioned that thermal equilibrium is when the gradient is no longer changing. Anderson commented that during the round robin it is important to identify the piece of equipment used for testing. Planche mentioned that the 4 mm plate is currently being evaluated in Germany with a different sample size and sample preparation method.

Corrigan requested those with the 4mm diameter plate geometry that would like to participate in the experiment should contact Dave Anderson directly.

Action Item(s):
**Action Item #201509- 1: Dave Anderson agreed to send the sample preparation protocols and the machine compliance verification protocol for the 4 mm PP test in DSR to post with the meeting minutes. Include warnings and guidance in the compliance check protocol related to the potential consequences of proper usage.**

## 7. MSCR Specification: Questions, Clarifications, & Emphasis. [Mike Anderson, AI]

Presentation Title: *Implementation of the MSCR Test and Specification: Questions, Clarifications, and Emphasis, Mike Anderson, Asphalt Institute.*

Summary of Presentation:
Mike Anderson acknowledged FHWA and members of the Asphalt Institute (AI) technical advisory committee. The presentation is an effort to summarize some identified issues, concerns, and challenges with the MSCR test; specifically related to implementation. Anderson noted the existence of AASHTO T350 for the MSCR test, AASHTO M332 for the PG specification using MSCR, and a draft practice for evaluating the elastic behavior of asphalt binders using MSCR test that was sent to AASHTO for review and publication consideration. A list of concerns, questions, and challenges were presented and summarized as follows: inconsistent implementation by specifying agencies; grade names in AASHTO M332; variability of MSCR test; selection of appropriate test temperature; leadership/champion; use of recovery-$J_{nr}$ curve for evaluating elastic response; use and relevance of $J_{nr}$-Diff as a specification requirement; use and criterion for intermediate temperature binder parameter ($G^*\sin\delta$); criterion for unmodified asphalt binders ("S" grades); original DSR criterion; and quick QC testing on original binder.

Bob Kluttz discussed the status of the ASTM Standard Specification for Performance Graded Asphalt Binder Using the Multiple Stress Creep and Recovery Test. Kluttz is chairing the procedure through ASTM. Kluttz presented a summary of the key points from ASTM member's negatives.

Mike Anderson discussed the test temperature for the MSCR test; pointing out modified binders, when tested at higher temperatures, would expect to behave differently than when tested at the climatic/environmental temperatures.

One of the issues is the use of recovery-$J_{nr}$ curve for evaluating elastic response. Some agencies are using the curve as is while some others such as Kentucky are specifying a minimum recovery value (REC-3.2). Kentucky is using the MSCR test as a replacement for their elastic recovery. It is being used with the M320 grade of PG 76-22, and a minimum recovery value of 60% is required at 64C. Some other states looked at the use of maximum phase angle and some correlations seemed to exist between the recovery and phase angle. Anderson presented the recovery-$J_{nr}$ curves for various 76-22 and 64-22 asphalt binders.

Mike Anderson also covered the issue with the selection of the appropriate test temperature. The guidance is based on selecting the environmental temperature based on LTPPBind 3.1; which is similar to the AMPT standard which includes some guidance on how to select the temperature using LTPPBind. There is a need to provide more guidance in the MSCR test and specify the allowable rut depth, depth of interest, etc. for the use of the LTPPBind. Also the issue arises within locations that choose "standard" temperature that is different than environmental temperature (e.g., owner chooses 64°C when LTPPBind would determine the climate is actually 58°C). Another issue is Southeastern states where 67°C is the standard temperature. Anderson noted better guidance is needed for selecting appropriate test temperature for MSCR. Anderson

also discussed the lack of guidance for selecting the appropriate test temperature when a grad dumping is made when using high RAP/RAS.

Anderson also covered the concern with the original DSR criterion where testing a PG 64H, V, or E asphalt binder at 64C will easily meet the G*/sin(delta) of 1.00 kPa compared to a 64S binder. The criterion for unmodified asphalt binder (S grade) was also presented. Based on recommendation from the Asphalt Binder ETG, the original criterion for $J_{nr}$ at 3.2 kPa was changed to a maximum of 4.5 $kPa^{-1}$. Anderson showed the less than or equal to 4.5 $kPa^{-1}$ criteria was equivalent on average to a G*/sin(delta) of 2.26.

Anderson presented the use and relevance of $J_{nr}$-Diff as a specification requirement. He presented the data from the Pacific Coast study that was coordinated by Asphalt Institute which included five different asphalt binders. Anderson discussed the implications and meaning of a passing or failing $J_{nr}$-Diff.

Anderson noted the variability of the MSCR test is a concern. He presented the results from the Western Cooperative Task group data set. He noted a misperception about high variability with the way the data is presented where incorrect higher testing temperatures have led to higher variability. Anderson also showed the variability of MSCR test results from the AI coordinated ILS and the AMRL proficiency samples. He noted the AMRL data is for unmodified asphalt binders and all binders were tested at the PG temperature. The AMRL data showed good reproducibility for the MSCR test results.

Anderson presented the use and criterion for intermediate temperature binder parameter. A PG 76-22 would be tested at 31°C and G*sin δ would have to be ≤ 5000 kPa while a PG 64V-22 (which is graded as PG 76-22) would be tested at 25°C and G*sin δ would have to be ≤ 6000 kPa.

Anderson concluded his presentation with the need for leaderships/champions in various areas and suggestions for path forward. He noted that the MSCR is an evolution in the PG system and need to repackage the message while recognizing that this is a major specification change instead of just focusing on MSCR as a new test.

ETG Comments, Questions, and Discussion:
John D'Angelo commented that FHWA's original data showed it is possible to have a polymer-modified asphalt binder below the recovery criteria line; the problem in these instances is the binder did not have a well-established polymer network within the binder. In other, words the polymer network had not been optimized within the binder.

Mark Buncher (AI) commented the Asphalt Institute guidance document on the use of MSCR test does have a discussion explaining the R3.2 versus $J_{nr}$3.2 chart (http://www.asphaltinstitute.org/mscr-information/).

Kluttz asked whether it is possible to move the R3.2 versus $J_{nr}$3.2 chart from AASHTO M332 to the draft practice for elastic recovery. Matthew Corrigan commented this will be at the discretion of the AASHTO subcommittee on materials. Kluttz also asked if there are any

objections of balloting the ASTM MSCR specification without having the chart as part of the standard specification while recognizing it is going to create a significant difference between AASHTO and ASTM. John Casola commented that this will have minimum impact in North America since AASHTO is what the governing agencies refer to; ASTM is the standard being used outside the US. Kluttz commented that the chart is also not being interpreted properly outside the US by several organizations. Corrigan noted the recovery curve is what the industry finds valuable. He noted that the educational piece on how to use the recovery curve is what might be missing from the standard to avoid misinterpretation. Kluttz noted that the ASTM audience might not have participated in MSCR educational activities. Howard Anderson (Utah DOT) favored the inclusion of the chart with some notes for clarification.

Planche commented that one of the issues outside the U.S. is related to negative elastic recovery values. Corrigan noted that the ETG forwarded to the SOM Technical Session 2b a clarification note on negative recovery. However, this happened at the same time when AASHTO was actively re-drafting and moving the provisional standard into a full standard because of the effort in the North-East U.S. and the note did not make it into the full standard. Corrigan will re-forward the information to SOM for their consideration within the AASHTO standard.

D'Angelo commented asphalt binders were formulated to meet the existing specification which required 2.2 kPa at the given temperature grade for the RTFO binder. He noted that all these materials are close to Newtonian even with the included polymer; hence the material will flow at exceptionally high temperatures without proper elastic recovery.

Dave Anderson asked whether the presented comparisons for the various asphalt binders were done at equal stiffness. Mike Anderson responded that all presented results are at isothermal condition and not iso-stiffness condition. Dave Anderson commented that the evaluation would be different if results were normalized to the same stiffness rather than comparing at the same temperature. Mike Anderson commented that there is a need to figure out the implementation aspect of the evaluation of asphalt binders at an iso-stiffness condition.

Mike Anderson asked the group for providing further input of any other issues that might have been missed and for any potential solutions on how to address some of the issues.

Corrigan noted the need to dedicate more time in the next ETG meeting to have further discussion about the topic. An effort is needed to differentiate technical items from the educational items.

Action Item(s):

**Action Item #201509- 2: Matthew Corrigan (FHWA) will forward the clarification note on MSCR negative elastic recovery to SOM Technical Session 2b for their consideration**.

**Action Item #201509- 3: Mike Anderson (AI) will draft a request to the ETG group for input and feedback on the issues/concerns and the development of an action plan for the MSCR implementation issues.**

## 8. REOB: Asphalt Institute Task Force Update. [Mark Buncher, Asphalt Institute]

Presentation Title: *AI's REOB Task Force, Mark Buncher, AI*

Summary of Presentation:
Mark Buncher (AI) announced that Asphalt Institute (AI) had information, guidance and studies on other type of modifications (PPA, SEA, PMA). The REOB task force (TF) was formed in august 2014 under the technical advisory committee (TAC) to develop an Informational Series (IS) document on REOB modification. The publication is modeled after AI's PPA Informational Series (IS-220) with the intent to help agencies make informed decisions. .The goal is to publish the IS document mid-2016.

He noted that AI is maintaining a public repository of REOB information (http://www.asphaltinstitute.org/re-refined-engine-oil-bottom-residue/) including: sixteen published papers and reports, twenty presentations at public industry meetings, and REOB manufacturer's information.

Buncher presented the outline of the draft REOB document which consists of six parts: General Overview and Intent of Informational Document; REOB Production and Manufacturing; Material Characteristics and Composition; Literature Review of REOB in Asphalt and Performance; HSE Aspects; Considerations for an Improved Binder Specification; and Frequently Asked Questions by Agencies and Answers. Buncher noted that the TF reached out to the National Oil Recycles Association (NORA) (www.noranews.org) for the Health, Safety and Environmental (HSE) aspects.

Buncher presented a summary update on the NEAUPG efforts. He mentioned that a new document had been developed and approved by the NEAUPG requiring all non-bituminous components added to an asphalt binder to be identified. He noted that it was unclear if all NEAUPG States will require this disclosure; however, many have indicated they would.

ETG Comments, Questions, and Discussion:
Bob Kluttz commented that the two draft ASTM standards on VTAE are nearly identical and the only difference is in flash point requirement. Discussion between ASTM Subcommittee D04.40 on Asphalt Specifications and D08.03 on Surfacing and Bituminous Materials for Membrane Waterproofing and Built-up Roofing led to the agreement of having a single standard for both paving and roofing under the jurisdiction of ASTM D04.40. The Task force working on it includes members from NORA, ASTM D04.40, and ASTM D08.03.

Gerry Reinke asked why the relevant patents (at least three) were not included in the review. Buncher responded that patents were not caught in the literature review of journals and the task force will consider them. Gayle King asked whether the related ETG presentations on REOB will be considered in addition to the published articles. Buncher responded that the information will be considered and the synthesized material from the ETG task force can be referenced.

## 9. REOB: Evaluation and Performance. [Gerry Reinke, Mathy Construction]

Presentation Title: *Some Properties of Binders with and without REOB with RAP & RASP + RAS NHDOT & Data from Vermont Cores, Gerry Reinke, Mathy Construction; with thanks to Jo Daniel, UNH; Beran Black, NH DOT; Bill Ahearn, VT DOT*

Summary of Presentation:
Reinke mentioned that the discussion on REOB over the past couple years made us aware of the need to age asphalt binders and mixtures more extensively than what we have been doing in the past. He stated that the issue is not targeted at REOB; it is targeted at additives which may have issues related to long term ageing and performance.

Reinke reported on the work they did with some states in the North East looking at binders recovered from lab and field mixes. Some mixes included REOB while others did not. Mathy worked with UNH and NH DOT on some of the mixtures produced in the field. Field mixes from Vermont were also tested.

Reinke presented the various mixtures while noting that the odd numbered mixes were mixes produced at the NH DOT laboratory while the even numbered mixes were produced at a local hot mix plant. He also noted that asphalt binders are coded without indicating suppliers or crude oil sources. Two of the mixes (S9 and S10) were only produced at the hot mix plant and did not have companion laboratory mixes. Mixes had different percentage of RAP and RAS.

The NH DOT lab performed high temperature DSR testing of recovered asphalt binders as well as BBR and ABC for low temperature grade. MTE ran the 4 mm DSR test to determine the complex modulus master curves for the asphalt binders. Using the 4 mm data, the R-value and the low temperature stiffness and m-value equivalents were determined. MTE also looked at 20 and 40 hour PAV aging of original asphalt binders. For selected recovered mix binders additional 20 hours of PAV aging were performed.

Reinke presented the complex modulus master curves for the various evaluated mixtures. He noted the master curves at low frequency level show separation of the material. The relaxation modulus for the NH DOT recovered and aged asphalt binders were also presented. Reinke noted the data shows, as the delta Tc goes more negative, the material shows less tendency to relax. He next presented the comparison between the BBR and 4 mm test results. The BBR tests conducted at the NH DOT lab were performed at relatively warm temperatures and only m-failure criteria was bracketed at 0.300. Accordingly the S-value never bracketed at 300 MPa; hence the data was extrapolated up to 300 MPa to get an estimate for the S-critical temperature which created some errors in the BBR results. The 4 mm tests were conducted at lower temperatures, from -36°C to +50°C, and calculation was done to bracket both stiffness and relaxation target values. Reinke noted that the BBR S-critical temperatures and the 4 mm results calculated to predict BBR S did not match. Similarly for the respective m-value calculated results. Comparison plots for the BBR and 4 mm test results were presented. Reinke also showed a good correlation between delta $T_c$ (from 4 mm test results and the adjusted BBR) and the rheological index R-value.

ABCD testing was performed at NH DOT on all recovered and PAV aged asphalt binder samples. The BBR m-critical temperature and the ABCD critical temperature did not show any correlation. Similar observations were found for the 4 mm DSR m-critical temperature. Better correlations were observed between the 4 mm DSR or the BBR S-Critical temperatures and the ABCD critical temperature, indicating that the ABCD is more tuned to the stiffness of the asphalt binder. Except for a couple asphalt binders, it was observed the lower the stiffness of the binder grade the better the ABCD cracking temperature. A good correlation was observed between the delta $T_c$ and the rheological index R-value of all evaluated binders combined. The plot was broken into three areas based on delta Tc and R-value.

Reinke mentioned that when it comes to low temperature grading there is a need to bridge both test results for the failure criteria. He also noted that the presented data once again support the need to age asphalt binders and mixtures to simulate extended aging time in the field regardless of whether REOB is used or not. The impact of RAP and RAS on mixtures doesn't show unless the mixtures are aged sufficiently.

Reinke presented the results for the Vermont core samples. Five cores from five different projects were submitted for testing. All mixes were produced with PG58-28 and approximately 20% RAP. Mixes were placed between 2008 and 2014. Torsion bars were cut from the top 0.5 inch of the cores. Binder was also extracted from the top 0.5 inch material and the 4 mm DST test was performed. The PG grading of the recovered binders as well as the metals content in the recovered binders were presented. The zinc content was between 14 and 50 except for binder recovered from core 5A which had a high zinc content of 203 indicating the presence of REOB. Sample 2A did not show high level of zinc but had an issue with relaxation. It shows a tendency not to relax even though it did not have REOB. Mixture and binder exhibit the same trends in terms of relaxation. Delta $T_c$ versus R-Value was presented. Sample 2A showed the largest R-Value and lowest value of delta $T_c$ (negative).
The torsion bar modulus data of the mixtures from the five different cores were presented. Core 3A was the oldest (placed in 2008) and showed the highest torsion bar modulus (i.e., stiffest) especially at lowest frequencies. He also noted that sample 2A which is from the project placed in 2013 with low zinc content, showed some problems relaxing. The results from the torsion bar were consistent with the G* data from the recovered asphalt binders. The potential observed issues with mix 2A are not due to the presence of REOB. Reinke presented the data for delta $T_c$ versus R-value. The binder recovered from core 2A (placed in 2013) had the lowest negative delta $T_c$ and the highest R-value. The material is a very soft asphalt binder. A summary of the results and findings from the evaluation of the Vermont cores was presented. One year is too short to find evidence of REOB and/or the impact of RAP content. He suggested that projects should be followed for several years.

ETG Comments, Questions, and Discussion:
D'Angelo commented that some binders without any REOB can have worse results then the binder exhibits from core 2A without REOB. This may be "bad chemistry" of the asphalt binder.

Dave Anderson commented that looking at R-value by itself is not enough and it needs to be complemented with the stiffness of the material.

Gayle King commented that ABCD is meant to predict transverse thermal cracking which is a single type event with no healing. It also has been shown that transverse cracking is a stiffness-controlled event. Hence, the fact that ABCD correlates better with stiffness is no surprise. However, the cracking distress of interest with delta $T_c$ and Glover-Rowe parameter is a result of surface effects due to thermal cycling where healing becomes critical. In the case of surface cracking, while stiffness is still important, phase angle contributes to the resistance of the material to thermal cycling distress. It is in these cases where REOB damage is being observed and long-term aging in the laboratory is necessary to observe such effect. It is a good that the ABCD and the m-critical temperature do not agree since they are trying to predict two difference cracking mechanisms. Reinke agreed with King, and posed the question of what should be the binder grade of the material when the delta $T_c$ is large and the material is controlled by m-value?

Corrigan noted other considerations may need to be taken when using high percentages of RAP and RAS and also adding something detrimental to long term mixture performance. Reinke responded something detrimental could be simply the source of the asphalt binder and not necessarily an additive; hence the need for extended aging when evaluating asphalt binders and mixtures

**10. REOB: TFHRC Research Update. [Nelson Gibson, FHWA – Presented by Adrian Andriescu]**

Presentation Title: *REOB Update from FHWA-TFHRC, Pavement Materials Team, TFHRC*

Summary of Presentation:
Adrian Andriescu noted the presentation is mainly focusing on the experimental plan from the study; the results and findings from the study will be presented in a follow up presentation tomorrow. He noted the change in $\Delta T_c$ was influenced by the addition of REOB but not by the addition of a hard binder to the base binder. The magnitude of $\Delta T_c$ increased with 40 hour aging. A summary of the findings from the past meeting were presented and are summarized below:

- REOB presence can readily be detected, however the exact content cannot be determined. The Round Robin XRF results may shed more light on this aspect.
- Effect of REOB depends on base binder (like PPA).
- Observed variation between REOB suppliers and their samples: same concentration can produce different PG grades.
- The 40 hour PAV is a reasonable approximation of 5 years in service.
- REOB softens and reduces tensile strength (binder notched tension (DENT); decreases mix wet and dry IDT strength; also seen in TSRST).
- In 2 of 3 cases, REOB improved binder intermediate temperature parameters for fatigue / strain tolerance (6% and 2.5% REOB blends).
- Rheological “disruption” occurred w/ highest %REOB (differences in low temperature m and S).
- REOB effects on Moisture Sensitivity: a) TSR ratio, strength and Hamburg performance decreases with increasing REOB when no anti-strip is added; b) REOB did not interfere with liquid anti-strip which improved TSR and Hamburg performance; c) Liquid anti-strip (0.4%) alters IDT strength and Hamburg deterioration more than REOB (2.5%-15%).

In summary, low concentrations of REOB did not appear to adversely affect binder and mixture properties. High concentration of REOB was consistent with loss of strength in different binder and mix test methods. It was recommended that further examination of m & S as a "flag" is warranted. The minimum value for S should also be reexamined.

Andriescu presented new updates from the study with the focus on m and S and the assessment of the ability of $\Delta T_c$ to discriminate asphalt binders with different levels of REOB. Rheological tests are conducted on XRF samples sent to FHWA by State DOTs. FHWA has tested 2,600 XRF samples. Binders were identified as having some dosage of REOB. A total of 86 asphalt binders (about 3% of the data set) were selected for further evaluation. A chart showing the estimated REOB content for the individual asphalt binders selected for testing was presented. The PG grades for the selected data sets were presented for 0-3%, 4-6%, 7-9%, 10-12%, and more than 13% REOB.

Andriescu presented the work plan for this effort which consisted of a verification of the effect of additives on high, intermediate, and low PG grades. The standard 20 hour and 40 hour PAV is planned for the BBR testing if sufficient asphalt binder quantity was provided. Separate evaluations will be conducted for asphalt binders with Ground Tire Rubber, Hydrolene, Used Motor Oil, Vegetable Oil, etc.

ETG Comments, Questions, and Discussion:
Mark Buncher commented for the 10-12% REOB, 64-22 and 64-28 seems to be the predominant grades. Buncher asked whether the REOB is exact or estimated based on XRF. Andriescu responded that the REOB content is an estimation at this point.

Reinke expressed his concern about the use of RAP since it becomes m-controlled and he noted that the use of pitch material might be fine while recognizing that some pitch materials might be worse than others. Andriescu responded mixtures with and without RAP are available along with mixtures made with REOB blended asphalt binder.

Jean-Pascal Planche commented there are many ways to get a high $\Delta T_c$ and not REOB related. Also he mentioned that another analytical tool is available to quantify REOB, called NMR. Planche also noted that zinc can come from other additives beside REOB such as GTR. Bob Kluttz questioned if it is possible to distinguish the saturates in REOB from the natural saturates in asphalt using NMR. Planche responded it is possible but only limited data is available.

Huber asked whether it is better to maintain the 20 hour PAV aging and set the criteria for 20 hours PAV rather than 40 hours PAV. Andriescu responded the $\Delta T_c$ is getting worse with the extended aging. Reinke commented the rate of increase in absolute values of $\Delta T_c$ is lower for unmodified binders compared to the binders with additives. Gayle King noted that it is important to identify the characteristics of the material at a critical stage and the 40 hour PAV seems to be representing the material at or close to failure.

**11. Binder ETG – REOB Task Force. [Geoff Rowe, Abatech – Presented by Mike Anderson, AI]**

Presentation Title: *FHWA Asphalt Binder ETG, REOB – Re-refined Engine Oil Bottoms Residue – Task Force; Report to the September 2015 FHWA Binder ETG.*

Summary of Presentation:
Mike Anderson mentioned that Geoff Rowe has drafted a thirteen page report summarizing the presentations that were made during the April 2015 Binder ETG meeting on REOB or related issues. The task force is charged to look at the presentations and provide further input and advice on the REOB issues including some recommendations on the test/parameter to be used. Rowe intends to work with the group to prepare a white paper with the hope to have it ready by end of this year so it can be discussed during the TRB meeting in January 2016 before submitting to the ETG.

A list of the seven presentations that were given at the last ETG was provided including a hyperlink to the downloadable version on the Asphalt Institute website. The key findings from each of these presentations were summarized and presented. The key findings will help in putting together the white paper.

The $\Delta T_c$ can be determined from the 4 mm rheology or the BBR test results. The $\Delta T_c$, G-R, Rheological index R-value, and cross over frequency are all interrelated. Some strong correlations were presented throughout the presentations that were reviewed. $\Delta T_c$ and G-R capture the same characteristics while R-value and cross over frequency capture different features of the master curve. The advantage of the $\Delta T_c$ is that it is easy to derive. G-R can be determined from existing BBR and DSR data or from the master curve data.

M. Anderson went over the consensus items out of the seven reviewed presentations as summarized by Geoff Rowe.:

- A concern exists from the agency/DOT perspective on the durability of asphalt surfacing
- $\Delta T_c$ and G-R could both be used to track performance. $\Delta T_c$ is used more often because it is readily available in the existing data.
- The amount of REOB generally influences the $\Delta T_c$ – but not all materials are influenced the same way.

M. Anderson discussed the proposed next steps for the Task Force.

- Develop a synthesis document that summarizes this information and presentations/updates from this current September 2015 ETG meeting.
- Consult further with agencies, DOTs, and manufactures to develop additional consensus items.
- Complete explicit math equations for use with different test schemes to demonstrate rheological aspects.
- Have this document ready for TRB meeting to be discussed – and available for this group in March 2016.

ETG Comments, Questions, and Discussion:
D. Anderson requested his name to be added to the Task Force members. Kluttz commented that some of the H2S scavengers utilized in asphalt are zinc containing and the level can be high particularly if using sulfur in SBS for cross linking.

Reinke commented that we are missing an opportunity as an industry if we do not take what the Asphalt Institute (AI) did in the 2011 AAPT paper and the other data that have been developed recently, and consider testing the top layer of field cores for $\Delta T_c$ to determine when to do pavement preservation regardless of the cause of the problem. $\Delta T_c$ is a great tool to catch the problem before pavement deterioration. There is a need to find a way to formalize that concept. M. Anderson responded that AI is working with Minnesota to identify the optimal timing for pavement preservation application by evaluating how $\Delta T_c$ changes with time. On a different project conducted by AI, they were able to see the $\Delta T_c$ drop off as the binder ages and correlated with the DCT test results for fracture energy. Anderson believes it is a great concept and needs to be further explored.

King commented that some of the projects in different studies have RAP and even though RAP hurt $\Delta T_c$ if extracted, it is not known whether the RAP is really part of the continuous phase of the binder or if the continuous phase of the binder had a different phase angle than the extracted RAP material. In other words we don't know how much of the RAP asphalt is acting as black rock. The problem becomes more complicated with RAS asphalt.

D. Anderson questioned whether by extending the testing to 40 hour PAV we are just making the difference among the various binders more obvious. Reinke commented that if we have 10 binders with all REOB in them, then the 20 and 40 hours will rank the same. The problem is if you have a set of blind binders with no information on the binders then the rate of aging is very different. D. Anderson commented the problem is then to determine whether there is REOB in the asphalt binder or not. Reinke commented we aren't interested in if REOB is in the binder or not; rather, we need to know how poorly a specific binder is going to age; and the 40 hour PAV is giving a good indication of aging rate.

King asked whether we can have a $\Delta T_c$ for mixtures with RAP using torsion bar test or BBR sliver test to develop a criteria for when to do pavement preservation. Reinke commented more testing is needed because of the variability in the mix testing with the torsion bar test

Corrigan mentioned the challenge seems to be not about whether $\Delta T_c$ can differentiate among the various materials rather what to use to establish the criteria for failure. A material exhibiting poor ageing characteristics or poor performance can pass the -5°C criteria at 20 hours of PAV but not after the 40 hours PAV. Huber anticipated the criteria would be different for the 20 hour PAV and the 40 hours PAV. Corrigan stated the threshold value might be different but collecting the 20 and 40 hour aging data allows checking for the progression of the material's aging and helps better identifying the poor performing material. D'Angelo commented the benefit of this approach is looking at parameters that give us an indication there is an issue with a given asphalt binder material in general and not focusing on a specific modifier such as REOB. Corrigan agreed, and noted the focus has been on REOB and RAP/RAS materials to develop such a threshold value for $\Delta T_c$ and there is no information on how other materials will compare to the threshold value.

M. Anderson commented in an ideal world industry would prefer to have a parameter and a criterion that is sufficiently sensitive that we don't need to do extended PAV conditioning. M.

Anderson asked the question whether the $\Delta T_c$ limit is sufficiently sensitive to provide the same conclusions we observe with the 40 hours PAV. Reinke mentioned at the 20 hour PAV you might be able to discriminate among the binders but it would be on the basis of the 0.1°C - 0.5°C variation between "good" and "bad" while at the 40 hour PAV the difference is in the order of 2°C or more and the discrimination becomes clearer; the reproducibility factor is an issues at the shorter duration. Reinke asked why not collect 20 and 40 hours information at this stage and analyze the data?

**12. Binder ETG – Binder Ageing Concerns Task Force. [John D'Angelo, D'Angelo Consulting]**

Presentation Title: *1) Review of several binder and VTAE blends; 2) Strange Asphalt: How do we capture them in the PG specification, John D'Angelo, Consultant*

Summary of Presentation:
D'Angelo presented the data for different PG64-22 asphalts binders with 0 to 20% VTAE (two types of VTAE). A table summarizing the difference between S and m grade was presented. He noted an increase in the difference between S and m grade was observed for the 20% VTAE. The results are a function of the base asphalt and the VTAE source. In a separate study, blends of VTAE and matched blends made with HVGO flux oil were also presented. In the table AS refers to liquid antistrip. Similarly, the results were dependent on the base asphalt and the source of VTAE. D'Angelo noted all presented results for $\Delta T_c$ are for 20 hours PAV only. Results for 20% RAP were also presented for 2, 6, and 10% VTAE. No large increase in $\Delta T_c$ was observed with the increase in VTAE. Similarly the results for 5% RAS were presented. An increase of 1.1°C in $\Delta T_c$ was observed when 8% VTAE was used to soften the control binder (from -4.3°C to -5.4°C). However, when 16% and 24% VTAE were used, a significant increase in difference between the S and m grades was observed. D'Angelo noted the results depend on the chemistry of the various materials when mixed together in combination.

D'Angelo concluded his first part of the presentation by noting that: a) both asphalt source and VTAE affect the final asphalt binder rheology; b) the S and m failure temperature difference is a good indication of VTAE quantity; and c) VTAE had a mitigating effect on RAP and RAS for S and m difference. D'Angelo stated base asphalt binders may be improved when modified; depending on the chemistry.

D'Angelo presented a second part of the presentation about a "strange" asphalt without VTAE; emphasized the presented results are from the bottom of the refining process.

The PG grading results for four asphalt binders from the same refinery were presented. D'Angelo noted most binders are from a single crude source except the second binder which is a blended crude. Most binders were PG64 except for the blended crude binder which was a PG58. A relatively soft material was observed via the BBR test results as reflected in the low stiffness values. Three binder with a single crude source were graded as PG64-22 while the blended crude asphalt binder graded as PG58-28. The viscosity grading (ASTM D3381) of all four asphalt binders were also presented. All looked normal except for the ductility data on the RTFOT aged asphalt binders which ranged between 22 and 42 indicating an issue with the

binders. The specification for ductility is either 75 cm for AC-10 or 50 cm for AC-20. The chemical analysis of the four asphalt binders seemed reasonable with relatively high asphaltenes. All saturates were relatively high and around 13 to 14 (typically looking at 5-10). A jump in the asphaltenes was observed on the RTFOT aged asphalt binders.

D'Angelo next presented the $\Delta T_c$ of all four binders which were in the range of -2.9°C to -5.3°C. D'Angelo mentioned that $\Delta T_c$ for asphalt sample No. 2 (-2.9°C) seemed odd and maybe could have been higher. He noted the m-value critical temperature had to be extrapolated on sample No. 2. Rowe's analysis procedures using BBR and DSR was used to get the various properties because the master curve was not available for those binders. All binders had an R-value between 3.1 and 3.6 except for Sample No. 4 which was 1.7; accordingly the cross over frequency was significantly high compared to the other three binders. D'Angelo noted the procedure used to calculate the parameters with the limited data does not necessarily capture everything. He also noted he couldn't calculate the Glover-Rowe parameter unless he extrapolated excessively (from 1 rad/sec to 0.005 rad/sec). For these binders, there was no observed correlation between $\Delta T_c$ and R-value. Overall the data is very limited in order to make any meaningful correlations between the various parameters.

D'Angelo discussed the next steps for the Task Force. One way could be putting a limit on the RTFO ageing and all four asphalt binders would not pass the criteria. The other approach would be to have a limit on $\Delta T_c$. Similarly with R-value and cross over frequency. Once of the issues is how to calculate those various parameters. D'Angelo mentioned that G. Rowe is working on an expedited way to be able to calculate these parameters but wondering how much error is introduced as part of these expedited procedures compared to the results obtained from a full master curve. D'Angelo reemphasized that REOB was not present in these four binders and all four of them are from a refinery (bottom of vacuum tower; no air blowing); hence the problem is much bigger than only REOB modified materials.

ETG Comments, Questions, and Discussion:
Corrigan commented that the results from the several binder and VTAE blends may emphasis an identified weaknesses in the current PG system to discriminate poor ageing/poor performing materials. D'Angelo commented we should look at a proper way to evaluate the material since the final product depends on the chemistry among the various material. Corrigan questioned that given all results are at 20 hours PAV, what would be the $\Delta T_c$ of the 10% VTAE with 20% RAP at 40 hours PAV? Corrigan noted the field element and knowing how these binders perform in a pavement with the intended field environment is needed.

Kluttz commented that unusual molecular weight distributions were observed for the binders with odd behaviors. D'Angelo noted the observed asphaltenes and saturates are high for the SARA analysis; hence would expect to have some strange molecular weight distribution; therefore, what is the next criteria needed to address some of these issues? G. King commented the 0.005 rad/sec was selected to match the ductility and it takes a long time to get that data. It would be interesting to see what the G-R parameter would be at the 1 rad/sec for those binders? There might be a way to adjust the G-R failure criteria to a reasonable frequency. D'Angelo commented it might be a shifting from a higher aging temperature in the PAV to get to the 0.005 for G-R parameter.

Planche commented the SARA data for all four binders were very similar and they all had high asphaltenes and high saturates. Such data can be the result of wax, not well dispersed polymer, REOB, or non-homogeneous material. In the case of these binders, it seems to be the later with an incompatible type of binder.

**13. Update: Development of Rubber Binder Specifications in California. [M. Zia Alavi, UCPRC]**

Presentation Title: *Development of Rubber Binder Specifications in California: Project Update, Zia Alavi and David Jones, UC-Davis.*

Summary of Presentation:
Alavi provided an overview of the asphalt rubber (AR) binder specification according to ASTM D6114 and according to Caltrans definition.

Alavi noted the definition of extender oil needs further clarification since it just refers to an aromatic material. The current specification for AR binder is based only on viscosity. The crumb rubber particle size limits the use of parallel plate geometry in DSR testing. A gap of four times the rubber maximum length is needed in accordance with AASHTO standard procedure; hence an 8 mm gap between the parallel plates would be necessary for CalTran's typical asphalt rubber binder. Accordingly the concentric cylinder geometry was considered. A comparison between the concentric cylinder (CC) and the parallel plate (PP) in terms of sample trimming, testing duration, testing temperature, required material, standard test method, and sample condition was provided.

Alavi presented the AR binder preparation requirements in California: a) when adding CRM, the asphalt binder plus extender oil temperature must be between 190°C (375°F) and 225°C (440°F); b) mixing/interaction duration must be at least 45 minutes; and c) during mixing/interaction period the temperature of asphalt rubber binder must be between 177°C (350°F) and 218°C (425°F).

Alavi presented the limitations in RTFO test method for AR binders. The RTFO test is not appropriate for AR binder because: a) aging temperature is not simulating AR binder temperature during mix production; b) non-uniform aging of AR binder (the RTFO bottles are not fully coated while testing); and c) it is difficult to obtain sufficient amount of AR binder from the bottles after testing. Accordingly, modifications were proposed for the RFTO test to accommodate AR binders including: a) increase testing temperature to 190°C from 163°C to simulate rubberized mix production temperature; b) modify the amount of binder sample (corresponding to 35 g of base binder in each bottle); and c) change testing time.

Alavi presented the experimental plan for the study which included laboratory-produced and field-produced asphalt rubber binders. The main reason for the laboratory produced asphalt rubber binder is to look at the influence of crumb rubber particle sizes. A limitation on the maximum rubber particle size may be required as well as determining if the use of extender oil can be optional. Two types of asphalt base binders (PG64-16, and PG64-16 + 4% extender oil

by weight of base binder) and two sizes of rubbers (passing #60; and passing #8 and retained on #60) were used.

Alavi presented the set up used to prepare AR binders in the laboratory. A mixer similar to the one recommended by Austroads was used. The mixer is not supposed to shear the material and allows for a proper circulation of the rubber material in the asphalt. Crumb rubber was added at a rate of 18% by total weight of binder. Mixing was done at 195±3°C for 85 min (15 min for adding rubber, 45 minutes at 2000 rpm, and 30 minutes at 1000 rpm).

Rheology testing using concentric cylinder geometry and FTIR measurements were conducted. Alavi presented the modifications imposed on the RTFO test. He mentioned that by increasing the temperature and amount of binder helped providing a full coating of the inside surface of the RTFO jar. He noted a concern with the RTFO test conducted at 190°C requiring a good ventilation system when running the RTFO test. Alavi presented the pros and cons of the proposed modified RTFO test:

- Advantages: full coating of the bottle; produce more RTFO residue; initial pre-coat of the bottle is much easier; residue is more readily poured out of the glass; easier to scrape the residue; produces more RTFO residue.
- Disadvantages: extra fumes and smoke while running the test; possible overheating of the binder (procedure will be validated using field produced binders/mixes)

For low temperature testing, modifications to the BBR mold were proposed in order to remedy some of the issues associated with pouring the binder and preparing a uniformly shaped binder beam. The modification to the BBR specimen preparation consists of pouring the sample into the molds typical side dimension facing upward compared to the conventional narrower top dimension BBR mold.

Increasing short-term aging temperature resulted in increasing binder stiffness and reducing phase angle. Larger sample size results in a reduced aging effect. However, it was not as effective as increasing the aging temperature. Increasing the aging temperature to 190°C increased the high PG temperature by up to 9°C. Using a modified BBR mold successfully remedied most of the limitations associated with the AR binder beam preparation. The torsion bar fixture and modified bob spindle are the required alternatives for characterizing AR binders at intermediate temperate range.

ETG Comments, Questions, and Discussion:

D. Anderson commented that the sensitivity of the BBR test is highly related to the thickness of the specimen and by flipping the pouring direction of the specimen you will be facing a large variability in the test results if the thickness of the specimen is not controlled. He also noted that the new BBR test method will be talking about using silicone paper which should solve the problems that are being faced with sample preparation. Alavi responded he will be looking at the variability of the results with the modified BBR specimen preparation along with other sample preparation options. Alavi noted these changes are recommended for their typical high rubber content and large size rubber particles.

D. Anderson suggested looking over the heating technique used to prepare the AR binder. He raised a concern of generating hot spots within the sample during preparation. D. Anderson

suggested a heating setup in an oil bath. Alavi agreed and noted an attempt to minimize hot spots was made by checking the internal temperature of the specimen during mixing for 1.5 hours. Alavi also noted the rubber is added at small rates into the asphalt binder to avoid any overshoot in the temperature to control the temperature within the specified limits. He also noted the mixer is not at the center but 1/3 from the edge in order to have enough circulation of the sample (circulation flow was checked using ink).

Ioan Negulescu commented a paper was published in AAPT 2014 by Gaylon Baumgardner discussed how to identify the amount of synthetic and natural rubber in a blend. Reinke asked why not look into the 4 mm DSR test for low temperature and not just the torsion bar test. Alavi responded particle size was anticipated to be an issue with the 4 mm DSR but limited testing will be conducted to confirm.. Ioan Negulescu suggested using a nitrogen blanket to minimize aging that is occurring during the 1.5 hours of mixing. Alavi responded the heating and mixing setup was aimed at simulating the field condition as much as possible.

Corrigan commented this work is trying in some way to simulate what is being done in the field environment to the extent possible in the laboratory environment; hence not the use of high shear blending, continuous agitation, and high mixing temperature. These considerations should be taken into perspective when assessing the presented effort. Corrigan acknowledged D. Anderson's concern with the issue on the heating mental; he questioned whether the issue of hot spots exists if the material is continuously being agitated and if so what is the solution? D. Anderson emphasized the need to be cautious with heating devices; he also suggested consulting with chemical engineers in order to address the mixing problem. Planche mentioned that similar research is being conducted at the University of Nottingham.

### 14. PCCAS Asphalt Rubber Binder Testing Efforts. [Shauna TecleMariam, Consultant]

Presentation Title: *PCCAS Asphalt Rubber Binder Round Robin Phase II, Shauna TecleMariam (Consultant)*

Summary of Presentation:
TecleMariam stated that PCCAS took a different approach to ground tire. A number of suppliers proposed that high concentration of ground tire rubber asphalt binders can be graded following the standard PG specifications. A round robin task group was formed accordingly. The first phase was limited in testing. TecleMariam presented the second phase of the round robin which consisted of three field samples that were tested in 20 different labs. A testing protocol was provided on how to run the test and all samples were run in triplicate. The base binders consisted of PG70-10, PG64-16, and PG64-22 from three different suppliers. The rubber content was between 18 and 22% (scrap tire and natural rubber).

TecleMariam noted very limited testing is currently being done on asphalt rubber according to the current specifications (cone penetration, resilience, softening point, viscosity). All labs were provided with written protocol and an excel spread sheet for entering data. All participating labs were asked to report back the equipment model and software used. TecleMariam noted the presented results are not final. The following were her observations from the study:

- DSR looks more reproducible as the binder ages.

- AASHTO reproducibility placed on the graphs show most of the data would fall within published ranges.
- ASTM was used for Elastic Recovery and results don't look very good, maybe method needs to be modified for better results.
- BBR m-value don't look bad.
- BBR stiffness does not look good but the numbers are very low, maybe the reproducibility is not as good when the numbers are low..

Outliers were defined as three standard deviations. The mass change was included but should not be used (most of the time asphalt material started to creep out of the RTFO bottle). Some lab participants were allowed to tilt their oven with the AASHTO protocol allowance (±1 degree tilt). TecleMariam noted the materials did separate during the PAV conditioning.

TecleMariam presented the results from the statistical analyses of the data for Sample A, B, and C. The results were mainly compared to the AASHTO reproducibility limits. Data is considered normal for skewness (<1) and Kurtosis (1-5). The mass change was not reported by all of the laboratories. Similar to terminal blend, there is PBATR specification in CA, and the effort focused on whether it can also be done for field asphalt rubber blends. TecleMariam noted the BBR stiffness results were different where the two standard deviations were larger than the AASHTO limits. The stiffness values were low which may have contributed to the higher variability. Sample B was the worse in terms of creeping out of the RTFO bottle and sample B was a softer binder than the others.

ETG Comments, Questions, and Discussion:
David Anderson questioned whether the outliers are caused by the results of very few labs. TecleMariam agreed and noted one or two labs were not familiar with the tests and caused the results to be skewed. D'Angelo questioned what is being tested and what the numbers really mean? Repeatable results might be achieved however previous work showed significant difference between the data from the cup and bob and 3 mm plates. TecleMariam responded the first goal was to check whether the results can be repeated and how the variability compares to the AASHTO reproducibility of the existing tests. The second goal, since the results were proven to be reproducible (except for the BBR S-stiffness), was to develop some kind of specifications that can be tested between labs. D'Angelo questioned whether the goal is to develop a specification to allow for checking consistency in the material? TecleMariam noted the effort is an attempt to move away from the current specification tests that is based only on four tests. D'Angelo commented if consistency is being looked at then why not stick with the original DSR instead of the RTFFO or PAV. TecleMariam mentioned the motivation was the current PBATR (terminal blend) specification in California.

Corrigan noted FHWA only participated in the second round of testing and the issue with RTFO material creeping out of the bottle in the second round was not observed by others in the first round. TecleMariam confirmed none of the labs from the first round reported an issue with the RTFO. She also noted the first round binder was a PG70. Corrigan noted tilting of the bottles, while it is still within the allowable standard tolerance, is what might be creating the scatter observed in the data. A one degree tilt results in uneven coating of binder within the RTFO bottle with a thicker pool of binder near the bottom. He also noted it might be difficult to fit

within Caltrans specifications without a need to change the geometry or conditioning procedures due to the high rubber percentage and large rubber particle size.. TecleMariam commented she will need to go back to the PCCAS and noted that some suggested running the RTFO test differently.

Corrigan commented FHWA encountered similar issues on asphalt rubber projects located across the country yet data is being reported without noting the testing deviations or issues encountered; which would lead many to believe there are none of these issues occurring. Reported results without including the deviations from the standard procedures and the issues encountered during testing provides very little confidence in the reported values. It is apparent the typical high rubber percentage and large particle size rubber asphalt material common in California cannot fit in the existing PG grading system. TecleMariam noted the first round was successful but it was only one binder compared to the second round which is three binders and three suppliers.

B.McGennis commented the purpose of the current tests are primarily to tell you that you are using enough time and temperature to get the proper reaction between rubber and asphalt. Hence, since suffering with material creeping out of the RTFO bottles why not simply run original DSR at a representative temperature? It would give you an idea about if the proper reaction between rubber and asphalt occurred. TecleMariam responded we don't know how many labs had problems with the RTFO. She noted Caltrans is trying to see how AR blends can be more generic rather than recipe blends requiring specific temperature and time to react and activate the rubber

### 15. NCHRP 9-49A WMA Long Term Field Performance. [Haifang Wen, WSU]

Presentation Title: *NCHRP 9-49A Project Update: Performance of WMA Technologies: Stage II – Long-Term Field Performance, Haifang Wen, WSU*

Summary of Presentation:
Wen presented an update on the findings from the NCHRP 09-49A study. Wen stated the objectives of the study was to identify the material and engineering properties of WMA pavements that are significant determinants of their long-term field performance, and to recommend best practices for the use of WMA technologies. A total of 27 field projects were evaluated with a total of 40 HMA-WMA pairs. Project distribution was provided in terms of the WMA technology, pavement age, traffic, and pavement structure. Wen noted most projects ranged between 5 and 10 years age and most of them were constructed as overlays. Field samples were collected and mixtures were evaluated for: IDT Dynamic modulus/creep compliance, IDT fracture at room and low temperature, and Hamburg rut performance.

Two field distress surveys were conducted in 2011 and again in 2013. The first survey showed 14 out of 24 projects exhibited transverse cracking (21 H-W pairs). The second survey on transverse cracking showed 22 out of 28 projects exhibited transverse cracking (35 H-W pairs). Overall HMA showed comparable or more/longer transverse cracks than the companion WMA.

The significant determinants of transverse cracking were determined by comparing material properties to field performance. The mix work density at 14°F and dynamic modulus were

found to be the most determinant factor for transverse cracking. In terms of binder, the BBR binder stiffness was found as a reasonable determinant factor.

The results of the first survey for top-down longitudinal cracking (wheel-path) were also provided where 8 out of 24 projects exhibited top-down cracking (18 H-W pairs) in the first round. Overall HMA had comparable top-down cracking performance when compared to WMA. In the second round, 14 out of 28 projects exhibited top-down cracking (24 H-W pairs). Overall WMA had slightly more top-down cracking performance than HMA. The mixture IDT strength and the mixture vertical failure deformation at 68°F were found to be the most determinant factors for top-down cracking. No binder properties correlated with top-down cracking.

In the case of rutting, HMA and WMA are shown to be comparable in terms of rut depth for the various WMA technologies. The rutting resistance index (RRI) from the Hamburg test results, the Low and high PG were found to be the most determinant factors for rutting. No moisture damage was observed in the field.

Wen discussed three projects where data was collected from the project beginning: MT I-15, TN SR 125, and IA US 34. The results for the PG grading, MSCR, and binder fracture tests on the extracted and recovered asphalt binders from field cores were presented. The binder properties for the 2011 and 2013 field cores were similar. On the other hand the effect of aging was more obvious in the case of the TN SR 125 and IA US 34 projects.

Wen followed with a presentation on aging modeling (not part of NCHRP study). Binders from all three projects (MT, IA, and LA) were aged in the laboratory at different temperatures and for various aging durations. A universal model with parameters was developed and presented.

ETG Comments, Questions, and Discussion:
Alavi commented Glover recently published a study showing the activation energy can be predicted from the RTFO and PAV testing on asphalt binders. Wen commented the universal model is for agencies that are not looking to run any testing and willing to sacrifice a little bit of accuracy. Planche suggested looking at the paper by R. Glaser on the aging model and the addition of sulfoxide to the model.

D. Anderson commented the log of the cross over modulus is the rheological index R-value. He noted the cross over modulus is only a part of the rheological characterization and the location on the frequency axis is also important for the full characterization (both need to be combined together for determining the rheological behavior).

Corrigan acknowledged the large level of effort and the significance of the work that went into this research effort. Corrigan asked Wen for an overall recommendation from the analyzed data. Wen responded that no specific binder properties can be recommended to predict field performance, however mix property was a better indicator of field performance.

A. Golalipour questioned the relationship between the low PG and rutting. Wen responded both high and low PG correlated to rutting. The low PG showed good correlation with rutting because typically the high and low PG were related.

### 16. Meeting Adjournment

M. Anderson adjourned the meeting for Tuesday at 5:08 PM.

## DAY 2: Wednesday, September 16, 2015

### 17. Call to Order

M. Anderson (Asphalt Institute) called the meeting to order at 8:04 AM.

### 18. Asphalt Binder $\Delta T_c$ and S Value. [Jack Youtcheff, FHWA]

Presentation Title: *Examining the use of ΔTc to Screen Presence of High REOB, Pavement Materials Team, TFHRC, Presentation Made by Adrian Andriescu*

Summary of Presentation:

Adrian Andriescu presented the results from the on-going TFHRC study on REOB. Two modification approaches were used in the study: (1) softening an unmodified PG to another PG (PG64-22 + 6% REOB → PG58-28), (2) diluting an unmodified PG (PG58-28+20% PG100-0 → PG69-24+15% REOB → PG58-28; PG58-28+2.5% REOB → PG58-28).

Andriescu showed the efficiency of REOB with different SHRP parameters. On average, for three different types of REOB, a 9%, 21% and 9% REOB for PG grade drop in the DSR high temperature, BBR m-value, and BBR S value were observed, respectively. Hence, showing that m-value is being modified with very low efficiency. In other words, more than double the quantity of REOB is needed to modify the m critical temperature compared to the DSR high temperature and the S critical temperature.

Andriescu presented the influence of REOB type on the delta $T_c$. The results for $\Delta T_c$ as a function of REOB content for both regular and extended BBR aging (2 times PAV) were also presented. A decrease in the absolute value for ΔTc is observed with 2.5% REOB before it starts increasing with the increase in percent of REOB. The difference between the regular and extended BBR results were more pronounced at higher REOB contents. Results for STOA and LTOA extracted PG grades from a mixture with 22% RAP were also provided. An increase in the $\Delta T_c$ was also observed with the increase in REOB dosage.

Andriescu also presented the BBR results versus transverse cracking from a field study in Rochester, MN (slide taken from a presentation by WRI). No correlation was observed between TSRT fracture temperature and ABCD temperature or BBR-S temperature. Some kind of correlation was observed between TSRST fracture temperature and the BBR-m value temperature.

Andriescu summarized the findings from the study.

- Presence of REOB can readily be detected but cannot identify the quantity (round robin XRF results may shed more light on this).
- The effect of REOB depended on the base binder (like PPA).

- Variations between REOB suppliers and their samples was observed. Same concentration can produce different PG grades.
- The 40 hour PAV is a reasonable approximation of 5 years in the field.
- REOB softens and reduces tensile strength
- In 2 of 3 cases, REOB improved binder intermediate temperature parameters for fatigue / strain tolerance.
- Rheological "disruption" occurred w/ highest %REOB

Andriescu concluded that low concentrations of REOB did not appear to adversely affect binder and mixture properties. High concentration of REOB resulted in consistent loss of strength in different binder and mix test methods. It was recommended to further examine the $\Delta T_c$ as a flag parameter and re-examine the current minimum S value.

ETG Comments, Questions, and Discussion:
Ray Bonaquist asked if there is a plan to extend this work into the RAP/RAS mixes/sections from the ALF especially since RAS also results in a large $\Delta T_c$. Andriescu responded current ALF experiment will not end before the end of this year and evaluation of RAP/RAS is currently in discussion. Alexander Brown commented adding polymers to the asphalt binder may also impact $\Delta T_c$ while anticipating the polymers are positively affecting performance. He supported the use of the word flag for $\Delta T_c$ triggering the necessity to look for the cause for a large $\Delta T_c$. Andriescu responded FHWA did not investigate the influence of polymer or PPA on $\Delta T_c$, but when adding REOB the $\Delta T_c$ becomes larger after a certain dosage rate. Andriescu noted a paper summarizing the effort has been submitted for publication at AAPT.

King commented RAS has an incredibly large $\Delta T_c$ and we don't know whether RAS is acting as black rock or not. Hence, we cannot extract the binder from the mix to get a $\Delta T_c$ as it will not be representative of the true $\Delta T_c$ of the binder in the mix. Hence, the focus should be on how to test the mixture for an equivalent property to m-value. This becomes valuable from the pavement preservation point of view to identify the appropriate time to apply a pavement preservation before cracking.

Kluttz commented polymer is a soft additive compared to asphalt and it may in the original formulation result in a 0.5°C to 1°C loss in $\Delta T_c$

**19. Mixture ETG RAP/RAS Task Force: Summary and $\Delta T_c$ Recommendations. [Jim Musselman, Florida DOT]**

Presentation Title: *RAP/RAS Team Update, Jim Musselman, Florida DOT and Gerry Huber, Heritage Research Group.*

Summary of Presentation:
Musselman presented an update on the Mixture ETG Task Force (TF) effort. He noted currently the main focus of the team is RAS. The main two items the TF was charged with were: 1) RAS asphalt binder availability; and 2) binder grade adjustment guidelines. Hence leading to the two issues of 1) how to address the stiffness/brittleness of the RAS binder, and 2) how much of the RAS binder becomes effective asphalt binder. In other words, how to assess the quality and

quantity of the RAS binder? Musselman noted the current approach uses a RAS binder availability factor between 0.7 and 0.85. It is up to the owner agency to determine the appropriate RAS binder availability factor. Furthermore, the current approach calls for a binder grade adjustment to the recommended virgin asphalt binder grade based on the percentage of RAS or RAP+RAS. Musselman mentioned that TF members came up with an alternative approach that focus on the brittleness of the blended asphalt binder using the critical temperatures ($\Delta T_c$). The alternative approach assumes the RAS binder is fully extracted and blended with the virgin binder; hence making it a worst case scenario where if blending is less than complete and a portion of RAS is acting as black rock; the impact of the aged binder on stiffening and relaxation is less than the laboratory would predict. If blending is complete and homogeneous, the impact on stiffening and relaxation would be accounted.

Musselman presented the pros of the proposed alternative approach: relatively simple approach; easy for states to make an informed decision on setting RAS limits based on available virgin binders and existing RAS materials; and cons: doesn't address mixture issues, VMA, if RAS binder does not become fully blended, some potential issues with virgin binders meeting the -5°C criteria. If RAS does not become fully blended, the binder volume would be less than calculated. For example a binder availability of 0.70 would result in a VMA reduction of ~ 0.50%.

To simplify the process further, the TF is looking at setting a maximum Recycle Binder Ratio (RBR) for mixtures with RAS. For example, a maximum RBR of 0.19 which corresponds to roughly 5% RAS with $\Delta T_c$ of -5°C. States that want to exceed the max RBR limit would need to evaluate $\Delta T_c$ on the actual materials used. In summary the TF believes $\Delta T_c$ is a good parameter to address quality but not the quantity of RAS binder. He noted the inclusion of RAP + RAS would also complicate the issue further and the TF has not addressed this RAP+RAS combinations.

ETG Comments, Questions, and Discussion:
Kluttz commented a very standard method in polymer science to toughen the material by putting a relatively small amount of tough material in a more brittle plastic so that when a crack tries to propagate it runs into the tough zones and stop. With more brittle material like RAS, we are talking about a maximum degree of mixing, but Kluttz questioned whether we have a minimum degree of mixing and we add the RAS (brittle material) into the mix would that promote cracking in the mixture? Such phenomenon cannot be determined from binder testing alone. Kluttz questioned whether there is data available that evaluated the performance of a mixture with fully blended RAS + virgin binder compared to a mixture with partial blending of RAS + virgin binder? The question is whether the unblended RAS binder is better or worse than the blended RAS binder with regards to the mixture performance.

Bukowski commented RAS binder in the mix has three stages: RAS binder coated on black rock, some is blended with virgin binder, and a part of RAS binder that is not blended (loose RAS binder in the mix) which is believed to be the most critical phase. Not all RAS materials are the same. D'Angelo commented that the availability of a current tool to assess RAS is what is critical. Bukowski mentioned that not all RAS materials are the same. R. West commented the

$\Delta T_c$ criteria would be used to select the virgin binder for a mixture that includes RAS. He also recognizes the need for a mixture test as well.

Huber questioned whether using $\Delta T_c$ is a valid approach for controlling or evaluating the influence of RAS binder property on the overall binder property. King commented he believes $\Delta T_c$ is a good approach, however the criteria $\Delta T_c$ of -5°C is when we think cracking is significant if RAS is fully activated and blended into the virgin binder; which is not likely the case in reality. Reinke commented you need to get to a very high level in RAS before the impact on $\Delta T_c$ becomes critical especially when using a good/reasonable virgin asphalt with a proper initial $\Delta T_c$ . He also mentioned in the Minnesota data, one of the binders had a $\Delta T_c$ of -4°C and was showing significant distresses in the field while the binder did not have any RAS or REOB. Reinke raised a concern about original asphalt starting with a 20 hours PAV $\Delta T_c$ = -5°C should not be used.

Corrigan asked what if at 20 hour PAV the material is at the border line of -5°C? The concern becomes how would that material behaves as it continues aging when 20 hours doesn't accurately reflect long term field ageing. He suggested looking at extended PAV conditioning such as 40 hours PAV. Corrigan mentioned critical information on the material behavior is being detected with the extended aging for both binders and mixtures, especially with high recycled binder ratios. He raised a concern with just having the -5°C at 20 hours PAV in the AASHTO procedure because valuable information is obtained at both 20 hours and 40 hours to understand the materials aging behavior related to field performance
Corrigan noted mixtures with only RAS are rare; and RAS would typically be used with the addition of RAP material in a mix. Hence, the TF would also need to eventually address the RAS+RAP component in the standard. Corrigan suggested the $\Delta T_c$ portion of the procedure need to include and be vetted by the Binder ETG while the TF concentrate efforts addressing the mixture issues as part of the Mix ETG. Musselman agreed with Corrigan's suggestion.
Huber commented an agency would look into RAS material and virgin binder material supplied to a specific area and evaluate how the two materials are being reacted based on $\Delta T_c$ and set a policy on the allowable RBR as opposed to conducting a mix by mix or project by project basis evaluation. Buncher commented several states have currently placed a limit on RBR, but what is being proposed by the TF is strictly a limit on the RAS binder ratio only.

Bukowski raised a concern that the proposed changes seem to be more liberal than what it is currently in the standard, especially given the observed issues with RAS material in the field across multiple States. Musselman agreed that the presented limit for RAS percent (i.e. 5% limit example) is an example number only and needs to be revised to bring the number lower in alignment with current recommendations..

Danny Gierhart commented there was a discussion about selecting a very conservative value for the RAS binder ratio above which a series of mixture testing and evaluation need to be completed. Musselman commented the TF also discussed the tiered approach where testing $\Delta T_c$ would be required above a specific RBR value (Tier 2). Reinke presented some data for manufactured waste RAS where the $\Delta T_c$ was not a concern when using RAS in the range of 2 to 3%. West commented binder was recovered from four un-trafficked test sections (non-load related type of cracking) from the NCAT track and $\Delta T_c$ was in range of -2.6 to -9.3°C. Two of

the sections -2.6 and -3.8°C did not crack while the -4.2°C showed some cracking and the -9.3°C showed severe cracks. Also a section from last test track cycle with 20% RAP and 5% RAS showed high extensive cracking after 6 years and it had a $\Delta T_c$ of -15.8°C. Also another section with only RAP in it had some cracking and had a $\Delta T_c$ of -6.2°C. It seems that anything below -5°C is cause for concern

Kluttz commented that there should be more emphasis on distinguishing between manufactured waste shingles with a $\Delta T_c$ typically -9°C and tear off scrap shingles with a $\Delta T_c$ typically -20°C. Louay Mohammad suggested the Tier 2 $\Delta T_c$ testing should be complemented with some mixture testing. Karl Zipf noted, in Delaware, manufactured waste shingles are used with some additional tear off scrap shingles in order to keep it off from sticking. P. Marks commented in Ontario manufactured sand is used to keep shingle stockpiles from sticking.

M. Anderson commented the proposed approach does not take into consideration whether it is manufactured or tear off; regardless, the limit on RBR is the same. There is still a need to work out the details for whether the virgin binder is to be S-controlled or m-controlled. Musselman commented the team has to assess whether the advantages of the tiered approach offset the potential negatives discussed. By setting a maximum RBR it might be sending the wrong message that adding RAS below the RBR limit is not a problem while in reality RAS is a very complex material and some additional testing would be needed. Corrigan commented it a tiered approach would be in line with the additional recommendations to AASHTO for an additional lab evaluation to understand the impact of the material on performance when trying to go for higher RAP contents as well.

Anderson noted the proposed $\Delta T_c$ of -5°C is based on how RAS influences the binder and not based on where the $\Delta T_c$ started. Bukowski commented while FHWA and SHAs were raising concerns with the use of RAS without engineering support based on reported incidents of pavement failure, others are hearing alternative presentations about RAS being easy to use and it is a great recycled resource. Hence, the need to develop clear national guidance on the use of RAS in asphalt mixtures within the standard.

D'Angelo noted if RAP and RAS are both being added to the mix then there is still a need to evaluate the combination of RAP and RAS. King mentioned the on-going effort under the NCHRP 09-58 and suggested for the task group to reach out to the research team.

Corrigan commented the task group effort is very relevant to the Binder ETG and needs to be coordinated between the Mix and Binder ETG. There is a need to see how this effort ties back to other relevant efforts that have been going on within the Binder ETG with materials other than RAS. Corrigan also raised a question about the assumption for the linear blending chart analysis for RAS materials or for RAP+RAS materials. A. Brown commented the blending of RAP with WMA is longer than with HMA; and the blending of RAS is even longer than WMA+RAP. Alavi mentioned based on his experience it was hard to blend the RAS with virgin binder so he ended up freezing the RAS crushing it and adding it as a powder to the virgin binder. Golalipour commented the diffusion rate and period are different for manufactured scrap and tear offs.

Musselman noted the task group is aiming at having modifications to these standards by March. Hence, the binder ETG input would be needed within the next six months. The mix ETG has work remaining on the mixture testing performance and the VMA issue. Corrigan asked what data is needed to help support the task group in recommending the appropriate limits in the standard? Musselman responded the group would like to know what $\Delta T_c$ limit to use and whether there is a need for extended aging.

Bonaquist commented the $\Delta T_c$ route requires extraction and recovery which necessitates recommendations to specify how to recover the RAS material. Bukowski commented a three tiered approach could be Tier 1 with a safe level of RAS, Tier 2 combination of binder and mix testing, Tier 3 further testing and evaluation needed

Action Item(s):

**Action Item #201509- 4: Binder ETG group will provide the Mixture ETG RAP/RAS Task Force with any data on delta $T_c$ values for mixtures with RAS and RAP. Also, provide guidelines/recommendations on the issues associated with extraction/recovery of RAS material.**

### 20. WRI's FPIII Contract Deliverables and Tech Briefs [Jean-Pascal Planche, WRI]

Presentation Title: *FPIII TechBriefs, J. P. Planche, F. Turner, R. Boysen, M. Farrar, R. Glaser, and J. Schabron, WRI*

Summary of Presentation:
Planche acknowledged the WRI research team, FHWA team, and the Binder ETG members and friends for support and direction. He presented the FPII contract background, deliverables, TechBriefs, and summary and perspectives. The scope of the project spread over different areas:

- Moisture damage mechanisms
- Oxidative aging mechanisms and modeling
- Nano-structuring and modeling
- Additives
- Reclaimed asphalt pavement studies
- Warm mix asphalt mechanisms and testing
- Emulsion test development

The deliverables consisted of 23 papers (technical white papers), 2 final reports, and 6 Techbriefs. The two final reports consisted of Volume I on Fundamental and Applied Research and Volume II on Methodology. A list of the 23 technical white papers was presented which are available online at: **http://www.westernresearch.org/transportation.aspx?id=2662**. Planche discussed further the findings from the six different techbriefs:

- 4-mm DSR (Dynamic Shear Rheometry): the test is provided as an alternative to BBR test especially for evaluating field samples.

- Asphalt Pavement – Micro-Sampling and Micro-Extraction Methods: rapid field sampling procedure was developed using hammer drill with a 1 inch masonry bit and vacuum dust collector. Asphalt binder is recovered from micro samples using solvent.
- The Universal Simple Aging Test (USAT): draft AASHTO method was developed for HMA/WMA simulated aging, polymer-modified asphalts were investigated, temperature and time values to simulate HMA and WMA were established. More validation is needed in both laboratory and field. Draft AASHTO method is also available for the emulsion residue aging. There is still a need to establish PAV time and temperature to simulate emulsion residue field aging.
- The Asphalt Binder Oxidative Aging Chemo-Mechanical Model: universal rate equation was developed which is based on both sulfoxide and carbonyl. Two universal arrhenius equations are required (same activation energies for about 30 asphalt binders).
- Automated HPLC SAR-AD Separation: a new way to analyze the generic composition of asphalts and heavy oils was developed. It is fully automated, combined, and advanced separation of Saturates, Aromatics, Resins and Asphaltenes. It is conducted on small scale samples and fast (2 mg, 4 hrs). Patents were issued and are pending.
- Analytical Method to Measure Water in Asphalt and its Application to Emulsion Residue Recovery.

ETG Comments, Questions, and Discussion:
Kluttz expressed his satisfaction with the finding that a constant rate exponent seems to be universal in the chemo-mechanical model. However, he was not expecting to find a universal pre-exponential constant. Kluttz also cautioned from using the model with modified asphalt binders due to the kinetics of polymers. Planche agreed the model works for unmodified asphalt and requires adjustments for modified asphalts.

### 21. Binder Rheology 101 – Fracture Through Stiffness. [David Anderson, Consultant]

Presentation Title: *Strength from Stiffness (Ultimate Properties Must Be Considered Relative to Stiffness), David Anderson, Professor Emeritus, Penn State and Geoffrey M. Rowe, Abatech.*

Summary of Presentation:
David Anderson acknowledged Geoff Rowe as a co-author of the presentation. Anderson defined ultimate properties as a property that can be used to characterize or rank a material at the time of rupture. He noted it can range between "fundamental" and empirical property. Some examples were given for the ultimate property tests such as: strength (not fundamental property, value depends upon specimen size and configuration, and easy to measure); fracture properties (properties independent of specimen size and configuration, difficult to measure-require viscoelastic characterization); and energy to Failure – Cohesive energy to fracture (not fundamental property, value depends upon size and configuration, easy to measure)

Anderson stated ultimate properties depend upon test temperature and rate of loading and obey time-temperature equivalency. The literature for a wide range of materials shows both linear, non-linear, and empirical index properties obey time-temperature superposition. Anderson stated the objectives of the presentation are to: (1) illustrate how rheology can be used as a descriptive tool for ultimate properties; (2) demonstrate that an understanding of rheology is necessary to

properly interpret and use ultimate properties; and (3) cover the three major items that need to be considered.

*Issue 1: Strength versus temperature*
Anderson listed a wide range of research where strength is normalized with respect to temperature. He emphasized to always go back and complete a literature review before the start of any new research study. Results from various literatures were presented. Anderson summarized stiffness is important to describe strength, strain and properties at break. Other parameters could be used that include effect of time and temperature, however, stiffness is conceptually easy to understand since it is typically used as a specification parameter. Properties are both a function of loading rate and temperature (applies to range of visco-elastic materials, bitumen, asphalt mixes, rubber, SBS, others, etc.).

*Issue 2: Brittle to instability flow (ductile)*
Anderson stated fatigue and fracture will exhibit a brittle to instability flow (ductile) transition. While stiffness can be used to define the transition between "ductile" and "brittle" failure, it is not a single stiffness value but a range. Failure mechanism changes as pass through transition where "True" fatigue behavior with crack propagation in traditional sense occurs below the transition, and crack formation by viscous flow occurs above the transition. Anderson discussed the evolution of failure in LAS test where flow is observed at a temperature above room temperature.

*Issue 3: Importance of rheological behavior when evaluating ultimate properties*
Anderson stated linear viscoelastic behavior relates to ultimate properties whether they be fatigue, "cracking" strength, or whatever the property of interest may be. There should be consideration of the time-temperature dependency of a given property. The transition between ductile and brittle is very important. He highly emphasized the need to conduct comparisons at equi-stiffness when comparing ultimate properties. Hence, requiring the determination of the stiffness characteristics accurately for the range that affects cracking.

ETG Comments, Questions, and Discussion:
Dave Anderson noted when using ultimate properties with respect to fatigue requires consideration of the time and temperature dependency of that binder. The true effect of a modification to a binder is only captured when comparing at the same stiffness property.

Mike Anderson asked while waiting for the TRB circular on binder rheology that Geoff Rowe, Dave Anderson, and JP Planche are working on, whether it would be possible to have a report detailing the information presented that can be shared with the Binder ETG group. Dave Anderson responded that it is something which he and Geoff Rowe would like to pursue but time availability plays a major factor.

### 22. LTPP Bind Software Update & Beta Testing. [Matthew Corrigan, FHWA]

Presentation Title: *Update and Improve LTPPBind, Matthew Corrigan and Larry Wiser, FHWA*

Summary of Presentation:

Corrigan has been helping to facilitate work with the FHWA LTPP section on updating LTPPBind software. He mentioned FHWA will be asking for volunteers to evaluate the alpha and beta versions of the new software. Some issues were identified with the climatic data of the current version of the LTPPBind software with regards to missing data, the distance between ground base weather stations (less than a 1,000 available in the US and a virtual weather station is created if a location is in between those ground base weather stations). The new project is specifically looking at a way to get more consistent and more robust climatic data set in order to use as the climatic information within the LTPPBind software

Corrigan noted the biggest change in the climatic data is shifting to the MERRA Weather Data Tool which is developed and processed by NASA. It is a very robust data set, is satellite based, updated very frequently using robust analysis to make sure data is appropriate and correct, and covers the entire word. Hence the LTPPBind product can be used for PG grade selection over the entire world and not just limited to North America.

Currently there is a complete data set that goes back to 1979. There is a two weeks delay in the population of the new data continuously being collected and added. Currently there are 4.2 million observations globally updated every six hours and populated to the products using these data every two weeks. The additional benefit, other than the robustness of the data set, is the additional data provided such as cloud cover and wind speed.

The current resolution is 1/2 degree latitude by 2/3 degree longitude data grid and NASA is working on improving that resolution. Corrigan mentioned currently no part of the US is going to be more than 25 miles away from one of the MERRA data grid points. In the future, with the expected improvements in resolution, it won't be more than 2,297 feet away from a MERRA grid point. Hence we shouldn't be dealing with data interpolation and other issues with the ground base weather station observations.

The new software is going to maintain the ability of using the LTPP climatic data as it existed before shifting it to MERRA. It will help to look into the impact of shifting to the use of MERRA on other products that make use of the climatic data such as the PavementME. The Alpha release is planned for January 10, 2016 at TRB and the beta release in April 2016. The current plan is to go-live on July 2016 with the release of the LTPP Standard Data Release 30. Alpha and Beta testers are needed. Corrigan encouraged contacting Larry Wiser, who is managing the program, if they are interested in beta testing the new LTPPBind analysis tool.

ETG Comments, Questions, and Discussion:

D'Angelo asked whether the software is going to be free of charge. Corrigan assumed it is going to be free like most everything created by FHWA. King commented they tried to use LTPPBind for determining the relative residue of chip seal for a Federal Lands Highway Division project in California. The project changed in altitude from 1500 ft to 8200 ft within 25 miles between the start and end of the project, resulting in a change of 4 PG grades and 3 PG grades on the high and low end, respectively. They were trying to estimate the PG grade needed by elevation throughout the road length. King questioned whether the new software will be able to provide the elevation of the weather site data and whether the LTPPBind has an elevation adjustment for the data in order to get elevation estimate PG grades. King asked whether the location does not

have to be at one of the grid points available in the data set and if there will be a possibility to have a point of interest between the grid points where an adjustment can be applied for the weather data. Corrigan responded since it is geospatial data it should accommodate the location differences by identifying latitude and longitude of the location. While currently the maximum distance is 25 miles from a MERRA data grid point, with the anticipated improvements it will be no more than slightly less than 2,300 feet. He noted that the current LTPPBind using the ground base weather stations have distances in excess of 100 miles between stations.

Action Item(s):
**Action Item #201509- 5:** ETG members and friends should contact Larry Wiser at larry.wiser@dot.vov if interested in testing the alpha and beta versions of the new LTPPBind software.

### 23. REOB: Effect of REOB on the Performance of Asphalt Mixtures Containing RAS [Louay Mohammad, LSU]

Presentation Title: *Asphalt Mixtures Containing RAS: Effect of REOB on Laboratory Performance, Louay N. Mohammad, Sam Cooper, William H. Daly, Ioan Negulescu, Sreelatha Balamurugan (LSU), and Gaylon Baumgardner (Paragon Services)*

Summary of Presentation:
Mohammad noted the study has two parts: mixture experiment, and binder experiment. The objective of the mixture experiment was to evaluate the low, intermediate, and high temperatures performance of conventional mixtures and mixtures containing RAS (with and without REOB as an RA). The experiment included a single PG70-22M; 0 and 5% post-consumer RAS; and 0, 5, 10, and 15% REOB (total of five mixes). LWT was conducted at high temperature, SCB at intermediate temperature, and TSRST at low temperature.

All mixes did well at high temperature and passed the Louisiana specification for the LWT rut depth. At intermediate temperature, the use of REOB decreased the $J_c$ value ($J_c$ decreased with the increase in REOB indicating an issue with cracking). At low temperature, the addition of RAS (no REOB) resulted in warmer fracture temperature, but the addition of 5% REOB restored the fracture temperature. When 10 and 15% REOB were used, warmer fracture temperatures were observed.

Ioan Negulescu presented the second part of the presentation focusing on the correlation of the molecular structure of asphalt binders to the fracture properties of asphalt mixtures. Asphalt binders were extracted from aged asphalt mixtures (5 days at 85°C) and tested under Gel Permeation Chromatography (GPR) and SARA. Quantitative data could be obtained by integration of the area under the GPC curve.

None of the recycling agents considered in this study mitigated cracking. Even if the mixtures containing RAS had only a fraction of the available RAS binder (36% in the case of PG705P), their asphaltenes content and the size of asphaltenes species as determined by GPC were not changed by the RA.

Negulescu showed a comparison between the critical strain energy release rate versus the content of asphalt species with MW larger than 20K Daltons. The MW threshold of asphaltenes greater than 20K Daltons is related to the stiffness of asphalt binders. Low $J_c$ values, less than the minimum Louisiana acceptance of 0.5 kJ/m$^2$, were registered for mixtures containing PG70-22M binders in which 3-6% asphalt species had MW > 20K Daltons (asphaltenes). However, the PG76-22M mixtures containing sufficient polymers to accommodate RAS retained satisfactory critical strain energy release rate $J_c$s of at least 0.6 kJ/m$^2$. The presence of residual high MW polymer in RAP appears to mitigate the stiffening effect of associated asphaltenes shown in previous slides.

In summary the SARA asphaltenes analysis by precipitation did not capture the total amount of associated asphaltenes in the binder as measured by GPC. Some associated asphaltenes may remain in the resin fraction. Asphaltenes component from the SARA was considerably smaller than the asphaltenes determined from deconvoluted GPC chromatograms

ETG Comments, Questions, and Discussion:
Kluttz raised a concern with the approach of defining the material by the retention time in GPC. He asked whether a SARA analysis was conducted on REOB itself and what was the asphaltenes content. Kluttz noted the polymer is low in REOB (less than 1%) and if concentrated can probably go up to no more than 5%. D'Angelo noted this study is about recycling agents (RA) and one of the RAs investigated was REOB. Hence, the observations can happen with any type of material that is trying to turn RAS binder back into an asphalt which is a significant problem. Mohammad noted this is a recycling agent and not a replacement of the binder.
Kluttz raised another concern is that the very high MW with asphaltenes is assumed to be because of an association and there is no guarantee that the ambient temperature is also associated with free asphalt particularly in high temperature. Dave Anderson noted that MW is not a cause (a co-variate) rather than a fact/observation. He also noted the presented information is about molecular composition and not molecular structure. We currently do not have a good micro-structural model for asphalt binders.

King commented with rejuvenators we are trying to accomplish one of the following: 1) break out the size of the huge molecular conglomeration that are happening especially when using tear off shingles and very oxidized material; hence the absolute numbers do not have a significant meaning but relatively we should compare different RAS material in the solvent and see which RA does interrupt the structure and reduces the size of the cells; 2) does the rejuvenator drop the glass transition of the maltenes in order to improve relaxation properties which has nothing to do with breaking the large molecular size but rather about making the fluid phase heal. Hence it is a relative comparison of materials and absolute numbers are not the correct way to proceed. Tabatabaee commented the observations should not be extended to all recycling agents, different RAs will have different compatibility with different fractions of the asphalt and GPC cannot be the appropriate tool to make a determination whether an RA is good or bad and what it is actually doing. Negulescu responded his statement was good or bad from the point of mechanical characterization of the mixtures. Kluttz commented the calculated MW is from the deconvolution and suggested subtracting the REOB spectrum.

**24. Others**

Corrigan mentioned presentations and minutes from the ETG meetings are now being posted online at the NAPA website: http://www.asphaltetgs.org/. Currently the last couple meetings are available and FHWA will explore how far back they need to go with posting the information from the Binder and Mixture ETGs.

Kluttz noted some refineries are using nonpetroleum based feedstocks to make asphalt products which in some cases they have very unusual properties particularly when trying to modify them (behaving in a very unusual way). These products in some cases are affecting producers and there is need to take a close look at these products.

Action Item(s)

**Action Item #201509- 6: Bob Kluttz to prepare a discussion for nonpetroleum based feedstocks to prepare asphalt binders for next ETG meeting.**

**25. Action Items and Next Meeting—Mike Anderson (Asphalt Institute) and Matthew Corrigan (FHWA)**

***Action Items:***

**Action Item #201509- 1: Dave Anderson agreed to send the sample preparation protocols and the machine compliance verification protocol for the 4 mm PP test in DSR to post with the meeting minutes. Include warnings and guidance in the compliance check protocol related to the potential consequences of proper usage.**

**Action Item #201509- 2: Matthew Corrigan (FHWA) will forward the clarification note on MSCR negative elastic recovery to SOM Technical Session 2b for their consideration.**

**Action Item #201509- 3: Mike Anderson (AI) will draft a request to the ETG group for input and feedback on the issues/concerns and the development of an action plan for the MSCR implementation issues.**

**Action Item #201509- 4: Binder ETG members and friends with any data on $\Delta T_c$ for binders with RAS and RAP are asked to provide the data to the Mixture ETG RAP/RAS Task Force. Also, provide the Task Force any specific guidelines/recommendations associated with extraction/recovery of RAS material.**

**Action Item #201509- 5: Binder ETG members and friends should contact Larry Wiser at larry.wiser@dot.vov if interested in testing the alpha and beta versions of the new LTPPBind software.**

**Action Item #201509- 6: Bob Kluttz to prepare a discussion for nonpetroleum based feedstocks to prepare asphalt binders for next ETG meeting.**

**26. Next Meeting Location and Date:**

The next meeting date was coordinated with the Mixture ETG and will be during the week of April 25th. Currently two potential meeting locations: Reno, Nevada and Salt Lake City, Utah. Corrigan noted this would be the last meeting for SME supporting the ETGs and there will be a new contract for next year. He thanked SME and Lori Dalton for their help and support throughout the previous year's efforts.

**27. Meeting Adjournment**

M. Anderson thanked everyone for their participation and adjourned the meeting at 12:00 pm.

## ATTACHMENT A

# Asphalt Binder Expert Task Group
**Oklahoma City, Oklahoma**
**September 15-16, 2015**
## Meeting Agenda - Draft

**Day 1 – Tuesday - September 15, 2015**

| | | |
|---|---|---|
| 8:00 am | Welcome and Introductions | **Baumgardner/M. Anderson** |
| 8:10 am | Review Agenda/Minutes Approval & Action Items | **Corrigan** |
| 8:15 am | Update: PAV Degassing Issues, and<br>Update: 4mm DSR Testing | **D. Anderson** |
| 9:00 am | MSCR Specification: Questions, Clarifications, & Emphasis | **M. Anderson** |
| | Binder ETG Discussion & Comment | |
| **10:00 am** | **BREAK** | |
| 10:15 am | REOB: Asphalt Institute Task Force Update | **Buncher** |
| 10:30 am | REOB: Evaluation and Performance | **Reinke** |
| 11:15 am | REOB: TFHRC Research Update | **Gibson** |
| **Noon** | **Lunch Break** | |
| 1:00 pm | Binder ETG - REOB Task Force | **Rowe** |
| 2:00 pm | Binder ETG - Binder Ageing Concerns Task Force | **D'Angelo** |
| **3:00 pm** | **Break** | |
| 3:30 pm | Update: Development of Rubber Binder Specifications in California | **Alavi** |
| 4:00 pm | PCCAS Asphalt Rubber Binder Testing Efforts | **TecleMariam** |
| 4:30 pm | NCHRP 9-49A WMA Long Term Field Performance | **Wen** |
| **5:00 pm** | **Adjourn for the Day** | |

**Day 2 – Wednesday - September 16, 2015**

| | | |
|---|---|---|
| 8:00 am | Asphalt Binder $\Delta T_c$ and S Value | **Youtcheff** |
| | Mixture ETG RAP/RAS Task Force: Summary & $\Delta T_c$ recommendations | **Musselman** |
| | Binder ETG Discussion & Comment | |
| **9:30 am** | **Break** | |
| 10:00 am | WRI's FPIII Contract Deliverables and Tech Briefs | **Planche** |
| 10:45 am | Binder Rheology 101 – Fracture through Stiffness Properties | **D. Anderson** |
| 11:00 am | LTTP Bind Software Update & Beta Testing | **Corrigan** |
| 11:05 am | REOB: Effect of REOB on the Performance of Asphalt Mixtures Containing RAS | **Mohammad** |
| 11:50 am | Summary of Action Items Schedule Next Meeting | **Baumgardner/Corrigan** |
| **Noon** | **Adjourn** | |

**ATTACHMENT B**

# FHWA Asphalt Binder Expert Task Force Members

| | |
|---|---|
| Chairman:<br>**Gaylon Baumgardner**<br>Executive Vice President<br>Paragon Technical Services, Inc.<br>2829 Lakeland Drive, Suite 2000<br>Jackson, MS 39232-7611<br>Phone: 601-933-3217<br>Cell: 601-842-3743<br>Fax: 601-933-3363<br>Gaylon.baumgardner@ptsilab.com | Co-chairman:<br>**R. Michael Anderson**<br>Director of Research & Lab Services<br>Asphalt Institute<br>2696 Research Park Drive<br>Lexington, KY 40511-8480<br>Phone: 859-288-4984<br>Fax: 859-422-1301<br>manderson@asphaltinstitute.org |
| Secretary:<br>**Matthew Corrigan, P.E.**<br>Asphalt Pavement Engineer<br>U.S.DOT - Federal Highway Administration<br>1200 New Jersey Ave, SE<br>HIAP, Rm E73-465<br>Washington, D.C. 20590<br>Phone: 202 366-1549<br>matthew.corrigan@dot.gov | |
| Members : | |
| **David A. Anderson**<br>Professor Emeritus of Civil Engineering<br>Penn State University<br>Penn Transportation Institute<br>201 Transportation Research Board<br>University Park, PA 16802-2321<br>Phone: 814-237-8585<br>daa@psu.edu or<br>DA.SC@COMCAST.NET | **Lyndi Davis Blackburn**<br>Asst. State Materials & Test Engineer<br>Alabama DOT<br>3700 Fairground Rd.<br>Montgomery, AL 36110<br>Phone: 334-206-2203<br>Cell: 334-850-6437<br>blackburnl@dot.state.al.us |
| **John D'Angelo**<br>Consultant<br>8528 Canterbury Drive<br>Annandale, Virginia 22003<br>Phone: 571-218-9733<br>Johndangelo@dangeloconsultingllc.com | **Joseph DeVol**<br>Asst. State Materials Engineer - Materials Testing<br>Washington DOT<br>1655 S. 2nd Avenue<br>Tumwater, WA 98512<br>Phone: 360-709-5421<br>DeVolJ@wsdot.wa.gov |

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|---|---|
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| **Ioan I. Negulescu**<br>Professor, Human Ecology<br>Louisiana State University<br>232 Human Ecology<br>Baton Rouge, LA 70803<br>Phone: 225-578-1684<br>inegule@lsu.edu and<br>ioannegulescua@yahoo.com | **Jean-Pascal Planche**<br>Vice President<br>Transportation Technology<br>Western Research Institute<br>3474 N. 3rd Street<br>Laramie, Wyoming 82672<br>Phone: 307-721-2325<br>jpkanch@uwyo.edu |
| **Gerald Reinke**<br>MTE Services<br>915 Commercial Ct.<br>P.O. Box 563<br>Onalaska, WI 54650<br>Phone: 608-779-6304<br>Fax: 608-781-4694<br>Cell: 608-317-0242<br>gerald.reinke@mteservices.com | **Geoff Rowe**<br>Abatech, Inc.<br>P.O. Box 356<br>Blooming Glen, Pennsylvania 18911<br>Phone: 215-258-3640<br>Cell: 267-772-0096<br>Fax: 772-679-2464<br>growe@abatech.com |
| **Karl Zipf**<br>Delaware DOT<br>Chief Chemist<br>DelDOT Adm. Center 800 S. Bay Road<br>Dover, Delaware 19901<br>karl.zipf@state.de.us | |

| Liaison Members: | |
|---|---|
| **Mark S. Buncher**<br>Director of Engineering<br>Asphalt Institute<br>2696 Research Park Drive<br>Lexington, KY 40511-8480<br>Phone: 859-288-4972<br>Cell: 859-312-8312<br>Fax: 859-288-4999<br>Mbuncher@asphaltinstitute.org | **Audrey Copeland**<br>Vice President, Engineering, Research and Technology<br>National Asphalt Pavement Association<br>5100 Forbes Boulevard<br>Lanham, MD 20706<br>Phone: 301-731-4748<br>Fax: 301-731-4621<br>Audrey@asphaltpavement.org |
| **Edward Harrigan**<br>Transportation Research Board<br>500 5TH Street, NW<br>NA 487<br>Washington, D.C. 20001<br>Phone: 202-334-3232<br>Fax: 202-334-2006<br>eharrigan@nas.edu | **Pamela Marks**<br>Head Bituminous Section<br>Materials Eng. & Research Office<br>Ministry of Transportation<br>Building C, Room 238<br>1201 Wilson Avenue<br>Downsview, Ontario M3M1J8<br>Phone: 416-235-3725<br>Cell: 416-779-3724<br>Pamela.Marks@ontario.ca |
| **Evan Rothblatt**<br>Associate Program Manager, Materials<br>AASHTO<br>444 North Capitol Street, NW<br>Washington, D.C. 20001<br>Phone: 202-624-3648<br>Fax: 202-624-5469<br>erothblatt@aashto.org | |

**ATTACHMENT C**

# Task Force Members and Assignments
# FHWA Asphalt Binder ETG

| Task Force Identification: | | Members Assigned to Force: |
|---|---|---|
| 1 | REOB | Geoff Rowe (Lead):<br>Bill Ahearn, Imad Al-Qadi, Dave Anderson, Thomas Bennert, Mark Buncher, Matthew Corrigan, John D'Angelo, Nelson Gibson, Pamela Marks, Louay Mohammad, Walaa Mogawer, Jean-Pascal Planche, Gerry Reinke, and Laci Tiarks-Martin. |
| 2 | Binder Aging Concern | John D'Angelo (Lead):<br>David Anderson, Darren Hazlett, Jean-Pascal Planche, Bob Klutz, and Geoff Rowe. |