FHWA Asphalt Mixture Expert Task Group

Asphalt Mixture ETG Purpose
The primary objective of the FHWA Expert Task Group is to provide a forum for the discussion of ongoing asphalt mixture technology and to provide technical input related to asphalt mixtures design, production and construction.

A total of 66 individuals attended the meeting (22 members, 2 contract personnel, and 42 visitors). Attachment A is the meeting agenda, Attachment B includes a listing of the Mixture Expert Task Group (ETG) members, and Attachment C is a listing of the Mixture ETG Task Force members.

Members of the FHWA Asphalt Mixture ETG in attendance included:

Frank Fee, Frank Fee, LLC (Chairman)	James Musselman, FDOT
Ray Bonaquist, Advanced Asphalt Technologies, LLC (Co-Chairman)	David Newcomb, Texas A&M University
John Bukowski, FHWA (Secretary)	Timothy Ramirez, PA DOT
Howard Anderson, UDOT	Darin Tedford, NDOT (represented/proxy by Charlie Pan)
Shane Buchanan, Old Castle Materials	Mark Buncher, (Liaison) Asphalt Institute
Ervin Dukatz, Mathy Construction	Audrey Copeland, (Liaison) NAPA
John Haddock, Purdue University	Edward Harrigan, (Liaison) NCHRP
Kevin Hall, University of Arkansas	Nam Tran, (Liaison) NCAT
Gerry Huber, Heritage Research Group	Pamela Marks, (Liaison) Ministry of Transportation
Y. Richard Kim, North Carolina State University	Evan Rothblatt, (Liaison) AASHTO
Louay Mohammad, Louisiana State University	Christopher Abadie, (Liaison) AASHTO

Members of the ETG not in attendance:

Tom Bennert, Rutgers University	Todd Lynn, Thunderhead Testing, LLC
Jo Daniel, University of New Hampshire	Allen Myers, Kentucky Transportation Cabinet
Adam Hand, Granite Construction, Inc.	R. Michael Anderson, (Liaison) Asphalt Institute

"Friends" of the ETG that were in attendance included:

Harold VonQuintus, Applied Research Assoc.	Jennifer Foxlow, Pike Industries
John D'Angelo, D'Angelo Consulting	Todd Arnold, Pine Test Equipment, LLC
Bob Kluttz, Kraton Polymers	Laith Tashman, Wentworth Ins. Tech.
John Barry, Crowley Chemical Co.	Adam Taylor, NCAT
Hassan Tabatabaee, Cargill Industrial Specialties	Hasan Ozer, University of Illinois U-C
Georgene Geary, GGFCA Engineering, LLC	John Harvey, University of California
Shenghua Wu, Washington State University	Jean-Paul Fort, COLAS USA
Andrew Hanz, Mathy Construction	Salman Hakimzadeh, Southwind RAS
Bill Cirqui, Mead Westvaco	Colin Franco, RIDOT
Nelson Gibson, FHWA	Jack Youtcheff, FHWA
Tom Harman, FHWA	Jeff Withee, FHWA
Walaa Mogawer, HSRC/UMass	Gerald Reinke, Mathy Construction
Ron Sines, Old Castle Materials	Andrew Berthaume, USDOT/VOLPE
Ali Regimand, Instrotek, Inc.	Tim Aschenbrener, FHWA/RC
Stephen King, IPC Global	Al Palmer, Safety Kleen
Don Christensen, Advanced Asphalt Tech.	Bill Criqui, Mead Westvaco
Alireza Zeinali, Instrotek, Inc.	Bill Buttlar, University of Illinois U-C
Phillip Blakenship, Asphalt Institute	Imad Al-Qadi, University of Illinois U-C
Mark Brum, Mass DOT	Tim Bronold, Testquip.
Edmund Naras, Mass DOT	Geoff Rowe, Abatech
Paul Montenegro, Black Mountain	Sergio Raposo, Abatech

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

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DAY 1: Tuesday, April 7, 2015

1. Call to Order

Chairman Fee (Frank Fee, LLC) called the meeting to order at 8:00 AM.

2. Welcome and Introductions

Frank Fee and John Bukowski welcomed everyone to the meeting. Walaa Mogawer welcomed everyone and overviewed the ATMC facility. Lori Dalton noted the sign-up sheets are being distributed for the ETG members and a separate sign-in sheet for friends of the ETG. Copies of the agenda were distributed prior to the meeting. Bukowski stated the presentations from the September 2014 meeting are available on data sticks. Bukowski announced that FHWA is working on a way to post the presentations and reports from the Asphalt Binder and Mixture ETG meetings online. Frank Fee asked everyone to introduce themselves.

3. Review Agenda/Minutes Approval & Action Items, Sept 2014 Meeting. [John Bukowski, FHWA]

John Bukowski noted the technical report from the last meeting was sent out by e-mail prior to the meeting. Bukowski asked if there were any revisions or corrections to the technical report. No corrections or revisions were noted. Bukowski mentioned any corrections or revisions to the technical report should be sent to him.

Bukowski reviewed the Action Items from the September 2014 Mixture ETG meeting. The following is a listing and status of the Action Items from the last meeting.

- Action Item 201409-1: The Asphalt Institute will update the ETG on its on-going activities related to the REOB topic.
  Update: Item is on the Asphalt Binder ETG agenda.
- Action Item 201409-2: Jeff Withee, along with the Asphalt Institute and NCAT, will report on the potential recommended changes to AASHTO standards on use of friction reducers and specimen preparation for the AMPT. The ETG should get this data to determine the variability with using two friction reducers and to not reuse friction reducers.
  Update: Item is on the agenda.
- Action Item 201409-3: The Asphalt Institute and NCAT will report on their activities comparing various performance tests and the ability to predict pavement fatigue performance.
  Update: Item is not on the agenda.
- Action Item 201409-4: Nelson Gibson will provide an update on the status of the FHWA ALF project at the next ETG meeting.
  Update: Item is not on the agenda.
- Action Item 201409-5: Lee Gallivan will prepare the task force recommendations/rationale for RAP changes to M 323 and distribute for comment to the ETG members/friends.

Update: Item is on the agenda.

- Action Item 201409-6: Matthew Corrigan will provide an update on the FHWA mobile lab testing/evaluation of GTR field projects.
  Update: Item was covered as part of the last September meeting agenda.
- Action Item 201409-7: Jim Musselman will provide an update and status report on the LTPP WMA project.
  Update: Item is on the agenda.
- Action Item 201409-8: The Construction Task Force will provide an update at the next meeting.
  Update: Item is on the agenda.
- Action Item 201404-1: David Jones to provide an update on ongoing work elements related to the University of California at Davis/CalTrans GTR project and Emin Kutay to provide an update on ongoing work elements on the GTR Michigan State University GTR project.
  Update: Item is on the asphalt binder ETG agenda.
- Action Item 201404-2: Richard Kim to provide the E* IDT final report and an updated draft standard incorporating recommendations from the final report to the ETG.
  Update: Item is on the agenda.

4. Subcommittee on Materials Updates/Comments. [Chris Abadie, Louisiana DOT – Liaison for the AASHTO Subcommittee on Materials]

Presentation Title: *SOM Technical Section 2d, Proportioning of Asphalt-Aggregate Mixtures, AASHTO Standards Update, Chris Abadie, LDOT.*

Summary of Presentation:
Chris Abadie reported on the Technical Section (TS) 2d under the Subcommittee of Materials (SOM) (http://materials.transportation.org/Pages/Membership.aspx). Abadie stated that the upcoming annual meeting will be in Pittsburgh, Pennsylvania on August 2-7, 2015. The midyear webinar meeting was held in February, 2015. A total of 20 members out of 48 members attended the meeting along with 18 friends and/or proxies. Table 4.1 summarizes the SOM 2d Ballots. Table 4.2 summarizes the reconfirmation ballots along with the state stewards assigned to each of the standards. Abadie wrapped up his presentation with a timeline for the 2015 AASHTO SOM publication cycle:

- ETG Recommendations by April/May
- Technical Section Ballot ~ May
- 2015 SOM Meeting (August 1-5, 2015 in Pittsburgh, PA)
- SOM Ballot Items due by September 15, 2015
- SOM Ballot Issued in October 2015
- Revisions Published July 2016

Table 4.1 Summary of AAHTO SOM 2d Ballot Review.

ACTION	DESCRIPTION	BALLOT STATUS
Revise R35 – "Superpave Volumetric Design for Asphalt Mixtures"	Clarify and provide a consistent definition of Ps, and Simplify VMA formula in sections 9.2 and 9.3.6 and to clarify the different purposes of Section 6.5 and 6.7 –wash and grade aggregate for material characterization.	Passed with no Negatives.
Revise TP 79 – "Determining the Dynamic Modulus and Flow Number for Asphalt Mixtures Using the Asphalt Mixture Performance Tester (AMPT)"	Made changes to the reference equipment specification in Sections 6.2 and 6.3- See page 2 and 29-31 of the minutes and added to Appendix X2 re small sample.	Passed with no Negatives or comments.
Revise MP 23 to clarify section 5.1 – (old MP 15) "Reclaimed Asphalt Shingles For Use in Asphalt Mixtures"	Add 5.1 gradation of shingles applies to processed and dry shingles prior to extraction of binder.	Passed with no Negatives or comments.
Revise T 245 – "Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus"	Remove the preparation of specimens.	Passed with no Negatives or comments.
Add New Standard R 68 – "Preparation of Asphalt Mixtures by Means of the Marshall Compactor"		No Negatives. A task force was formed to include emulsions and to review metric temperature conversion and other minor edits.
TP 117 – "Determination of the Voids of Dry Compacted Filler"	Misc. re-wording of apparatus (plunger mass, pilot bar procedure, use of depth probe for 2nd height measure).	Passed with no Negatives or comments.
New Provisional Standard TP 116 – ''Rutting Resistance of Asphalt Mixtures using Incremental Repeated Load Permanent Deformation (IRLPD)"		One negative addressed at Mid-year meeting. Provision passed.

Table 4.2 AASHTO SOM Reconfirmation Ballots.

AASHTO	STEWARD	BALLOT STATUS
R30-02; Mixture Conditioning of Hot Mix Asphalt.	Alabama	Reconfirmed 2015.
T167-10; Compressive Strength of Hot Mix Asphalt.	Idaho	Missouri will consider deleting this standard at summer meeting.
T246-10; Resistance to Deformation and Cohesion of Hot Mix asphalt (HMA) by Means of Hveem Apparatus.	Nevada	Reconfirmed 2015.
T247-10; Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.	Nevada	Reconfirmed 2015.
T340-10; Determining rutting susceptibility of Hot Mix Asphalt (HMA) Using the Asphalt Pavement Analyzer (APA).	Kentucky	Reconfirmed 2015.
T342-11; Determining Dynamic Modulus of Hot mix asphalt (HMA).	FHWA	Reconfirmed 2015.
T320; Determining shear strain and stiffness of asphalt mixtures using the Superpave shear tester (SST).	Louisiana	Reconfirmation due in 2016.
T322-07; Determining Creep Compliance and Strength of Hot Mix Asphalt (HMA) Using Indirect Tensile Test Device.	Florida	Reconfirmation due in 2016.
PP60-14; Preparation of Cylindrical Specimen Using the Superpave Gyratory Compactor.	FHWA	Reconfirmation due in 2016.
PP61-13; Developing Dynamic Modulus Master Curves for Asphalt Mixtures using the Asphalt Mixture Performance Tester (AMPT).	FHWA	Reconfirmation due in 2016.
PP76-13; Troubleshooting Asphalt Volumetric Differences between Superpave Gyratory Compactors (SGC's) used in the Design and Field Management of Superpave Mixtures.	FHWA	Reconfirmation due in 2016.
TP105-13; Determining the Fracture Energy of Asphalt Mixtures using the Semi	Minnesota	Reconfirmation due in 2016.

Circular Bend Geometry (SCB).		

ETG Comments, Questions, and Discussion:
Bukowski noted that a Provisional Standard has a maximum of eight-year time period and if not adopted as a Full Standard, the Provisional Standard will be discontinued. He pointed out that *three Provisional Standards have been in publication for 7 years and need to be considered for ballot to be adopted as a Full Standard*. Bukowski will send Abadie suggested recommendations on the four Provisional Standards where FHWA is listed as steward (T342, PP60, PP61, and PP76). Bukowski will also send Abadie a list of recommendations on the RAP/RAS sections for AASHTO M323 and R35 along with a marked up copy of the standards.

Frank Fee noted that the Mixture ETG will be relying on Chris Abadie, on behalf of the AASHTO SOM Technical Sections, to report on issues and matters that are of interest to this group and where the ETG can provide the necessary help and input needed.

Abadie asked Louay Mohammad to report on some of the updates from TS 2c – Asphalt-Aggregate Mixtures under SOM. Mohammad participated in the webinar meeting which was held in March 20, 2015. Mohammad mentioned that two standards from the NCHRP 09-40: "Optimization of Tack Coat for HMA Placement," were balloted and passed with some comments and a negative vote on one of the standards. Additionally, Timothy Ramirez mentioned that several revisions were proposed for the AAHSTO T209-12: "Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA)." There was one negative vote and after discussion it was agreed not to pursue the proposed revisions in 2015 and to defer the revisions for next year.

Action Items:
Action Item #201504- 1: Bukowski will send SOM (Abadie) suggested recommendations on the four Provisional Standards where FHWA is listed as steward (T342, PP60, PP61, and PP76).

Action Item #201504- 2: Bukowski will send SOM (Abadie) a list of recommendations on the RAP/RAS sections for AASHTO M323 and AASHTO R35 along with a marked up copy of the standards.

5. Update on Related NCHRP Activities. [Edward Harrigan, NCHRP]

Presentation Title: *NCHRP Asphalt Research, April 2015, Edward Harrigan, NCHRP.*

Summary of Presentation:
Edward Harrigan reported on the progress of the NCHRP projects which are of interest to ETG group. The topics in the presentation were divided into three separate parts: Warm Mix Asphalt, Materials and Mix Design, and Pavements.

Part I: Warm Mix Asphalt

- NCHRP 09-52: "Short-Term Laboratory Conditioning of Asphalt Mixtures," Texas A&M Transportation Institute (August 2015). The objective of this project is to

determine a short-term laboratory conditioning that simulates plant mixing and processing to the point of loading in the transport truck and the initial 3 years of field performance. Data is showing that within 2 to 3 months the WMA and HMA aging are equal. The AASHTO R30 long term procedure yields average 2 years aging (as little as 1 year and as long as 4 years were observed). The following significant factors are found to affect aging: binder source and aggregate absorption.

- NCHRP 9-53: "Properties of Foamed Asphalt for Warm Mix Asphalt Applications," Texas A&M Transportation Institute (Completed). The objective of this project was to determined key properties of foamed asphalt binders that significantly influence the performance of asphalt mixtures. A mix design method is developed to determine the optimum water content and checks workability (SGC) and coatability. Best coatability and workability were observed at 1-2% water content in the laboratory and field. NCHRP Report 807 is anticipated to be published in June 2015.
- NCHRP 09-54: "Long-Term Aging of Asphalt Mixtures for Performance Testing and Prediction," North Carolina State University (May 2016). The objective of this study is to develop a laboratory procedure to simulate long-term aging of asphalt mixtures for performance testing and prediction. A detailed comprehensive testing matrix is designed to correlate rheology and kinetics of asphalt binders aged in the laboratory and long term in the field to asphalt mixture properties. Preliminary results support 09-52 finding on AASHTO R30.
- NCHRP 09-55: "Recycled Asphalt Shingles in Asphalt mixtures with Warm Mix Asphalt Technologies," National Center for Asphalt Technology (September 2016). The objective of this study is to develop a design and evaluation procedure for acceptable performance of asphalt mixtures incorporating WMA technologies and RAS, with and without RAP, for project-specific service conditions. Field experiment includes new (WI, AL, TN) and existing field projects [IL (2), TX (2)].
- NCHRP 09-59: "Relating Asphalt Binder Fatigue Properties to Asphalt Mixture Fatigue Performance," Advanced Asphalt Technologies, LLC (Awarded). The objectives of this study are: 1) to determine asphalt binder properties that are significant indicators of the fatigue performance of asphalt mixtures and validate them with field data, and 2) to identify or develop a practical, implementable binder test to measure properties that are significant indicators of mixture fatigue performance for use in a performance-related binder purchase specification.

Part II: Materials and Mix Design

- NCHRP 01-55: "Performance-Based Mix Design for Porous Friction Courses," National Center for Asphalt Technology (July 2016). Mix design based on SGC while considering rutting, raveling, cracking, moisture susceptibility, permeability, noise reduction, and friction.
- NCHRP 09-48: "Field versus Laboratory Volumetrics and Mechanical Properties," Louisiana Transportation Research Center (June 2015). The objective of this study is to determine sources of variability for volumetric and mechanical properties of asphalt mixtures among LMLC, PMLC, and PMFC specimens. The meta-analysis of literature data sets was inconclusive and hence required collection of new data sets. Harrigan noted that the project was very difficult to conduct and to collect the data necessary for the analysis. Significant differences in properties and predicted performance between PMFC

and LMLC or PMLC were observed. The identified key factors were: baghouse fines, aggregate absorption and hardness, and stockpile moisture.

- NCHRP 09-56: "Minimizing the variability of Ignition Furnace Correction factors, National Center for Asphalt Technology (October 2016). The objective of the study is to develop a correction factor verification procedure to troubleshoot non-comparing results of AASHTO T308.
- NCHRP 09-58: "The Effects of Recycling Agents on Asphalt Mixtures with High RAS and RAP Binder Ratios, Texas A&M Transportation Institute (October 2017). The objective of this study is to evaluate the effectiveness of recycling agents in asphalt mixtures with high RAS, RAP, or combined RAS/RAP binder ratios (0.3 to 0.5). Includes both a laboratory and field experimental program. A panel meeting is scheduled at the end of April to discuss Phase I findings and Phase II experimental plan.

Part III: Pavements

- NCHRP 01-54: "Guidelines for limiting Damage to Flexible and Composite Pavements Due to the Presence of Water," Applied Pavement Technology, Inc. (August 2016). The objective of this study is to develop guidelines for practicing engineers on how to reduce or limit damage due to water while considering pavement structure, roadway geometry, climate, materials, and construction and maintenance practices.
- NCHRP 09-51: "Material Properties of CIR and FDR Asphalt Concrete for Pavement Design," University of Maryland (June 2015). In the wrap up process. The objective of this study is to propose material properties, test methods, and distress models for including the performance of pavement layers prepared with CIR and FDR AC in Pavement ME Design. Materials and data from more than 19 field projects in U.S. and Canada were completed.
- NCHRP 20-07/Task 339: "Best Practices for Crack Sealing and Crack Filling of Asphalt Pavements," Dale S. Decker, LLC (Completed). NCHRP Report 784 is published.

Harrigan mentioned that the standing committee on research met last week and the following are the selected projects for FY 2016.

- D-04: "The Impacts on Pavement Performance of Changes in Asphalt Production," ($1,000,000) – e.g., looking at REOB and how their introduction affects pavement performance. This project was combined with D-10 on low temperature properties of asphalt binders. The project will included laboratory and field performance.
- D-08: "Guide Specifications for Pavement Preservation Treatments: Chip Seals and Microsurfacing," ($300,000).
- F-01: "Triggers and Timings for the Placement of Pavement Preservation Treatments for Asphalt Pavements," ($350,000).

<u>ETG Comments, Questions, and Discussion:</u>

John Bukowski asked Harrigan whether he can provide a summary of the NCHRP Project 09-49A: "Performance of WMA Technologies: Stage II—Long-Term Field Performance" since Haifang Wen will not be able to make it to the ETG meeting for his presentation. Harrigan summarized the objective of the study and noted that long-term performance is being defined as 5 to 10 years of in-service field performance. The study is dealing with 5 new field projects constructed during the project with performance data from time zero as well as about 20 existing

field projects. The performance of the existing projects are 5 to 10 years old. The new projects are built in 2011 or 2012 (4 or 5 years old). Cores are taken from the pavement and are evaluated in the laboratory. No significant differences in performance were observed between HMA and WMA sections. The results so far support the findings from the NCHRP 09-47A.

Mark Buncher asked if there is any overlap between the 09-58 and D-04 projects. Harrigan responded that the project panel on D-04 will try to minimize the overlap and make sure the two studies are complimentary. Frank Fee noted the existence of ASTM D4552: "Practice for Classifying Hot-Mix Recycling Agents," and D5505: "Practice for Classifying Emulsified Recycling Agents." David Newcomb noted that the definitions within ASTM on recycling agents are broad and he doesn't believe that a definition on rejuvenator is currently available. John D'Angelo noted that 09-58 project is trying to define the effect of rejuvenators on the asphalt binder and mixture properties. Frank Fee questioned whether bio-products are included in the study and it was noted by D'Angelo that they are being incorporated.

The call for the panel members for D-04 is to be released early May and the Panel is to meet late July/Early August to write the RFP and hope to have a contractor selected by end of 2015. Bukowski noted that it will be important to have the appropriate expertise on the panel. Harrigan asked anyone interested to be on the panel to email EHarriga@nas.edu.

Harrigan provided the link to the NCHRP website (http://www.trb.org/NCHRP) where the various on-going and completed projects can be found along with associated documents and reports.

6. AMPT Specification. [Jeff Withee, FHWA]

6.1. AMPT Specifications, Jeff Withee (FHWA)

Presentation Title: *Asphalt Mixture Performance Tester - Specifications*

Summary of Presentation:
Jeff provided a presentation outlining the suggested revisions and comments for: PP60 – Specimen Fabrication, TP79 – Modulus and Flow Number Testing, PP61 – Master Curve Development, and AMPT Equipment Specification.

- PP60 – Specimen Fabrication: Recommend for full standard in 2016
  - 3.4 consistently use 'end flatness' term.
  - 9.6.3 Section numbering and Table 1.
  - X1.3.2 consistent dimensions (mm)
- TP79 – Testing Procedures: Recommend for full standard in 2016
- PP61 – Master Curves: Recommend for full standard in 2016
- AMPT Equipment Specification: Currently the specification is the Appendix E: "Equipment Specification for the Simple Performance Test System" of NCHRP Report 629. Past discussions revealed the need to have a standalone AASHTO Provisional Specification (MP-XX).

Withee shared with the group a preliminary outline of the proposed AASHTO for the AMPT Equipment Specification. He mentioned that volunteers would be needed to review the draft standalone AASHTO Provisional Specification (MP-XX). Withee noted that the NCHRP equipment specification covers dynamic modulus, flow time and flow number. He suggested to discontinue Flow Time from the AASHTO AMPT Equipment Specification since the test is not being generally used. Accordingly, no objection was noted.

Withee noted that the computation for dynamic modulus and flow number is very detailed in the NCHRP equipment specification. Realizing that multiple test methods will be referring to the Equipment Specification, he suggests moving the dynamic modulus computation to an annex in TP 79 and changing the flow number computation (Francken model calculation) from the appendix to an annex to clarify that these need to be mandatory. He mentioned that the annex will primarily be used by equipment manufacturer developing the software. Withee noted that this will not preclude a manufacturer from providing other computations of flow numbers beyond the Francken model rather than at a minimum the calculation by Francken model should be included.

Withee mentioned that the equipment calibration is currently in an Annex to TP79 and should be in the equipment specification. He is proposing to move what is currently in Annex B (calibration of the AMPT) into the equipment specification as it will apply to the different referenced test methods.

Withee mentioned that he will follow up with the state's stewards for TP107 and TP116 which both reference the NCHRP specification to make sure that the AASHTO Equipment Specification is also suitable to these two standards.

ETG Comments, Questions, and Discussion:
Bukowski asked about Withee intention to proceed with the writing of the draft AASHTO. Withee responded that he talked to Ed Harrigan to get the NCHRP equipment specification in word format and then the first effort would be copying over and reformatting with some of the mentioned discussions into a draft AASHTO on standalone equipment specification. Then there will also be a draft on the AASHTO TP79 which will need to be looked at in conjunction with the draft AASHTO specification. Withee can forward the drafts to the ETG members and friends for review and input.

Matthew Corrigan clarified that the proposed equipment specification is just formatting the NCHRP equipment specification into an AASHTO format. He pointed out that the specification that came out of the NCHRP Report 629 will remain the same and it does not need further modification. Withee responded that he wasn't proposing any changes or modifications at this point aside from the few discussed exceptions to TP79. He mentioned that the first round is to get it accepted as a standard using what already been balloted in AASHTO or in NCHRP and in the future potentially make changes as needed.

D'Angelo asked about the findings from the study completed by the flow number task group which looked into different testing methods and how it may affect the equipment specification.

Bukowski responded that what is proposed is to take the existing standard which is a NCHRP and convert it in an AASHTO format and look for comments and feedback from the group.
Nam Tran questioned whether the equipment calibration should be in the test method or at least have a section in the test method on calibration referring to the equipment specification. Withee responded that there will be a calibration section in TP79 for example referring to the standalone AASHTO for equipment specification.

Bukowski mentioned that the plan is to have the draft AASHTO Equipment Specification completed, commented by ETG, revised, and submitted to AASHTO for 2016 ballot.

Ray Bonaquist asked whether the acceptance section on testing and what need to be done to accept the equipment will remain in the AASHTO Equipment Specification. Withee responded that this is an important information that the user and purchaser should be aware off and should be carried over to the equipment specification. Bonaquist followed up that there will also need to be some significant changes to the description of the loading in order to properly include the tension type tests. He noted that the original specification was intended to produce compressive type forces. With certain type of actuators going through zero becomes a huge issue. Actuators may meet the compressive load standard but when changing from tension to compression the seals move and the actuator doesn't go through zero easily. Bonaquist noted that real thoughts will have to go into how to describe and how to test for this issue that may happen with the actuator when going from compression to tension in order to properly include the fatigue damage type tests.

Bukowski mentioned that FHWA is acting based on the need that has been raised by others over the years for an AASHTO specification that describe the AMPT equipment which can be updated as necessary.

Frank Fee suggested getting the equipment manufacturer also involved in this activity.

Action Items:
Action Item #201504- 3: Jeff Withee will prepare the draft AASHTO Provisional Specification for the AMPT equipment and share with ETG members and friends for feedback and comments.

6.2. Friction Reducers for AMPT Testing, Nam Tran (NCAT)

Presentation Title: *Comparing Friction Reducers for Use in AMPT Testing*

Summary of Presentation:
Nam Tran noted that NCHRP 09-29 study suggested that test variability in flow number (FN) can be reduced with improved guidance for fabrication and use of friction reducers. He also noted that AASHTO TP79-13 recommends the use of two layers of latex membrane and paste silicone grease at the rate of 0.25 +/- 0.05 grams. Tran stated the objectives of this study are to: 1) investigate the effect of latex (paste and spray silicone), Teflon (single and double without grease), and reused latex (past silicone) on the FN test results and variability; 2) select

appropriate friction reducers for FN; and 3) confirm that the selected friction reducers are not affecting the dynamic modulus results.

Tran reported that a plant produced asphalt mixture was used in the study and the FN test was conducted unconfined with a deviator stress of 87 psi and at a temperature of 60.5°C following NCHRP 09-33 method. He presented the testing plan for the FN and dynamic modulus (E*). He noted that four replicates per flow number test were conducted. Tran noted that effort was made to ensure specimen air voids are similar and not statistically significantly different among specimens. The test results for the flow number are presented. Tran noted that the single layer Teflon had a statistically significantly different FN value. He noted that they also examined the shape of the specimen and pictures for selected specimens before and after testing for different type of friction reducers are presented. Tran showed how with the single Teflon and double Teflon friction reducers bulging occurs on both sides of the specimen while a constant deformation is observed with the spray silicone. Tran noted that while the coefficient of variation values (COV) for the various friction reducers test results were similar, it was surprising to discover that the double Teflon showed a significantly lower COV. He suggested more testing need to be done in order to confirm the very low COV for the double Teflon. Tran also showed comparison between the results of the new and the reused friction reducers where no significant effect for the reuse of the friction reducer after two weeks was observed.

Tran summarized the findings from the study by noting that single-Teflon friction reducers yielded higher FN results, double-Teflon and latex friction reducers did not statistically affect FN results, both single-Teflon and double-Teflon friction reducers showed "bulging" effect, and reusing friction reducers once did not statistically affect FN results. He also concluded that single-Teflon and latex friction reducers did not statistically affect E* results. Tran concluded the presentations with the following two recommendations:

- Maintain the AASHTO TP79 recommendation for using the two-layer latex friction reducers for FN test but allow for the use of paste silicone, dry-type silicone spray, or wet-type silicone spray and adjust the application rate to 0.20 +/- 0.05 grams.
- Use two-layer Latex with any of the silicones or single-Teflon friction reducer for E* test with an adjusted application rate of 0.20 +/- 0.05 grams.

Tran finally noted that a study needs to be conducted to determine if the same set of friction reducers can be used to test one set of FN or E* specimens.

ETG Comments, Questions, and Discussion:
John Harvey inquired whether the shape of the permanent strain versus the number of repetitions was examined to see if the friction reducers have any influence on the accumulated strain curve. Tran responded that it has not been looked at and only FN values were evaluated.

Gerry Huber commented that while double Teflon showed bulging, the flow number results were well in line with the results of the other friction reducers but with a significantly lower coefficient of variation.

Bukowski asked about the recommendations for the TP79 Standard. Tran commented that the recommendation is to revise the standard to allow, in addition to the paste silicone which is currently in the specification, the use of dry-type silicone spray and wet-type silicone spray with the slightly modified application rate of 0.20 +/- 0.05 grams. Withee commented that the current application rate in the standard is 0.25 +/- 0.05 grams.

6.3. Performance Test Specimen Fabrication, Phil Blankenship (AI)

Presentation Title: *Effect of Specimen Preparation Variables on AMPT Tests, Alireza Zeinali (InstroTek)*

Summary of Presentation:
Zeinali noted that he worked for Asphalt Institute when the project started before he moved to InstoTek. He also noted that the study is a joint effort between Asphalt Institute and Advanced Asphalt Technology and includes two phases. The Phase I evaluation addresses the following three aspects: 1) How different is the temperature distribution in various forced-draft ovens; 2) Does the oven quality make any difference in conditioning of the samples; and 3) Does frequent opening/closing of the ovens' door affect the conditioning of the loose mixtures. Zeinali summarized the conclusions from the Phase I of the study and it was observed that oven quality and power makes a large difference in stability and recovery, mix temperature varies during conditioning, and opening the oven doors to stir the mix may not be prudent and can lower the mix temperature in some ovens.

The next part of Zeinali presentation was on the results from the Phase II of the study which focused on the identification of the sample preparation variables that significantly affect the AMPT test results, determination of the acceptable range for the significant factors, and making recommendations to minimize the AMPT test variability. A total of 12 variables were considered in the experimental plan: mixing temperature, binder time at mixing temperature, mixer type, mixing time, loose mix conditioning temperature, loose mix conditioning depth, loose mix stirring, mold loading, placement in mold, additional time at compaction temperature, gyratory specimen height, and test specimen air voids. Zeinaly noted that a partially factorial experiment was designed with no main effects being confounded with any two factor interactions. A total of 96 samples were tested. He also stated the three main goals for the Phase II study were: 1) determine the allowable tolerances of factors based on allowable E* test error, 2) improve AMPT tests reproducibility, and 3) refine the AASHTO PP 60 standard. Zeinali presented the results of the statistical analysis for the dynamic modulus data at 20°C and different loading frequencies as well as for the flow number data. He highlighted the factors that showed significant effect on the dynamic modulus data and flow number.

Zeinali summarized that most of the variables included in the study had a significant effect on dynamic modulus, phase angle, or flow number results. He also listed specimen air voids, loose mix conditioning temperature, and loose mix stirring as the most identified effective factors. He noted that a 1% increase in the specimen air voids resulted in a decrease of the 1-Hz dynamic modulus by 442 MPa. Zaneili also noted that stirring the mix during conditioning resulted in higher dynamic modulus, and stiffer samples. He suggested that limits need to be set on significant factors to control the variability of the dynamic modulus and flow number tests.

Zaneili recommended that a new standard practice should be created for the sample preparation of AMPT E* samples which can be extended and applied to other test methods such as IDT, DC(t), SCB, Beam Fatigue, APA, and HWT. He provided recommendation limits for the various evaluated factors and asked the ETG members and friends for input and feedback on the proposed limits.

ETG Comments, Questions, and Discussion:
Gerry Huber asked whether storing the specimens for a month doesn't impact the mixture properties. Zeinali responded that the increase in stiffness was significant up to four weeks and afterwards no significant change in the stiffness was observed. Phil Blankenship commented that the change in stiffness was about 25% and it may has to do with the aggregate water absorption of the mixture which was around 1.5%.

Gerry Huber inquired how the mixing temperature can be controlled by +/- 1°C. Zeinali, responded that this was the temperature when the mixture ingredients were taken out of the oven and the change in temperature that occurs afterwards.

Gerry Huber asked about the magnitude of the difference in results due the planetary mixer versus the bucket mixer. Zeinali responded that the mixer type had only an effect on the flow number results and not on the dynamic modulus results. Phil Blankenship commented that for practicality purposes the planetary mixer may be recommended along with a note to report whether another type of mixer is used similar to what have been done with the solvent type for the extraction and recovery method. Blankenship also noted that all the results will be in a final report that will be submitted to FHWA and recommendation of practical limits for changes to AASHTO R30. Huber commented that bucket mixer is the most common one, should you have to select between the two type of mixers. Frank Fee clarified that the flow number based on the two type of mixers is different but the research team is not making any judgments on which one is more accurate.

Kevin Hall questioned how accurate does the flow number has to be and in what system is it going to be used. Zeinali responded that ranking the mixtures among themselves would be difficult with a low accuracy in the test results. Hall made a request to take into consideration practicality and the model/system where the data will be used when selecting the tolerances. Blankenship commented that the study is to understand the cause of the differences in test results. Chris Abadie questioned how can the effect of all other factors on air voids can be isolated.

Jim Musselman asked how does the recommended tolerance of +/-5°C on the loose mixture conditioning will affect the ovens currently used in laboratories. Zeinali responded that two of the ovens used in this study met this criteria.

Frank Fee inquired about the current status of the report and when it will be made available. Zeinal responded that the report will be submitted in couple month to FHWA. Richard Kim commented that this study is also important for the NCHRP study on long-term oven aging of asphalt mixtures and the location of the mixture in the oven and the air flow issue will influence

the loose mixture aging. Bukowski commented that when reviewing the report from Asphalt Institute make special note of the items that will be of importance to the AASHTO standard recommendation.

Pamela Marks asked about possibly having correction factors to adjust the test results when violating some of the defined factors such as temperature and air voids. Zeinali responded that the development of such factors that can apply to any given mixture would require a comprehensive and large experimental plan that would include different type of materials. He followed by noting that mixtures are different and have different characteristics which would most likely results in many different factors.

Louay Mohammad asked whether there will be a procedure to check for the variation of the temperature in the oven. Zeinali responded that currently the calibration for the ovens is based on only one point location and a procedure is needed for the calibration to be based on four or six point locations in the oven. Blankenship commented that the biggest finding of this study is that the opening and closing of the oven door has a significant influence on the results and it was observed that the smaller 110 volts ovens cannot recover the temperature fast enough like the large ovens. Blankenship also agreed that calibration is important and at one point there will be a procedure that can be achieved by current labs. Kevin Hall commented that the study is a well done ruggedness study clearly revealing the influential factors on flow number and dynamic modulus and it should be followed with an Inter Laboratory Study (ILS) to develop the precision and bias statements.

Action Items:
Action Item #201504- 4: The Asphalt Institute will share the performance test specimen fabrication report with ETG members and friends for feedback and comments.

6.4. Fatigue and Cracking Tests Evaluation, Phil Blankenship (AI)

Presentation Title: *Evaluation of laboratory Performance Tests for Fatigue Cracking of Asphalt Pavements.*

Summary of Presentation:
Blankenship noted that Mike Anderson is the principal investigator of the study which originally consisted of two phases with the Phase 2 not being approved for funding. Blankenship started with a background on the factors affecting fatigue cracking of asphalt pavements and the various tests developed by different research institutions. He mentioned that the objective of the study is not to select and refine a specific test but rather to try to understand how the various tests work and the sensitivity of these test methods. The Phase 1 test plan included seven devices, one binder grade, one aggregate source and gradation, and two aging conditions (4 and 24 hour loose mix aging at 135°C). Blankenship noted that the 24 hour aging represents the top two inches of the asphalt pavement. He referenced the study from University of Illinois by Andrew Braham et al. on in-place mixtures where a 24 hour aging was selected to be appropriate for the fracture energy evaluation.

Blankenship noted that the mixture specimens after 24 hour aging were too brittle for the AMPT S-VECD fatigue test which resulted in several of the specimens breaking at the platen even when a lower strain level or a warmer test temperature was used. He also mentioned that the S-VECD test is meant to be a higher level design test and one of the best predictive tests available nowadays but it is not necessary for every lab to run at this time. Blankenship noted that the indirect tensile strength test (IDT) is the only test that has a standard and is part of AMRL accreditation. He presented the IDT data where the difference between the 4 and 24 hour aging is more significant at 25°C when compared to 4°C. He also presented data in terms of the time to peak load and noted that the peak load alone is not enough to fully describe the mixture behavior and there is a need to combine with the strain values.

Blankenship reported on the beam fatigue test results and showed an example of a good relationship between the number of load repetitions to failure from the beam fatigue test to the total pavement cracking from field survey. He reported that the beam fatigue test was able to show the difference between the 4 hour and 24 hour aging and the results were different between a sinusoidal and a "haversine" load.

Next Blankenship reported on the results of the dissipated creep strain energy (DCSE) test where a difference was observed between the 4 hour and 24 hour loose mixture conditioning. The test results for the disk-shaped compact tension test [DC(t)] were also presented. The overlay tester was also used in accordance with Tx-248-F. Blankenship noted that it required the preparation of six samples and the error in the test results was still large.

Blankenship also reported on the semi-circular bending (SCB) test results from Louisiana State University. The SCB test was conducted with all three notch depths and a difference was also observed between the 4 hour and 24 hour loose mixture aging. Mohammad noted that the error was about 10%.

Blankenship showed a summary slide for ranking the various tests by equipment cost, sample preparation, run test, data analysis, speed of the test, and sensitivity to aged mixture samples. He also noted the effort undergoing under NCHRP 09-57 and the brochure prepared by Texas A&M summarizing the various cracking tests and the differences among these tests. He also concluded that aging of asphalt mixtures along with adjustments to the test temperature for climatic conditions is needed to evaluate cracking of pavements.

<u>ETG Comments, Questions, and Discussion:</u>
Louay Mohammad proposed to look at the strains associated with the IDT test results to compute the toughness index parameter. He also proposed to evaluate the data after the peak time and load since it provides information about the ductility of the material.

Mohammad commented that the test methods should be categorized by the testing temperature when comparing the various test results and their associated variability.

Geoff Rowe commented that in the last meeting the ETG suggested to look at the test results in relation with the asphalt binder properties by adjusting for the stiffness of the binder based on the test temperature and loading time. Blankenship agreed that this should and can be done.

Richard Kim inquired about the height of the AMPT test specimens. Blankenship responded that gyratory samples were compacted to 180 mm height and a specimen was cored out of the gyratory specimen and cut to a height of 130 mm. Kim commented that good test results were obtained by NCSU for high RAP mixtures in the S-VECD test. Matthew Corrigan commented that FHWA worked on eliminating the end platen failures and was able to test asphalt mixtures with very high concentrations of RAP and RAS material up to 65% binder replacement including 5 days and 10 days specimen conditions at 85°C. He also mentioned that a clear ranking is observed with the S-VECD test results at the 5 days and 10 days long-term aging conditioning. He noted that a very rapid failure at lower number of cycles is observed with the stiffer and brittle materials. Corrigan noted that that strain conditions had to be adjusted from the recommended strain values in the standard procedure because of the brittle material in the mixture. Corrigan raised a concern for Blakenship's reporting that the test is not appropriate for higher aging conditions or not appropriate for the average usage, since based on FHWA experience the test can not only differentiate between mixtures' performance but also allow the use of test results to model distresses versus just having a pass/fail criteria which by itself is a tremendous value. Blankenship agreed with Corrigan and requested to adjust his earlier comment to clarify that the learning curve was more complicated than anticipated.

6.5. Experiments on Candidate Cracking Tests, Randy West (NCAT)

Presentation Title: *Preliminary Results if Simple Durability Tests on Mixes from the FHWA ALF Experiment, Randy West, NCAT*

Summary of Presentation:
Randy West noted about the importance of establishing a link between laboratory test results and field performance. He mentioned that the original plan was to get materials from WesTrack and replicate those mixtures which had various levels of fatigue cracking in the field. Unfortunately one of the stockpiles was missing from the MRL and the WesTrack material was excluded from the experiment. The FHWA ALF mixture samples obtained from MeadWestvaco were used for this study. West stated the objective of this limited study to determine if results of selected tests correlate with observed cracking performance from the 2013 FHWA ALF experiment. He mentioned that the selected tests are not a very comprehensive group rather than a subset of the existing cracking tests at ambient temperatures. He noted that the intent is to try to find a simple test that could be used in a mix design and quality assurance approach. The ALF experimental design was presented and mixtures from the 10 lanes were obtained. All lanes were built to a target of 4 inches of asphalt mixture. Testing of the lanes under the ALF began in Fall 2013 and is expected to be completed in Fall 2015. The list of evaluated tests included Cantabro (ASTM D7064-08), SCB (LTRC modified by Zhou), IDT Work (NCAT), Overlay Tester (Tex-248-F modified by Ma). West mentioned that mixtures were sampled during production and reheated following NCAT procedure to minimize aging. He also stated that mixtures were compacted to Ndesign and air voids were not controlled, however the air voids were all within 3 to 5%.

The results for the Cantabro test were presented. The results were sorted from the highest loss to the lowest loss with the error bars representing one standard deviation. The virgin mix on the plot is shown in blue color. An average coefficient of variation (COV) of 19% was observed.

West pointed out that the main purpose is the ability of the test to differentiate between one mix and another while considering the testing variability. He also pointed out that the results from the field are not yet available.. West also showed the results for the modified overlay tester which is run at a higher frequency than the frequency recommended in the standard and by defining failure from the peak normalized load times cycles rather 95% reduction in initial load. He also noted that the old IPC jig was used to run the overlay test in the AMPT. An average COV of 32% was observed. Next the IDT fracture energy results were presented. West pointed out that the IDT test is the performance test used in Japan for evaluating high RAP mixtures and the parameter used is the ratio of the peak stress to deformation (not strain) at peak stress. He noted that the ratio is being called modulus in Japan while recognizing it is not actually a modulus. West conducted a similar calculation with the NCAT data but the numbers were an order of magnitude different than the criteria. An average COV of 19% was observed. No statistical difference among the mixtures was observed for the IDT test results. The SCB test was conducted in triplicates at each of the three notch depths. West noted that error bars are not presented since the average of the triplicate is used to calculate Jc parameter. An average of COV for the area to peak load was 27%.

West mentioned that based on preliminary observations only the Cantabro was able to statistically differentiate the virgin mix from any other experimental mix and statistical analysis of SCB data has not been finalized yet.

ETG Comments, Questions, and Discussion:
Louay Mohammad commented that the same mixtures were tested at LTRC and a smaller variability was observed. He also noted that the thickness of the tested specimens is 50 mm which is different from the standard specimen thickness of 57 mm. Mohammad asked about how the comparison to ALF performance will be made if the mixtures have not been aged before testing. Nelson Gibson responded that the mixtures at the ALF will be two years old and monitoring of the dynamic modulus is being conducted using field cores from the pavement sections every six months. Gibson also mentioned that the cracked sections are showing bottom-up fatigue cracking and the bottom of the asphalt layer is seeing less aging than the top of the layer. He also reported that the ALF sections are cracking after 30,000 to 120,000 cycles.

Frank fee inquired about testing samples from the pavement especially that a difference in compaction exist between the lab and field compacted specimens. West responded that Fujie Zhu and Nelson Gibson have tested core samples.

Gerald Reinke asked about how to take the test results for unaged mixtures and extrapolate to what might happen in the field after in-service aging especially for RAP/RAS mixtures which might look very good at the unaged stage. West responded that this is exactly the purpose of this study and he noted that not all problems occur until after 10 years of in-service life and there is a need for a quick and practical screening test to be used by agencies and the industry. West also noted the need for additional experiments and the study presented is just a piece of the overall effort. Frank Fee suggested looking at some of the early LTPP pavements with RAP where both the RAP and virgin mixtures showed similar performance for the first five years before they started diverging from each other.

7. NCHRP 9-57 Design of Field Validation of Lab Tests to Assess Cracking Resistance. [David Newcomb, TTI]

Presentation Title: *Experimental Design for Field Validation of Laboratory Tests to Assess Cracking Resistance of Asphalt Mixtures*

Summary of Presentation:
Dave Newcomb reviewed the various tasks involved in the project. He stated that the first two tasks were completed and consisted of collecting and providing information to invited participants at a workshop to select for each of low temperature, reflection cracking, bottom-up cracking, and top-down cracking a maximum of three tests for further validation. He also noted that currently the work is continuing Tasks 3 and 4 which consist of developing a plan for the experimental design and laboratory evaluation.

Newcomb mentioned that an interim report identifying the various cracking tests was completed and a series of webinars on the various cracking tests were also conducted. He also mentioned that nine cracking test videos were produced and they are available on the web (a list of the web links is included in the presentation). A cracking tests booklet was also prepared and distributed to the participants during the workshop. Newcomb described the process that was used during the workshop for ranking the cracking tests by the participants. He noted that participants included 50% from DOTs, 30% from industry, and 20% from academia. Newcomb reported the weighting factors developed by the participants based on their importance and by large the lab-to-field correlation was ranked first, followed by test sensitivity to the mixture, and then test simplicity and variability. Test complexity and availability of the test method ranked last.

Newcomb provided the ranking of the cracking tests by the participants. He also noted that the SCB test developed by University of Illinois was not part of the literature review but it was brought up by one of the participants to the workshop. In addition, the participants were asked to, rank key factors for designing field experimental test sections, and identify field test sections.

ETG Comments, Questions, and Discussion:
Frank Fee commented about adding age to the key factors for the experimental test sections design. John D'Angelo commented that the variability increases significantly when doing the validation with lab tests and having mixtures from any roadway in general for the validation without a control would lead to some misleading results. Newcomb agree with D'Angelo and noted the work under NCHRP 09-48 for the difference between field and laboratory results. He also noted that the attempt is to determine a good discriminator between a brittle mixture and a ductile mixture.

8. AMPT Small Sample Specimen Status. [Nelson Gibson and Jeff Withee, FHWA]

Presentation Title: *AMPT – Small Scale Specimens, Jeff Withee and Nelson Gibson, FHWA*

Summary of Presentation:
Jeff Withee mentioned that the recommended revisions for AASHTO TP 79-15 on small scale specimens were revised and approved by AASHTO to be in Appendix X3. This will allow for

testing small scale specimens from field core samples. Withee provided the text for Appendix X3 in the presentation.

Nelson Gibson followed with a presentation on the ALF study used to quantify how laboratory-measured dynamic modulus change with time and depth. He noted that the ALF study is a three year project and will allow a check on how much RAP and RAS will affect aging. Cores are being taken from the top lift every six month and from the bottom lift every twelve month (ALF sections are built in two lifts). Based on the past work with ALF a lot less aging was observed at the bottom lifts. Gibson showed a layout of the ALF highlighting the four sites which are being loaded and the their footprints (North, Middle, and South zones) which never get loaded and from which cores being taken. Pictures for the coring setup at TFHRC for the small scale dynamic modulus samples were shown. Gibson noted that two 38 mm diameters specimens can be cored sideways out of the six inch diameter core sample. He noted that the same setup of the regular scale dynamic modulus specimens is being used except for the use of smaller platens and a spacer. Gibson showed the master curve data thus far along with the air voids content for the cores from the top and bottom lifts for each of the lanes. The results were shown in a qualitative manner with no numerical analyses. He noted a difference in the air voids among the various cores with some of the six month air voids being higher than the zero month air voids. There is a need to account for the air voids levels when comparing the dynamic modulus master curves. Gibson attributed the observed difference in in-place air voids to the stopping and backing up of the roller compactors at the north and south zones during construction. The sampling plan got adjusted and cores are now being taken from the middle zone. Gibson will collect feedback from the ETG and others as well as suggestions to how to account for aging and time at the ALF experiment.

The second part of Gibson presentation was about the process to account for the effect of air voids on dynamic modulus. A correction factor defined as the ratio of the predicted E* at the target 7% air voids to the predicted E* at the in-place volumetrics from the cores was calculated using both Hirsch and Witczak predictive models. The correction factors were function of the model used to predict dynamic modulus but the trends were similar. Gibson showed that about every 1% change in air void content and associated VMA, and VFA changes, there is about a 5% change in E*. He also showed that a difference of 2% or less in the air voids of two core samples would result in a difference in dynamic modulus of 10% or less.

The last part of Gibson presentation was on the data for a study on performance-based mix design. The test results were shown at the 2015 TRB annual meeting. The study is based on materials from one ALF lane that was redesigned for three different VMA contents, three different air voids contents, and compacted to three different levels of air voids. The calculated strains at the bottom of the asphalt layer changed with the design VMA, design air voids, and in-place air voids. The design VMA was found to have the biggest control over how the mixture engineering properties change followed by design air voids, then in-place air voids. Gibson showed that a 1% change in air voids led to an overall average of 5.9% change in dynamic modulus. Gibson mentioned that based on the data it seems possible to calculate and apply a correction factor for the dynamic modulus values obtained from cores obtained from ALF with different densities. The change in predicted fatigue life was significant and on average equal to 25% with every 1% change in air voids.

Gibson concluded that he has confidence in using small scale geometry for dynamic modulus. Tracking is underway for how the ALF mixtures are changing with time and depth. There is a need to incorporate the effect of air voids and degree-days into the analysis.

Richard Kim presented the work under NCHRP IDEA project on the development of small specimen geometry for asphalt mixture performance testing. He noted that Cassie Castorena is the PI of the project. Kim mentioned that originally the VECD was developed as a monotonic test then it was changed to cycling loading because of limitations in AMPT to apply a pulling force to some of the stiff mixtures. But then using smaller specimen geometry, monotonic testing can be conducted in the AMPT because of the less force required to pull the specimen. The goal of the study is to develop ancillary devices for small specimen testing in AMPT. This effort is in partnership with Instrotek. Another goal of the study is to determine if small cylindrical (38mm x 100mm) and/or prismatic (50mm x 25mm x 100mm) specimens give equivalent dynamic modulus and direct tension test results to full size specimens. Establishing the number of test replicates required is another goal of the study. Phase I consists of developing test set-up and resolution of testing of field cores. The set-up for small specimen testing in the AMPT has been completed with the help of IntroTek. All results will be statistically evaluated. Phase II consists of resolution of testing small specimens extracted from laboratory gyratory compacted specimens. Kim mentioned that the project started on January 2015 and will end sometime middle of next year.

ETG Comments, Questions, and Discussion:
Kevin Hall asked what might be the cause for the increase in air voids. Gibson responded that cores from the first and second cycles were taken from the north, middle, and south zones. Densities from the middle zones were appropriate and logical. At the north and south zones is where the rollers had to slow down, stop, and back up which then affected the densities of the cores taken at the fringe of these two sections. The original thought was to take the core samples as far as possible away from where the ALF is going to be loading. After the observed issue with densities all cores are now being taken from the middle zone section. He noted that north, middle, and south zone sections are all 200 feet long.

Bob Kluttz asked whether any more of a variability is observed with small scale cores than with large scale cores. Gibson responded that the variability is about the same between the two core sample sizes however the small cores had slightly lower air voids by about 0.5%.

Hall commented that there should be enough data to show that cores from the north and south zones are different from those taken from the middle zone supporting the decision for dropping out the data from the north and south zones.

Frank Fee asked whether the samples used under the NCHRP Idea project are from the ALF. Kim responded that all samples are separate set of mixtures obtained from NCDOT. The NMAS ranges between 9.5 and 25 mm with a 38 mm diameter specimen. Kim noted that it is not part of the plan to evaluate diameter size specimens larger than 38 mm. He also noted that typically 25 mm NMAS are used in base asphalt layers which tend to be thicker than the top lifts.

9. E* TP62, T342, TP 79 Alignment Rods Issue. [Matthew Corrigan, FHWA]

Summary of Presentation:
Matthew Corrigan mentioned that Dr. Matthew Witczak had sent a letter to the AASHTO Subcommittee on Materials and AASHTO joint Technical Committee on Pavements concerning the current dynamic modulus and AMPT specification. Specifically, questioned was the validity of dynamic complex modulus measurements utilizing the asphalt mixture performance tester (AMPT) specimen instrumentation protocols. Corrigan mentioned that FHWA was asked to respond to the letter while noting the two primary issues raised in the correspondence: 1) LVDT instrumentation currently being specified or used with existing equipment manufacturers, and 2) gauge length. The presentation consisted of an update on this subject and the information provided to AASSTO Subcommittee on Materials and joint Technical Committee on Pavements.

A team was assembled composed Matthew Corrigan, Ray Bonaquist, and Nelson Gibson collaborating with the equipment manufacturers. There are two sets of standards that currently exist. The criticism was primarily on the AMPT standards of TP79, PP60 and PP61 versus what he was comparing and how he was collecting the data from the GCTS manufacture model using AASHTO T342 which was developed as more as a generic methodology for any kind of servo hydraulic system to do E* testing. Corrigan noted the particular issue of the guide rod assembly and linear bearings. The issue posed, was whether these need to be used/required in order to maintain the deformation measurements more in the vertical position during testing and should have been preserved in the specification. Corrigan noted that Nelson Gibson was involved with the early work on this under NCHRP 9-19, and Ray Bonaquist was also involved in the NCHRP 9-19 project, additionally he was the PI for the NCHRP 9-29 which developed the equipment specification. Corrigan noted that the information that was put in the standards has addressed the concerns recently raised. The primarily issue is due to the on-specimen gauge point requirement in order to measure deformation and becomes only a concern at high temperature where the gauge points start moving away from each other if the LVDTs are experiencing too much strain force and compensating springs are not being used. This would lead to error in the calculated dynamic modulus. The developed standards limit the high testing temperatures and have gone through different iterations of either compensating springs to the magnetic mounted extensometer allowing for some degree of rotation. Additionally friction reducers are specified in the standard to reduce the tendency for barreling and non-vertical displacement. Corrigan noted that all the issues raised with regard to the guide rod have been addressed.

The secondary issue has to deal with the gauge length. The NCHRP 9-19 recommendation was to use four inch gauge length while the AMPT uses 70 mm gauge length. Corrigan noted that the four inch gauge length was driven by the flow number requirement and not dynamic modulus. The use of 70 mm gauge length is not in conflict with the early work on NCHRP 9-19 and the following work on NCHRP 9-29.

Another point that Corrigan brought up is the data quality check required in the standard to ensure not to have the gauge points moving away from each other. He referred to Table 1 in AASHTO TP79 on data quality statistics requirements. Data output from one of the devices was shown as an example of quality data check in which a reversed drift is observed indicating that

the gauge points are moving away from each other and could be the result of testing at high temperature for the specific mixture.

Corrigan noted a report was prepared and submitted to the AASHTO Subcommittee on Materials and AASHTO Joint Technical Committee on Pavements. Based on the provided justifications it was concluded that additional study or comparisons of the current AMPT instrumentation system is not warranted. He also noted that in the early stages of the NCHRP 09-29 project, Bonaquist discussed with equipment manufacturers about using non-contact systems which were not economically feasible at that time of the initial NCHRP 9-19 effort.

ETG Comments, Questions, and Discussion:
Don Christensen asked whether this issue was brought up because of observed differences and discrepancies in his measurements compared to what others are doing following TP79. Corrigan responded that the correspondence to AASHTO mentions a comparative study. Not knowing all other details about the data quality indicator measurements that are currently in the specification or whether spring compensators were used, the focus of the response was on the two primary issues of gauge length and guide rod assembly and the rationale behind the specifications in the current standards.

Nam Tran asked about the reason for the difference between the two data sets. Corrigan responded that the difference was primarily at the high test temperature, and again, not knowing all the details about the data collection, it was uncertain what caused the differences between the two measurements. Premise raised by the correspondence to AASHTO was that the T342 protocol should have been extended and put into the TP79 protocol. Corrigan noted that through the NCHRP 9-29 project and all the development of the equipment standards and the test standards those issues have been resolved if the protocol and the requirements are being followed. He also noted that the NCHRP 9-19 project abandoned using the guide rods during the study because it was suspected that when severe barreling was occurring, the guide rods were starting to bind the LVDTs themselves.

Christensen commented that there could be a variety of other possible explanations for discrepancy in modulus measurements between two labs and the observed differences should not be assumed to be because of differences in test procedures. Corrigan mentioned the response letter along with the presentation will be part of the minutes.

10. Task Group Review Update: T-321 (Beam Fatigue). [Geoffrey Rowe, Abatech]

Presentation Title: *difference Between Fixed and Floating Reference Points – AASHTO T321, Bill Criqui, MeadWestvaco*

Summary of Presentation:
Geoff Rowe started by mentioning considerable effort has been underway for the past five years on improving the beam fatigue standards. The definition of failure has been revised to be the same in both AASHTO and ASTM standards which led to improvement in the coefficient of variation when comparing data from the two standards. Rowe mentioned that the next phase of

the work was to try to standardize the test loading waveform between the two standards. Rowe mentioned that there may be a need for two parts in the standards to address the different types of issues in the equipment.

Bill Criqui followed with the rational for the ASTM D7460 ballot action. First, it was decided to have a title change from "asphalt concrete" to "asphalt mixture" in accordance with recently updated ASTM D8 clarification, a waveform origin with graphical updates, scope statement updates to ASTM form and style, and removal of references to any equipment manufacturers from standard. Currently both the AASHTO T321 and ASSTM D7460 are put together according to the legacy data and some of the newer equipment is running in different modes and with different reference points (fixed or floating). The original SHRP apparatus use a fixed reference point. Criqui mentioned that haversine waveform loading should be removed from the standards. He presented data from Canada comparing the fixed versus the floating reference points. The number of cycles to failure was higher by 100,000 cycles for the fixed reference point with the upward sinusoidal waveform when compared to the downward sinusoidal waveform (similar to the legacy SHRP data). The difference was attributed to the gravitational effect of the beam. With some of the new equipment with the floating reference points the cycles to failure increased by almost double.

Criqui mentioned that the equation in both AASHTO T321 and ASTM D7460 reference the neutral axis for calculations. The drawings for the new ASTM standards were provided. The test temperature is being included in the standard based on the LTPPBind at 20 mm below pavement surface with a range limit between 10 and 20°C. Criqui noted the dimension differences among various equipment. Depending on the equipment setup, the distance "L" for the calculation of the displacement is variable from one equipment device to another. He noted that it is hard to have all the data collected based on one standard since the fabricators have different equipment designs.

Criqui mentioned that the reference point is affected by multiple variables in the mix design such as aggregate size, aggregate shape, density, binder grade, etc. It is also affected by specimen response due to temperature selection during flexural beam fatigue testing, mix design sag between the outside and inside clamps due to gravitational effects, and friction values of mix design during flexural beam fatigue testing.

Criqui presented a list of fabricator and operator specific issues. He noted that some of the older equipment has not been upgraded which have a fixed point in the middle of the frame and do not have free translation hence leading to beam stretching. Criqui gave an example of a polymer modified beam that was deforming (sagging between the clamps) while sitting in test apparatus before the start of the test because of the viscoelastic nature of the asphalt material. Such behavior cannot be clearly detected in a floating reference LVDT while it clearly shows up in the fixed reference LVDT.

Criqui concluded his presentation by noting the need to possibly having several revisions to the standards and pointed out that an inter-laboratory study cannot be completed between a fixed reference and a floating reference LVDT.

ETG Comments, Questions, and Discussion:
Frank fee asked about the next step and noted the existence of older equipment with particular configurations and a lot of data collected over the years and newer equipment being used without any recognition to the changes. Criqui responded that it will very difficult to have an inter-laboratory study and there is a necessity to inform the users of the need to have free translation..

John Harvey commented that there was a conference a couple of years ago on the same topic and there are three main issues. The first one is the horizontal translation which should be rectified otherwise it is totally a different type of test; the second is the sinusoidal versus the haversine load waveform which is currently being evaluated at UC Davis along with data from the Australian Road Research Board (ARRB); and the third is the reference point for the LVDT which can also be looked at with the two different setups currently available at UC Davis (four fixed reference point devices and two floating point devices). Harvey suggested evaluating each of these issues and then standardize the tests accordingly.

Frank Fee commented that in the meantime there is a need to at least advise the lab users about the potential differences between the tests. Geoff Rowe noted that the difference between the standards was particularly observed when started working with polymer-modified asphalt mixtures and typically such differences where not observed with unmodified asphalt binders even with different equipment setups. Harvey commented that UC Davis is evaluating terminal blend rubber mixtures, wet process rubber mixtures, and high RAP mixtures covering different type of mixtures and stiffness. Harvey proposed forming an advisory team to identify the three issues in a very concise way. He noted that UC Davis will have enough data including twenty years of performance data and calibrated models to field testing that will help evaluating the sinusoidal versus haversine issue. At this moment the tendency in California is to move to sinusoidal load waveform and stop using haversine waveform. Harvey followed up that the reference point requires some more data and analysis and then the decision would be either it does not make a difference or it is significant and requires equipment modification.

Phil Blankenship commented that some of the equipment is still stopping the test at fifty percent reduction in initial stiffness and there is a need to modify the software by the manufacturer to reflect the changes in the new standard.

Bukowski commented that the process appears not to be simple and there are a lot of steps to be completed and it may sound easy to recommend making changes to the equipment but it is very challenging for states to invest in new equipment. Harvey commented that sinusoidal versus haversine and the fifty percent stop of the test are both a software issue. Bukowski replied that a list of recommendation steps is needed from the easiest to the most challenging issues. For example, the first step could be recommendations for software changes. Rowe suggested preparing and submitting within three months a white paper to the group and equipment manufacturer summarizing the differences and issues. Bukowski noted that the white paper should not only list the problems but also some of the solutions by grouping the issues on how they can be possibly addressed from the most simple to the most challenging.

Harvey asked what if the equipment manufacturers do not agree on the proposed solutions/changes. Frank Fee commented that the ultimate goal is to be able to get consistent

results with various labs and equipment. If that is not possible, then each of the equipment will have its own standard and the user will get to pick what standard to use.

Louay Mohammad commented that this is an important matter that needs to be resolved quickly since a lot of decisions are being made based on the flexural beam fatigue test as a cracking test. Bukowski replied that this was the main reason for forming the ETG task force and the need to have a standardized test.

Action Items:
Action Item #201504- 5: The Bending Beam Fatigue task force led by Geoff Rowe will draft a white paper elaborating on the main issues and potential solutions for the beam fatigue test.

11. Report IDT Study Final Update. [Richard Kim, NCSU]

Presentation Title: *Proposed IDT E* Specifications.*

Summary of Presentation:
Richard Kim mentioned that the results from the ruggedness study were presented before and the findings from the ruggedness study were introduced in the three new proposed specifications: 1) Preparation of Indirect Tension Performance Test Specimens; 2) Determining the Dynamic Modulus for Hot-Mix Asphalt (HMA) Using the Indirect Tension Testing Method; and 3) Developing Dynamic Modulus Master Curves for Hot-Mix Asphalt Concrete Using the Indirect Tension Testing Method. The final recommendation limits, as a result of the ruggedness study are provided for air voids, temperature, specimen thickness, gauge length, and horizontal strain (in order to remain in viscoelastic range). All the changes are incorporated in the latest files emailed to ETG before the meeting. A final report is available summarizing the approaches and steps taken in ruggedness study and the basis for making these recommendations. Kim mentioned that the three standards are ready to be submitted to AASHTO SOM.

ETG Comments, Questions, and Discussion:
Bukowski commented that Kim has been working on these standards with the ETG group for several years. He noted that the three standards are quite involved and it appears to be more appropriate to have all three of them as standalone standards. Bukowski mentioned that he will send an email on behalf of the ETG to AASHTO TS 2d including the final report for the rational and the three standards for consideration and discussion by AASHTO. Frank Fee commented that the purpose of the work when it started was to be able to test field samples and a lot of work and effort has been done.

Presentation Title: *Evaluating Different Ways to Predict Pavement Cracking Performance*

Summary of Presentation:
Richard Kim also presented some of the recent work on predicting fatigue performance of asphalt pavements. Different ways of predicting pavement cracking performance is presented using data from two different pavement sections: the NCAT Test Track Pavements (7 inch) and the FHWA ALF Pavements (4 inch).

The first approach uses a combination of both S-VECD and LVECD. The LVECD alpha program has been released to alpha testing group which includes fifteen different organizations. The damage contour of the pavement can be obtained as a function of time. The second approach which is typically used consists of conducting fatigue testing to determine the fatigue relationship and combining the results with a simple mechanistic analysis to get the strains at the bottom of the asphalt layer and then predict the number of cycles to fatigue failure.

Kim showed that for Approach 2, the controlled-stress assumption works better for the 7-inch pavements (NCAT Test Track pavements) while the controlled-strain assumption works better for the 4-inch pavements (FHWA ALF pavements). The ranking of the mixtures was also shown based on energy which includes both stress and strain. Regardless of pavement thickness the right ranking of the mixtures is being observed with the energy based analysis.

ETG Comments, Questions, and Discussion:
Gerry Huber asked whether there was a seven inch OGFC at the NCAT test track pavement sections. Kim responded that the OGFC was only on the surface.

John Harvey commented that this is chapter 3 in SHRP A-005 where hundreds of tests were ran in stress-controlled and strain-controlled and as long as you run controlled-stress and use stress or you run controlled-strain and calculate strain you should get the correct ranking for the mixtures.

Action Items:
Action Item #201504- 6: Richard Kim will submit the IDT specifications to SOM (Abadie) on behalf of ETG for consideration and discussion.

12. Report Task Force RAP/RAS. [Lee Gallivan, Consultant]

Summary of Presentation:
John Bukowski mentioned that Lee Gallivan has retired. There are recommendations from the RAP/RAS task force on AASHTO M323 and AASTO R35 and ETG review from 2014 that will be forwarded to the AASHTO TS 2d. The overall recommendation to the TS 2d would not be to go directly to ballot but rather look at all the recommended changes to the procedures and maybe, as decided by the TS 2d, form a group to look at the recommended changes (quite many both editorial but some technically significant). John Bukowski will email the information to Chris Abadie as soon as possible.

Bukowski noted the need to continue the RAP/RAS task group and asked for a leader to this task force to replace Lee Gallivan. He noted that there is still a lot of work to be completed, such as the controversy over the TP78, which was recently revised, concerning the RAS binder contribution, the cracking issues that number of states are observing with the five percent RAS, and the older three tiers recommendations in TP78. Jim Musselman will be the new leader of the task force and will be assisted by Tim Aschenbrener.

Bukowski and Fee adjourned the meeting at 4:42 PM.

DAY 2: Wednesday, April 8, 2015

1. Call to Order

Chairman Fee (Frank Fee, LLC) called the meeting to order at 8:05 AM.

2. Recycled Materials – Performance Prediction. [John Bukowski, FHWA]

Bukowski noted the increase in the amount of RAP and RAS usage and the need to make sure the best performance is attained, especially utilizing predictive test procedures.. The ETG is open to having discussions on the topic and extra time is devoted on the agenda and all inputs are welcomed.

2.1 RAS & RAP Mixes Fatigue/Fracture Resistance, Imad Al-Qadi (UIUC)

Presentation Title: *Impact of RAS and RAP on Asphalt Mixtures' Fracture: The Need for a Cracking Potential Index, Imad Al-Qadi and Hasan Ozer, UIUC*

Summary of Presentation:

Imad Al-Qadi mentioned that the project is sponsored by Illinois department of transportation. He noted the current increase in the usage of RAP and RAS in the state of Illinois. The purpose of the project is to determine a test that will allow to differentiate between the fracture of asphalt mixtures at low and intermediate temperatures. Al-Qadi listed four challenges with the use of RAP and RAS in asphalt mixtures. The research approach included plant and lab field mixtures. Some of the mixtures included recycled concrete and steel slag. The study attempts to correlate the results to modulus and fatigue. Three approaches were taken into consideration in the study: 1) mixture characterization, 2) theoretical development, and 3) chemistry and composition. He mentioned that colleagues at the Illinois sustainability center are working on the chemistry and composition component. The SCB at intermediate temperature was selected for this study after the review of other available cracking mixture tests. The review assessment was based on: 1) feasibility, practicality, and repeatability, 2) meaningful spread in test output, 3) test parameters, 4) correlation to independent tests and engineering intuition, and 5) correlation to field performance. A coefficient of variation less than 20% was reported for both the fracture energy and peak load from the SCB test for 21 different mixtures with a range of asphalt binder ratio (ABR). Fracture energy curve cannot differentiate well among the various mixtures with different ABR when measured at low temperature. However, fracture energy results may be contradictory. Al-Qadi showed how two different mixtures can have identical fracture energy but totally different behavior in the load-displacement domain. A flexibility Index (FI) was introduced which is function of fracture energy and the slope at inflection point. A comparison between approximate crack velocity and FI was presented. A comparison between the TTI Overlay tester and the SCB FI was also presented. Similar trends were observed between the two tests for the poor and good mixtures. The difference between the two tests was for the marginal mixtures where the effect of ABR was better observed with the FI from the SCB test. Finite element simulations were conducted for the SCB test. The Digital Image Correlation (DIC) was also used to study the full displacement/strain fields. Very small error was observed between the DIC measurements and the LVDT measurements. An external LVDT is proposed to measure the

load-line displacement. A decrease of the fracture process zone was shown with the increase of RAS amount.

A draft categorization of mixtures using flexibility index and thresholds was presented. Results for two field projects from Illinois (Pulaski and US52) were presented. The Pulaski project consisted of an asphalt overlay on top of an existing PCC with a leveling course in between. The US52 project consisted of an asphalt overlay on top of an existing asphalt pavement with also a leveling course in between. The leveling mix was loaded with RAP and RAS which mitigated the purpose of the leveling course layer (resulted in a brittle behavior). Good correlation was observed between FI and the field performance.

Al-Qadi concluded that we need to have a better way to engineer our asphalt mixtures. Illinois is moving forward with the SCB test. Cores from eight to nine districts in Illinois were collected and the flexibility index has been correlating well with field performance.

ETG Comments, Questions, and Discussion:
Matthew Corrigan asked elaborating on the inputs for the FI calculation. Al-Qadi explained how to calculate the various parameters that go into the equation of the FI which is the area under the curve divided by the slope. He noted that Gf is the total area under the curve, and A is a correction factor to correct for the specimen geometry (thickness). A cut off value of 0.1 kN is used for the calculation.

John Harvey commented on using a similar index but divided by the stiffness with very good correlation is being observed with the field performance. Al-Qadi noted that with their data the FI correlated as well if not better with the field performance.

Randy West commented that the typical frame used for indirect tensile does not collect the data at the sampling rate needed for the test. Al-Qadi responded that while the testing frame is capable, a chip will need to be added to allow for the machine to collect the data at the appropriate frequency. The loading rate is 2 inch/min and worked with the Humboldt equipment. West asked how samples are being conditioned. Al-Qadi responded that three conditioning levels were done: 1) using the Interlaken environmental chamber, 2) using an oven, and 3) using a water batch. While the environmental conditioning was the best, the water bath conditioning came exactly next and too close to the environmental chamber. Hence it was decided to go with the water batch conditioning at 25°C for two hours. No aging is being done on the mixtures

Don Christensen asked about the test temperature ranges that can be used. Al-Qadi responded that currently only 25°C is being used. Christensen commented what would be the temperature range if we want to examine the relationship between the mixture modulus and FI. Al-Qadi noted that several tests were run in this study including multiple temperatures and rates and such data can be extracted.

John D'Angelo asked how to apply the findings from the core test results on testing mixtures at the mix design stage. Al-Qadi responded that the study will be looking at building the flexibility index based on the test results of plant-produced mixtures along with testing cores from

pavements with known field performance. Also the in-service life of the various materials/pavements is being considered and that is where the correction factor will be used.

Geoff Rowe asked since only one test temperature is proposed then for which climate zone is the test applicable. Al-Qadi responded that while the test temperature is constant the test is conducted on mixtures using the appropriate binder grade for a given location.

Kevin Hall asked whether there are any preliminary recommendations on what to use for Type I, II, and III for the FI. Al-Qadi responded that flexibility index values of 2 and 4 are the initially recommended limits.

Frank Fee asked about the timeline for a procedure. Al-Qadi responded that the specification is available and ready to be shared with the ETG for feedback and inputs. He noted that the value for "A" factor is pending the completion of the testing. Fee asked whether the implementation of the test and associated issues have been considered. Al-Qadi responded that the implementation phase was left to Illinois DOT to develop the implementation process.

2.2 RAS and/or RAS with Various Recycling Agents, Louay Mohammad (LSU)

Presentation Title: *Evaluation of Asphalt Mixtures Containing RAP and/or RAS with Recycling Agents, Louay N. Mohammad and Sam Cooper, Jr., LSU.*

Summary of Presentation:
Louay Mohammad presentation focuses on the ongoing work of RAP and RAS mixtures with various recycling agents and includes two parts. Part 1 is a RAP/RAS methodology and mixture test results while the Part 2 includes the work from the pool fund study TPF 5(294). Mohammad mentioned that the binder results from Part 1 will be presented at the binder ETG meeting. RAP is widely used in Louisiana however RAS is not allowed at the moment.

Mohammad referred to Note 6 in AASHTO PP78 where the RAS asphalt binder availability factor is assumed to range from 0.70 to 0.85 and that additional research is required to define the interaction of asphalt binder from RAS.

The objective of the study is to assess the laboratory performance of mixtures containing RAP and/or RAS with and without recycling agents at high, intermediate, and low temperature. Mohammad noted using the nomenclature of recycling agents rather than rejuvenators or softeners. A list of the evaluated mixtures is presented with the maximum RAP and RAS contents being 15 and 5 percent, respectively. The evaluated recycling agents included a soft binder, a vegetable derived oil, naphthenic oil, and asphalt flux or REOB. The mix design methodology was presented. The first step is to conduct a conventional mix design for the no RAP/RAS mix (Mix 1) and then conduct the design for the mix with 5% RAS but with no recycling agent (Mix 2). With Mix 2 only 50% of RAS binder of total available of 1.4% was used as contributing based on the volumetrics. With recycling agents the contribution of asphalt binder from RAS increased. The percent of binder contribution depended on the type of recycling agent used. The asphalt binder availability from RAS ranged between 50% and 100%.

The laboratory performance tests used in the study are the loaded wheel tracking test (LWTT) at high temperature, the semi-circular bending test at intermediate temperature, and the thermal stress restrained specimen test (TSRST) at low temperature. As expected, in general, the high temperature performance was not affected with the use of RAP/RAS and recycling agents. Louisiana criterion for rutting is 6 mm for the LWTT. The only mix that was slightly higher than the 6 mm criterion was the mix with the PG52-28 soft binder as recycling agent. The SCB test results showed different resistance to cracking for the various mixtures depending on the recycling agent. Mohammad noted that the RAP in Louisiana includes polymer. The minimum Jc of 0.5 KJ/m^2 was derived from a field study through correlation with laboratory results. The reduction in the TSRST fracture temperature for the high ratio of recycled binders was not as detrimental as the reduction in Jc at intermediate temperature. The low PG of extracted asphalt binder track was well within the TSRST fracture temperature.

A table summarizing the performance of the various mixtures as compared to the control mixture was provided. High temperature was not a problem in general, most of the mixtures suffered at intermediate temperature, and a difference was observed at low temperature but in general mixtures had similar performance. Mohammad noted that Louisiana DOT is moving forward with the SCB test.

Mohammad reported on the Part 2 of the study, dealing with the pool fund study TPF 5(294). The participating agencies are Colorado DOT, Florida DOT, and Louisiana DOT. Mixtures from two field projects from each of the participating states will be evaluated. Each project will have two mixtures, a conventional mix (may include up to 15% RAP) and a high RAP and/or RAS mixture. Whenever possible cores will be collected. The research includes a binder evaluation and a mixture evaluation study. In the binder study, rheology and chemistry are being conducted. In the mixture study, several fracture tests are being conducted. Each of the mixture tests will be ranked. All evaluated mixtures are plant produced and an effort will be made to minimize reheating as much as possible. The mixtures will be long-term aged for five days at 185°C.

ETG Comments, Questions, and Discussion:
Frank Fee asked how the RAP/RAS was incorporated in the samples used for testing. Mohammad responded that the RAS itself was heated and then mixed with recycling agent for 30 minutes. Then the RAS and recycling agent mix were heated in the oven for 30 minutes and then added to bucket mixer where superheated aggregates where placed on top. The composite mix was blended together and then the virgin asphalt binder was added on top and all mixed together. Finally the mixture was put in the oven for short-term aging. Fee asked if the mixing procedure was validated with what occurs at the plant. Mohammad responded that no it hasn't been validated with plant production.

Gerry Huber asked about the situation of the remaining 0.9% binder from the RAS in Mix 2. Mohammad responded that the remaining binder is assumed to be black rock. Huber followed up by asking how the black rock was accounted for in the volumetric calculations. Mohammad responded that the VMA is kept constant for all mixtures and the 0.9% asphalt binder was included in the total Gsb of the aggregate. The 0.5% contribution in Mix 2 was computed from the total asphalt binder content needed to achieve the 4 percent air voids. Huber commented that

the VMA of the stones is influenced by the packing characteristics of the aggregates and adding the shingles disrupt the packing characteristics of the material. Mohammad responded that this was taken care of as much as possible through a proper selection of an aggregate blend gradation similar to that with the RAS material.

John D'Angelo commented that in order to get similar results extra virgin binder had to be added to the mixture. The RAS binder is still binder and it is not rock but it is certainly not an asphalt cement as the typical PG binders.

Randy West asked whether the total asphalt binder content was the same or different. Mohammad responded that the total asphalt content was kept constant at 5.3 percent as well as the VMA was kept at the same level. West raised serious concerns about the effect of rejuvenators being evaluated. He questioned the assumption about the RAS binder contribution. Frank Fee commented that if you believe in the results from performance testing then you can accept the presented approach since performance testing will dictate what mixture and binder content to use. However, the long-term conditioning of asphalt mixtures is an issue that will still need to be worked out.

Bob Kluttz asked whether the RAS is manufacture waste or tear off and what compaction temperature was used. Mohammad responded it was tear off RAS with a 162°C for the compaction temperature. Kuttz commented that the temperature is very close to the softening point of tear off shingles during compaction. Varying the temperature by a little bit can lead to different results since you are right near the temperature at which the tear off shingle act more like a solid or like a liquid.

West suggested that the binder portion from RAS be treated separately than that from RAP. Al-Qadi agreed with West comment and noted a study a Delft that showed a temperature of 180°C is needed to get diffusion. Mohammad noted the use of superheated aggregates is needed to help diffuse the recycled material.

Hassan Tabatabaee asked how the dosage rate for the recycling agent was determined. Mohammad responded that the supplier recommendations were followed and he noted that this study did not look at the change in binder grade with different dosage rates.

2.3 Mix Evaluation Using Disc-Shaped Compact Tension, Bill Buttlar (UIUC)

Presentation Title: *Stability with Crack-Resistance in Modern Mixes: Performance-Based Mix Design, Bill Buttlar, UIUC*

Summary of Presentation:
Bill Buttlar mentioned that rutting distress has not been a major concern in Illinois and Hamburg test seems to be predicting mixtures' resistance to rutting at high temperature in Illinois. The capability to measure fracture energy with cylindrical specimens, an acceptable repeatability, and need for a "true fracture test in tension" were all his motivations for selecting to use the Disk-Shaped Compact Tension DC(T). The DC(T) test is described in ASTM E399 with the geometry

slightly modified to account for differences in the fracture behavior of steel and asphalt concrete. The DC(T) apparatus is now located in approximately 15 different laboratories all with automated calculation for the test results. Buttlar mentioned that all surface mixes tested at low temperatures exhibited a coefficient of variation (COV) less than 10%. In general a lower COV is observed with better temperature control, smaller NMAS, and lower temperature. In a pooled fund study, the DC(T) correlated well to field transverse cracking while the SCB was found to have high COV and poor correlation to field cracking in a blind study. Buttlar presented the DC(T) based thermal cracking specification for fracture energy as a function of traffic level in terms of ESALs. The recommended low-temperature cracking specification for loose mixture is from a published report in 2012 by the Center for Transportation Studies. A validation of the DC(T) test results with RAP mixes was presented. On average, the fracture energy of the RAP mixtures was equal to 623 J/m^2 compared to 2,021 J/m^2 and 411 J/m^2 for a PG58-28 and PG64-22 with no RAP mixtures, respectively. Buttlar also presented the test results from his forensic investigation of some recent pavements in Chicago. The test showed that higher asphalt binder replacement (ABR) mixes could meet the most stringent standards when properly designed. He also noted that reflective cracking was identified as a major source of surface cracking in his investigation.

Buttlar presented the work on his RAS Binder Availability Study. The effect of RAS on a performance-space diagram was studied. Furthermore, the study explored the performance-based approach for recycled mix design using the standard mix design principles with performance testing as alternative to AASHTO PP78-14. Volumetrics were held constant among the evaluated mixtures. Designs assuming 85 and 70% binder availability were conducted. Performance-Space diagram for partial versus manual complete blending was presented.

ETG Comments, Questions, and Discussion:
Chris Abadie asked whether any of the mixtures included crumb rubber. Buttlar responded that some of the SMA mixes had GTR.

Gale King asked whether any advanced aging test was conducted. Buttlar responded that aging was not looked at in detail because of budget constraints. Previous work has been published at AAPT on the evolution of fracture energy from DC(T) with aging where total fracture energy was observed to go up at first and then back down.

A question was asked, how we can make sure not to misuse the asphalt mixes and have the appropriate application to avoid such instances where failure occurs because of improper use of the asphalt mixture as an overlay on top of a Portland cement concrete (PCC). If RAS is going to decrease the fracture energy and higher fracture energy is desirable to resist reflective cracking, then why would we be placing a mixture with reduced fracture energy on a PCC with joints and cracks when it is not going to perform well? Buttlar responded that it is hard to stop reflective cracking in asphalt overlays on top of PCC and accordingly instead of investing with a softer asphalt binder when we know that the reflective cracking is going to occur, use a typical straight run asphalt binder. The same philosophy can be used with recycling materials if we already know that reflective cracking is going to occur. In that case a sustainable mixture is being used with recycling materials. Buttlar noted work has been conducted on reflective cracking from PCC and it was shown mixes will allow a fracture energy from the DC(T) beyond 1,500 for the

overlay mixture to combat and slow down reflective cracking. It is a matter of matching the expectation with reality.

Again it was noted, that it is important in selecting the proper materials considering where they need to be placed and the underlying pavement condition. If data is showing a decrease in the performance with the higher use of RAS in terms of fracture energy then there is a need to put a practical engineering limits to make sure we are successful as we move forward with implementation.

Randy West asked whether the data points on the performance-space diagram are from lab or plant mix test results and whether the established criteria varied between plant mixes and lab mixes. Buttlar responded that most of the data are for field core samples and the rest are from plant mixtures. The calibration of the low temperature cracking study was based on field cores from pavements with known field performance in terms of cracking. West asked how the results would be adjusted for mix design criteria. Buttlar responded that the limit was raised 15 percent on fracture energy.

John Harvey commented that a similar performance space is being developed in California but a third dimension of actual structural design has been added.

2.4 ALF Experiment – Status, Nelson Gibson (FHWA)

Summary of Presentation:
Nelson Gibson presented a summary of the ALF experimental design. He thanked the ETG group for the past input provided to develop the ALF experimental design. The ALF includes three variables: recycling content (RAP/RAS), warm mix technology, and virgin binder performance grade. The shingles in the experiment were tear-off material.

A status of the ALF loading was presented. More than 60% of the loading has been completed. Currently loading is being conducted for Lane 7 and Lane 2. It is anticipated that data from the ALF experiment will be available by end of the calendar year. The pavement sections are being surveyed for permanent deformation, cracking, and nondestructive testing for modulus analysis using the portable seismic analyzer (PSA). Crack length accumulation with time is monitored. Crack length correlated with crack area and thus crack length is being used. The PSA used to keep track of how structural integrity changes with time even before cracks showing up at the surface. It is about 50% loss in the modulus before the crack appears at the surface. The exact point in time when the crack appears at the surface is unknown but we get very close. Lane 5 (40% ABR RAP PG64-22) and Lane 3 (20% ABR RAS PG64-22) are performing the worst.

The S-VECD results for the re-compacted loose mixture in the gyratory at the unaged and aged stage were provided. The long-term aging consists of aging loose mixture in the oven for five days at 85°C. Data from the AMPT is analyzed to determine the damage characteristic curves, C(S), and then the simulated number of cycles to failure. The analysis was conducted for the thin perfect construction, thick perfect construction, and the as-built (thin) construction. The composite modulus of the aggregate base was provided. Line 1 and Line 2 had stiffer aggregate

base modulus. Line 10 and Line 11 had softer aggregate base modulus. In place density specification is 93% +/-1%. The bottom lift had slightly higher densities because of the further densification of the layer when placing and compacting the top layer.

Texas A&M completed the TTI Overlay testing for cores from the ALF sections. The top and bottom lifts were tested separately at 20°C and 0.020 inch. A comparison between the TTI overlay tester and the S-VECD test results at fixed strain was presented.

A comparison between the lab cracking tests and the field performance was presented for the S-VECD and the TTI overlay tester. The number of cycles to failure from the S-VECD was determined using the as-built layer thicknesses, in-place modulus, and associated strain at the bottom of the asphalt layer. The TTI Overlay tester showed very good correlation with the ALF number of passes to pavement first crack for both bottom and top lift cores. An analysis combining both the S-VECD and the TTI overlay tester was presented.

The future steps were summarized. Collaborative testing is being conducted for beam fatigue, SCB, IDT, TTI overlay tester, and Cantabro.

ETG Comments, Questions, and Discussion:
Jim Musselman asked whether the overlay tester was conduct at 0.025 inch displacement. Gibson responded that the information was provided by Fujie Zhou as 0.02 inch of displacement.

Tom Harman commented that we don't build virgin mixtures nowadays and the comparison should be conducted with respect to the 20% RAP mixture as the control and not the virgin mix. Gibson responded that both comparisons can be done.

Geoff Rowe asked about the software and method used for the back-calculation. Gibson responded that first EVERCALC program with linear elastic analysis was conducted for the known asphalt dynamic modulus and layer thicknesses to back-calculate the modulus of the base layer, and then a forward linear elastic analysis was conducted to estimate the strains at the bottom of the asphalt layer. Recently Dynatest conducted a backcalculation analysis with stress softening subgrade and stress hardening aggregate base. Accordingly strains might change. Rowe commented that Abatech software includes five different models for unbound materials and can consider cross anisotropy.

2.5 Construction Task Group Activities [Erv Dukatz, Mathy Construction]

Presentation Title: *New and Reconstituted Mix ETG – Construction Taskforce, Erv Dukatz, Mathy Construction.*

Summary of Presentation:
Erv Dukatz commented that a standard for measuring in-place density does not currently exist. A synthesis topic entitled "Longer Pavement Life from Increased In-Place Density of Asphalt Pavements" was submitted and approved for funding by NCHRP. The funding request is $75,000.

Presentation Title: *STH 77 Project Objectives, Erv Dukatz, Mathy Construction.*

Summary of Presentation:
The second presentation from Erv Dukatz was on the performance test results on a STH 77 project. Wisconsin DOT accepted a proposal that good performing mixtures can be made with high Binder Replacement Ratio's (BR). Accordingly the mixture should have no rutting, which is not an issue in Wisconsin; should reduce thermal cracking which is a huge issue in Wisconsin; and reduce intermediate temperature fatigue cracking such as top down cracking. Dukatz noted that Wisconsin likes to place thin asphalt overlays which are subjected to reflective cracking and top down cracking.

STH 77 was divided into two sections. One section was a high BR mixture made with RAP. The high BR mixture failed the Hamburg criteria when only two hours of short-term aging was applied in accordance with Wisconsin specification. When four hours of aging was imposed, the mixture easily passed the Hamburg criteria. This highlights the continuing importance of considering the effect of aging. DC(T) and SCB test results were also presented. The concept of balanced mix design is used for the specification using the SCB and DC(T) tests against the Hamburg rut depth. The J_c from the SCB test at 25°C did not pass the 0.4 KJ/m2 criteria. When the SCB test was rerun at the LTPP intermediate temperature of 15°C for Wisconsin, the J_c results met the minimum suggested criteria of 0.4 KJ/m2.

Work also has been conducted on calculating the dissipated strain energy. The test was ran at three different temperatures. The shape of the load displacement plot used to calculate the total crack energy is controlled by the dissipated strain energy. A plot was shown illustrating the change in dissipated energy with temperature is non-linear.

The R30 long term aging was used to age the PG58-40 high BR sample for 5-days and 10 days at 85°C. To speed up the testing, the aging protocol suggested by Phil Blankenship of the TAI was tried, aging the samples at a higher temperature and for a shorter time. To determine the effect of the shorter aging, samples were prepared with three different PG 7-28 binders. For each binder two sets of samples were prepared, one set aged for 12hours at 135°C and the other for 24 hours at 135°C. . The Jc results from the 58-40 RAP mixture were obtained at 15°C while the results for the 70-28 mixtures were obtained at 28°C. The polymer mixture (sample 70-28 WF) showed better results with the highest plastic energy after both 12 and 24 hours of aging. For all the mixes the plastic energy decreased with aging. The PG 70-28 samples without polymer had elastic energy values which increased with length of aging. The PG 58-40 which was modified to meet the project specifications showed little change with 5 and 10 days of aging.

Dukatz mentioned the ASTM new draft standard procedure on SCB at intermediate temperature which includes the important findings on how to calculate the dissipated energy component. Currently efforts are underway on a ruggedness testing with five different laboratories. The draft standard procedure will be updated with the findings from the ruggedness testing. Dukatz mentioned Richard Steger is the chair of ASTM D04.20 and the chair of the subcommittee under which this work item resides and he is planning within the next month to put the test procedure for committee ballot. Ten laboratories are participating in the inter laboratory study (ILS) to test

the compliance of the testing machine (metal specimen, plastic specimen, and three different types of asphalt specimens). Dukatz mentioned the cooperative agreement between ATSM and AASHTO.

ETG Comments, Questions, and Discussion:
Imad Al-Qadi commented that SMA mixtures with rubber, RAP, and RAS have been working well in terms of performance since additional asphalt is being added to the mix. Al-Qadi asked whether the mixture remains cost-effective and sustainable (economic) by adding polymer into the SMA. Dukatz noted it is the duty as an engineer to pick and design products that meet the specification and are safe and cost effective.

John D'Angelo asked how to reconcile the data from testing the mixtures for the two asphalt binders 70-28 and 58-28 at two different temperatures because of the difference in their binder intermediate grade. Dukatz responded that the recommendation is to test the mixture at the binder intermediate temperature for the climate and not for the binder grade.

Louay Mohammad commented that performance should never be compromised because of sustainability. He also commented that there is an effective intermediate testing temperature for a given climate similar to what is being done with the flow number test. He also cautioned about using the slope from the SCB test data to calculate the energy which deviates from the classical and theoretical approach used. He referred to Rey Roque for using a different test to calculate the slope of the line.

Gayle King cautioned against four hours aging for performance testing. Laboratory mixtures prepared with four hours oven aging from WesTrack looked very good in the Hamburg test. Then when early cores were taken from the pavement and tested in the Hamburg, the test indicated damage. The predictions from the core testing were consistent with later field performance of the pavement. The asphalt binder is soft at the initial stages and that is the aging stage at which we need to run the rutting test. Cracking is the opposite where four hours is not enough and we need a longer aging period to get the critical condition. Aging of core specimens is not leading to a uniform aging across the specimen and maybe loose mixture aging is the way to go. King noted NCHRP studies that are in great need for an appropriate long term aging protocol in order to have the proper aging stage for comparison and evaluation. Frank Fee commented that especially when we have materials with varying combination of products, RAP, RAS, etc., they need to be related to the constructed materials aging in the field. Dukatz noted that all the presented SCB test results from STH 77 were from tests conducted on plant production samples taken during paving.

Frank Fee commented that the synthesis on the in-place density should provide guidance on how to move forward with the next step based on the findings from the study. The other remaining issue will be the joints construction. Dukatz responded that the synthesis does include both the density of pavements and joints.

Jim Musselman noted that nine projects were submitted this year to be considered by NCHRP 20-07 panel with three of them coming from the AASHTO SOM and most likely one of those

three projects will go forward for funding. Support from the states on the panel is needed for the in-place density synthesis topic.

3. Update on the WMA LTPP Experiment [Jim Musselman, Florida DOT]

Presentation Title: *LTPP SPS-10: Warm Mix Asphalt (WMA) Overlays of AC Pavements, Jim Musselman, Florida DOT*

Summary of Presentation:
Musselman provided an update on LTPP SPS-10 since the ETG helped formulating the experimental plan. Musselman mentioned that the WMA was adopted fairly quickly in the United States and there may be some concerns with long term performance. Under the LTPP program, there is a planned total of sixteen projects with every project/experiment to include a hot mix, a warm mix with foaming process, and a warm mix with chemical additive. Musselman noted that during the project panel review there was not enough organic admixtures. The project consists of a two to four inches of asphalt overlay of an existing asphalt pavement. Desirably, the mixture should contain 10 to 25% RAP binder replacement. The mix design and asphalt binder grade selection are based on agency's standard practice. Due to budget limitations the testing is limited to small scale dynamic modulus on roadway cores, asphalt binder testing on original binder, Hamburg wheel test on original plant mix after production, and mixture volumetric characteristics. Since the testing is limited the ETG group suggested supplementary tests that highway agencies might perform on their relative sections. The projects are planned to be built within the next 12-14 months. To date eighteen projects have been nominated with thirteen projects accepted, three projects rejected, and two projects being evaluated.

Agencies can build additional test sections that will be monitored as part of the LTPP program. Some of the recommendations that came up from the ETG for the supplemental test sections are variable density levels, WMA produced at HMA temperature, other WMA technologies, high recycled binder ratio (>0.25) mixes.

The contact information for LTPP regional coordinators was provided. The list of approved projects under each region was provided. Manitoba and Ontario are participating in the study with one project for each. In summary, to date, 13 of the 16 projects have been selected: 5 Western regions, 5 Southern region, 2 North Atlantic region, and 1 north central region. Most states added supplemental test sections except for Texas DOT.

ETG Comments, Questions, and Discussion:
Tom Harman suggested that data should be presented as percent asphalt binder replacement as opposed to RAP percentage. Musselman noted that this might have been the terminology when the plan was developed but making the change is a good suggestion for the LTPP panel.

Randy West commented that the main value he sees in the supplemental sections is their use in the evaluation of cracking tests. Musselman responded that if anybody needs to get additional samples now it is the time to contact the agencies and make the request since the sections will be monitored. Musselman will try to track down the materials request form for the LTPP test sections.

David Newcomb asked whether there is any deadline for making the requests since NCHRP 09-57 might be a benefit to these LTPP experiments. Musselman responded that it would be good to at least have a request noting the projects.

John Bukowski noted that a LTPP webinar documenting what was done in New Mexico was scheduled for this week.

4. Ground Tire Rubber in Pavements Manual [Audrey Copeland, NAPA]

Presentation Title: *Best Practices Guide for Manufacturing, Storing, Handling and testing Rubber Modified Asphalt Mixtures, Audrey Copeland.*

Summary of Presentation:
Copeland is seeking the ETG input for what to possibly include in the guide. The guide is being developed through NAPA and FHWA cooperative agreement but also with assistance from NCAT where some of the work is being done under their cooperative agreement. The two lead authors so far on this guide are and Carolina Rodezno and Richard Willis.

FHWA has not updated their guidance on using rubber in asphalt pavement since the 90s. Copeland noted that FHWA is the best agency put the guidance together on the national level. In 1991 ISTA mandated the use of minimum amount of rubber in asphalt pavements. The mandate was lifted in 1995. Copeland showed data from literature, in the 1990s the majority of the rubber was still going to landfills however in the 2000s a lot of the rubber is now being used in tire derived fuel and in 2013 as ground tire rubber. A pie chart for the 2013 ground rubber market was presented. Seven percent of ground rubber is being used in asphalt. About 600,000 Tons of ground tire rubber is consumed in the market which is equivalent to about 60 million tires out of which about 41,000 tons of GTR is used in asphalt pavements. The guide will include information collected from a survey that NAPA completes with its members on the state by state use of rubber in asphalt mixtures. A list of agencies currently using GTR in asphalt mixtures is provided. The first challenge encountered is defining a universal terminology for the use of rubber in asphalt pavement. A meeting was held at NCAT back in September among the authors at NCAT, industry, and rubber pavement association. There will probably be a follow up meeting once getting closer to the first draft. At the meeting it was decided to have a flow chart for rubber modified asphalt mixtures to help mapping out the rubber process in asphalt pavements.

An outline of the nine chapters to be covered in the best practices guide was presented. Copeland went in details on what has been done on each chapter. A list of potential benefits and challenges was provided. A table laying out the difference between asphalt rubber and terminal blend including sizing, GTR content, blending and digestion, tank storage agitation, PG grading, and performance history was prepared and included in the chapter 3 of the guidance document. Copeland mentioned that chapter 4 discusses the applications of rubber within asphalt mixtures and pavement preservation. Copeland noted that help is needed in writing the preservation

portion of the guide. She asked for suggestions to who might be able to help in writing the use of rubber in pavement preservation.

A timeline was provided with the expected date of completion for the Best Practice Guide being the end of 2015. The review process consists of NAPA technical committees, Asphalt Pavement Alliance, Rubber Pavement Association and other rubber associations, and Expert Task Groups. There will also be some implementation effort once the guide is completed consisting of technical brief(s), webinar series, and potential regional workshops.

Copeland announced the activities from the pavement economics committee and highlighted some of the tools supported by NAPA that are available online such as: PaveXpress, THINLAY for pavement preservation, IRI Explorer, and the Environmental Product Declaration (EPD). She also announced the Research Project Summary publication. PaveXpress is based on AASHTO 1993 and 1998 guide for AC and PCC and current efforts by industry to modify this empirical method. PaveXpress is user friendly and available at no charge. Heather Dylla is leading a major effort by NAPA to develop environmental products declarations (EPD).

Copeland also introduced the http://driveasphalt.org/ dedicated website which emphasizes the benefits of asphalt. NAPA started a positive advertisement campaign for asphalt benefit focusing on the drivability of asphalt. The website also includes a whole series of graphics that were developed to explain such areas as perpetual pavements, etc. Finally, some videos are also included. The website includes the benefits of asphalt in terms of speed of construction, smoothness, noise, safety, and sustainability.

Copeland also mentioned that the report from their recent tour in Japan on high RAP use in asphalt pavements.

ETG Comments, Questions, and Discussion:
John D'Angelo commented that there is no depolymerization and devulcanization of rubber and it shouldn't be in the guidance document. Bob Klutz noted that the correct term is degradation. Copeland responded that degradation should then be the focus.

Copeland asked how the process would be for the ETGs to participate in the review process of the Best Practice Guide. Bukowski suggested that it might be better to have any members or friends to send an email to Copeland asking to be added to the list of reviewers, and specifying the chapters of interest. Copeland responded that would be fine and asked the requesting emails to be sent to her with the designated chapter(s) to review.

John Harvey commented that RPA has been associated with one product and there is currently a lawsuit regarding some other processes and the RPA wet process. Need to be extra careful to make sure you get input from other groups such as Paramount. They are a producer of another wet process product. Copeland appreciated the comment. Harvey also noted that rubber in RAP mixes seem to be missing from the guide. Harvey expressed interest in reviewing the guide and providing feedback. Harvey also noted the initiative in California for the PG+5 specification (5% rubber) to be used throughout the state. Copeland will follow up with Harvey on the California initiative.

Frank Fee asked whether a designated group will be working on standardized definitions for the various products. Copeland responded that Richard Willis and Carolina Rodezno are working on a set of proposed definitions and that will be one of the first things that can be turned over to the ETG for comments and feedback.

Bukowski noted that FHWA published a technical brief last year on the use of recycled tire rubber to modify asphalt binder and mixtures and basically it addressed some of these issues. He proposed to maintain a common terminology between what is in the FHWA technical brief and what is going to be in the NAPA guide. Frank Fee commented that the Northeast users/producers group tried to survey the states for terminologies but did not much get responses from the states. Bukowski noted that FHWA cannot be involved in surveying the states. The survey mentioned and a possible future one might be done through the AASHTO SOM. FHWA can look at past surveys and consolidate the information.

Jim Musselman commented that the terminology is so important and it is different from a state to another. He suggested identifying key players (e.g., Florida, Texas, Arizona, California) to review the proposed definitions and to make sure the terminologies are based on some engineering properties.

Matthew Corrigan commented that some activities are going on at the PCCAS because of the California direction with rubber and there will be an update at the binder ETG. He also noted the round robin work and the RTFO issue with the material coming out of the bottle. Shauna Tecle-Mariam will be updating the group on the PCCAS activities.

Walaa Mogawer commented that Massachusetts DOT is doing a crumb rubber project. He also asked whether the activator rubber which is another process will be part of the guide. Copeland responded that she will make a note of that process. She also noted that it seems like another survey needs to be conducted in order to capture the different processes and especially the terminologies.

Bukowski commented that an AASHTO survey was done last year on crumb rubber modifiers and about 35 states responded. Bukowski will provide Copeland a copy of the AASHTO survey.

Action Items:
Action Item #201504- 7: Members and friends of the ETG will email Copeland if they are interested in reviewing the GTR Best Practice Guide. Reviewers are asked to specify in the email which chapters they are interested in reviewing.

5. Optimized Mix Design Approach [Shane Buchanan, Oldcastle Materials Company]

Summary of Presentation:
Buchanan's presentation covered the following topics: Why the need for an Optimized Mix Design (OMD) approach, what is currently being done in response to observed performance issues, what is the proposed framework for OMD, and what are the next steps. Recent issues

with premature cracking are being observed on dry mixtures. NAPA created a pavement performance task group in response to the performance issues and premature pavement cracking. It had been concluded there is a need to start using more creativity and innovations and better apply the current knowledge and available resources. About 1.4 million tons of HMA are produced in U.S. every day which is equivalent to 2500 lane miles at 12 feet wide and 1.5 inch thick between New York and Las Vegas. Specifications are changing rapidly as agencies search for ways to improve durability. The main focus is to increase the volume of effective binder in the mixture. There is an observed lack of thorough understating and adequate understanding of volumetric. Agencies had been searching for solutions in regards with Ndesign. Some agencies established a single gyrations level for all mixtures. The understanding was by dropping gyrations, more asphalt binder would be in the mixture; this approach does not always provide the anticipated increase in binder content. You may well end up with the same effective volume of binder even with dropping the number of gyrations. Examples for Alabama and Virginia DOTs were provided.

ATRB circular EC186 provides an interesting approach to this issue. It recognized that "VBE (the effective volume of binder) is the primary mixture design factor affecting both durability and fatigue cracking resistance. Durability and fatigue resistance improve with increasing VBE." The mix design manual developed in NCHRP Project 9-33 recommends that agencies should consider increasing the design VMA by 1.0% "to obtain mixtures with increased asphalt binder content, which can improve field compaction, fatigue resistance, and general durability."

Some states are looking at balanced mix designs. Texas has Hamburg and the Overlay Tester (OT), Louisiana has Hamburg and SCB, and New Jersey has APA and OT. Another approach by some in Indiana is to target 5 percent air voids in the lab to the 5 percent air voids in the field.

Originally industry built rich binder mixtures and when Superpave mixtures were adopted, in some cases they were too dry. Conventional mix designs are largely recipe driven. A better approach would be based on optimized performance. Goals of mix design: stability, durability, and constructability.

The basics of mix design are to get the appropriate binder to provide good stability and durability performance. The four components of OMD are: material evaluation and selection, mixture stability performance evaluation, mixture durability performance evaluation, and mixture workability evaluation.

Emphasis should be on using local materials, maximizing recycling, and engineering the binder for the given application while providing performance. Lower gyrations will keep aggregate from breaking. Could use a single gyration level based on locking point. Some have proposed to study binder adjustment assuming 90% of the RAP binder is effective and 70% of binder from RAS contributing to the total binder in the mixture. Use M323 VMA as basis for high volume traffic. Especially critical is need to be accurate with bulk gravities for volumetric calculations.

Performance based mix design stresses innovation and puts decisions in the hands of the designer. Asphalt binder demand in mixes may increase using an optimized mix design

approach; however, the cost can potentially be offset by many items such as local aggregate materials, alternative binders, etc.

For a stability check use basic available rutting tests; but make sure the threshold criteria is correct for the mixture and its application. For a durability check utilize one of the many cracking tools available based on the mode of distress anticipated for the mixture to be placed. Cracking prediction is the weak link in performance testing.

In the interim while waiting for other studies to be completed for crack prediction a simple test such as Cantabro test might provide a very quick, low cost durability indication. Examples for design performance curves are provided such as APA versus Cantabro plot.

In summary there is a need to evaluate the mix economics and optimize mix workability.
Proof of concept testing is being conducted with selected Oldcastle companies. Buchanan noted that this is a long term effort, but we must start now.

ETG Comments, Questions, and Discussion:
Frank Fee commented that the ETG in 2010 put together the document HIF-11-033 which is a review of aggregate and asphalt mixture specific gravity measurements and their impacts on asphalt mix design properties. It may be beneficial to again look to this document and see if recommendations can be made to AASHTO SOM for changes in current standards. Geoff Rowe commented that all the mix design plots are based on one property versus the other (e.g., AC versus AV) while a volumetric chart would be much more useful which includes all the individual charts in one plot. As a community we need to adopt such a plot where all the limits for the various properties are shown on one graph allowing for a better visualization of the target zone. Such a volumetric plot gives a great understanding for the engineers.

Randy West thanked Buchanan for bringing this to the ETG and noted the slide about the goal at some point to get to performance based testing and we are still debating which cracking test needs to be uses. In the interim we need to use a practical test to try to make the mix durable. West appreciated the fact that this is also being moved forward by a contractor. West also commented that one of the real issues with volumetrics is our ability measure aggregate specific gravities. Virgin aggregates specific gravities are an issue as well as RAP. NCAT with Elie Hajj at UNR done some work trying to find which method works best for RAP aggregates and we couldn't find one method that worked for everything. He believes that number of states are making mistakes with aggregate specific gravities by using either effective specific gravities or taking shortcuts for test methods such as using Rice test to calculate effective specific gravity for RAP or using an assumption for RAP aggregate absorption which all are leading to errors in volumetrics.

Bob Klutz referred to a comment made by Buzz Powel that if the mix is workable in the lab it is probably not going to perform that well on the track, and if they have a really hard time to work with the material in the lab then it has a much better chance to perform very well on the track. Klutz continued by saying that a material with a very strong interlock of the aggregate structure is a very tough and durable material but at the same time it is much more difficult to get that interlock during construction. Buchanan responded that he doesn't think that all mixes that are

hard to work are hard to lay down and vice versa. If possible there is a need to optimize workability and performance.

Klutz asked how to develop a specification that balances state and contractor concerns. Newcomb commented that one way would be by using a balanced mix design for example with the absolute lower limit set at cracking limit and the maximum limit set at rutting limit.

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

Presentation Title: *NCHRP 9-49A Project Performance of WMA Technologies: Stage II Long-term Field Performance, Haifang Wen and Shenghua (Edward) Wu*

Haifang Wen could not make it to the meeting and the presentation was made by Shenghua (Edward) Wu.

Summary of Presentation:
Wu noted the objective of the study is 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. The study included a total of five new projects constructed in 2011/2012 leading to 10 HMA-WMA pairs, and 22 in-service (existing) projects in addition to 1 HVS section leading to 40 HMA-WMA pairs. A field distress survey was conducted with the first round being in 2012 and the second round in 2014/2015 following the LTPP distress identification manual for cracks and rut depth. Cores were taken at the tip of the crack. The field cores test plan included: IDT dynamic modulus/creep compliance; fatigue-IDT fracture at room temperature; thermal cracking-IDT fracture at low temperature; and rutting/moisture Hamburg. The asphalt binders were also evaluated for: 1) PGs; 2) MSCR (rutting); 3) monotonic at room temperature (fatigue); and 3) monotonic at low temperature (thermal cracking).

The results of the first survey for transverse cracking were provided where 14 out of 24 projects exhibited transverse cracking (21 H-W pairs). Overall HMA showed comparable or more/longer transverse cracks than the companion WMA. Wu also presented the transverse cracking comparison between HMA and WMA in terms of WMA technology. The mix work density at 14°F was found to be the most determinant factor for transverse cracking (16 out of 21 HMA/WMA pairs). A transverse cracking regression model was developed based on mixture fracture work density (FWD), eight-year low temperature hour, overlay thickness, and total HMA layer thickness. Another regression model was also presented for the fracture work density as a function of VFA, Gse, binder failure strain at 41°F, asphalt binder content, and percentage passing #50 sieve size.

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). Overall HMA had better or comparable top-down cracking performance when compared to WMA. Wu also presented the top-down cracking comparison between HMA and WMA in terms of WMA technology. 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 (12 out of 17 HMA/WMA

pairs). A top-down cracking regression model was developed based on number of service years, vertical failure deformation of mix, overlay thickness, average annual daily traffic, and cumulative UV index during the service period. Another regression model was also presented for the mixture vertical failure deformation as a function of binder intermediate temperature, VFA, and percentage passing #16 sieve size.

The results of the second survey for rutting were also provided. No measureable rut depth was observed from the first round of survey. The 1/16 inch criteria is used to compare the rut depth of HMA and WMA pavements. 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 was presented. The RRI is the number of cycles multiplied by one minus the rut depth. The data showed that a higher RRI or a high PG resulted in less rut depth in the field. The higher the binder percent recovery of binder @3.2 kPa the higher the RRI (better rutting resistance). The higher the VFA the lower rutting resistance was observed. The aggregate gradation was also found to affect RRI. The higher binder absorption also led to better RRI.

Wu concluded his presentation on transverse cracking, longitudinal cracking, and rutting. Work is undergoing for the data analysis on the second round of field distress survey results, the testing on new-pavement project (2nd round sampling), and the validation of previous findings. Wu acknowledged NCHRP support and state highway agencies contributions.

ETG Comments, Questions, and Discussion:
Kevin Hall asked whether the team is specifically tasked with comparing the WMA performance to the HMA performance, and Wu responded affirmatively. Hall commented, as you gather more data and near the end of the project, if the agency can allow 2000 ft/mile of cracking and the WMA shows 500 ft/mile and the HMA shows 250 ft/mile then you will be reporting that the HMA did twice as well than the WMA while both of them are far exceeding the expected performance. If they both work within the required criteria, then it does not matter how much one works better than the other. Wu responded that the most determinant factors are needed to make recommendations on how to improve the quality of the pavement. Louay Mohammad commented that at the end, once everything is gathered, there will be a threshold for a given distress and your point will be considered within the context of this threshold.

Matthew Corrigan commented since this was one of the very early NCHRP projects on warm mix, the premise was to compare the companion pavement sections in terms of equal or better performance and that was the direction provided to the research team from the project panel. Corrigan asked which projects are continued to be monitored. One of the interesting things is to continue to look at the performance of those earliest projects and then add projects with some newer technologies that were not available earlier so you got a broad range of performance from these early projects that are now approaching ten years. Wu responded at least five projects are overlapping with the NCAT project. Wu noted some discrepancies between the collected data from both teams. The research team looked at 9-47 data for use in this project. Corrigan commented that the research team is continuing to monitor those early sections during the contract of this project, and it will be important to consider the amount of time the material has been under traffic and environmental conditions when reporting and comparing the distresses.

Corrigan applauded the team from the standpoint of amount of data that has been collected, reported, and the aggressive schedule. He asked about the progress from the standpoint of finalization of the project, when the data analysis and the final report are expected to be completed. Mohammad responded end of year 2015. Mohammad commented that one of the objectives from this study as requested by the panel is to identify the material properties measured from the tests approved by the panel that affect the performance. Some of the earlier projects from NCAT did not have the materials to perform the all tests.

West thanked the presenter for the work and for pointing out to some of the factors affecting distresses. West asked about the IDT specimen size. Wu responded that all IDT specimens are field cores and consisted of 4 inch diameter by 1.5 inch thick. West asked about whether the calculated VFA is based on the total volume of the core or based on mix design. Wu responded that the VFA is calculated from the recovered asphalt binder content. In some cases the VFA was calculated based and on the mix design information.

7. Optimizing Laboratory Design Five Percent Superpave (Superpave5) [Gerry Huber, Heritage Research Group]

Summary of Presentation:
Huber talked about his idea of designing mixtures at higher air voids. The concept of designing to four percent and building pavements to eight percent originally comes from the Marshall mix design. It was a decision to move that forward into Superpave. There was a discussion during the time of setting up the volumetrics for Superpave of having the design air voids and field compacted air voids equal. The decision was made back then is that the concept of Marshall air void criteria was well understood and would be easier in implementing Superpave.

Data from work done by Brian Powell on NCHRP report 573 shows that 55% of the evaluated cores had less than 92% density with some of them have very low density down to 85%. Powell also observed that after two years of in-service the density stabilizes. The increase in density pretty much happens in the first two years. Although the decrease in air voids (increase in density) is good for the durability of the mixture however it is only in the traffic wheel paths and the other strips of the pavement are not being compacted and they are still at the original density.

Huber's asked can we design a mixture at five percent air voids and build it at 95% density. The main motivation for this effort is durability. The concept is to design for five percent instead of four percent air voids but without a change in the asphalt binder content. A laboratory study was conducted at Purdue University under the supervision of John Haddock which included three mix designs. The original M323 design is 100 gyrations and four percent air voids. A mix design at 70 gyrations and five percent air voids was achieved with the same asphalt binder content and with a VMA target that is one percent higher than the M323 mix. The 50 and 30 gyrations mixtures required each a change in the aggregate gradation to achieve the same binder content at five percent air voids and a higher VMA target (1% higher). The rut resistance of the four different mixtures (three mixes designed to five percent and compacted to five percent and the control mix designed to four percent and compacted to seven percent air voids) in terms of flow number were presented. Huber noted that Ndes has an impact on the rut resistance of the mixture but density has a much greater effect on the rutting resistance on the mixture.

The laboratory study concluded that 30 gyrations at 5% air voids and 95% Gmm compaction gave similar or better mechanical (Marshall stiffness and flow number) properties than the 100 gyrations design at 4% air voids and 93% Gmm compaction.

In the second part of his presentation, Huber presented a trial mix that was constructed in late 2014. The trial mix was the N30 (5% air voids), 19 mm mixture and 3 inch thick. Huber noted it was a cool day. No change to rolling patterns was needed to get the 95% density. Loose mixtures and cores were sampled. QA volumetric test results were presented. Testing for permeability, Hamburg rut testing (short and long-term aging), and SCB (short and long-term aging) are being conducted. Huber concluded with the next step in his effort which is for DOT to develop a trial specification for a mix design set at 50 gyrations.

ETG Comments, Questions, and Discussion:
Howard Anderson asked for the present air voids for the Hamburg rut testing specimens. Huber responded that Hamburg testing was conducted at 5% air voids. The regular 4% mix design is compacted to 7% percent on the road and that is where the 7% air voids is coming for Hamburg testing.
Dukatz told the group that 25 mm and 37.5 mm base mixes in WI for interstate warranty projects had been design as 777 mixes. Designed at 7% air voids, produced at 7% air voids and the pavement compacted to 7% air voids.

8. Other Topics

Bukowski announced that FHWA developed the Highway Materials Engineering Course which is a six weeks training course. The accredited AMRL lab in Frederick, Maryland is used for the lab portion of the course which is broken into two, one-week of training session on-line and two, two-week sessions at the AMRL. FHWA recently concluded a preliminary review course with 25+ state attendees. The course will again be offered later this year and eventually all the course materials will be posted online. First preference to attend the course is given to states. A total of thirty spaces are available. Bukowski asked those who are interested to email Jeff Withee.

9. Action Items and Next Meeting—Frank Fee (Frank Fee, LLC) and John Bukowski (FHWA)

Action Items:

Action Item #201504- 1: Bukowski will send SOM (Abadie) suggested recommendations on the four Provisional Standards where FHWA is listed as steward (T342, PP60, PP61, and PP76).

Action Item #201504- 2: Bukowski will send SOM (Abadie) a list of recommendations on the RAP/RAS sections for AASHTO M323 and AASHTO R35 along with a marked up copy of the standards.

Action Item #201504- 3: Jeff Withee will prepare the draft AASHTO Provisional Specification for the AMPT equipment and share with ETG members and friends for feedback and comments.

Action Item #201504- 4: The Asphalt Institute will share the performance test specimen fabrication report with ETG members and friends for feedback and comments.

Action Item #201504- 5: The Bending Beam Fatigue task force led by Geoff Rowe will draft a white paper elaborating on the main issues and potential solutions for the beam fatigue test.

Action Item #201504- 6: Richard Kim will submit the IDT specifications to SOM (Abadie) on behalf of ETG for consideration and discussion.

Action Item #201504- 7: Members and friends of the ETG will email Copeland if they are interested in reviewing the GTR Best Practice Guide. Reviewers are asked to specify in the email which chapters they are interested in reviewing.

10. Next Meeting Location and Date:

The next meeting date was coordinated with the Binder ETG and will be during the week of September 14th. The meeting will be in Oklahoma City, Oklahoma.

11. Meeting Adjournment

Frank Fee and John Bukowski thanked all attendees for their participation on the ETG and attending this meeting. The meeting was adjourned at 4:40 pm.

ATTACHMENT A

Asphalt Mixture Expert Task Group
Fall River, MA
April 7-8, 2015
Meeting Agenda – Draft

Day 1 – April 7, 2015

8:00 am	Welcome and Introductions	**Fee/Bonaquist**
8:15 am	Review Agenda/Minutes Approval & Action Items September, 2014 Meeting	**Bukowski**
8:30 am	Subcommittee on Materials Updates/Comments	**Abadie**
9:00 am	Update Related NCHRP Activities	**Harrigan**
9:30 am	Break	
10:00 am	AMPT Specification • Friction Reducers for AMPT Testing • Performance Test Specimen Fabrication • Fatigue and Cracking Tests Evaluation • Experiments on Candidate Cracking Tests	**Withee** **Tran** **Blankenship** **Blankenship** **West**
	Noon - Lunch Break	
1:00 pm	NCHRP 9-57 Design of Field Validation of Lab Tests to Assess Cracking Resistance	**Newcomb**
1:30 pm	AMPT Small Sample Specimen Status	**Gibson/Withee**
2:00 pm	E* TP62, T342, TP 79 Alignment Rods Issue	**Corrigan**
2:30 am	**Break**	
3:00 am	Task Group Review Update T-321 (Beam Fatigue)	**Rowe**
3:30 pm	Report IDT Study Final Update	**Kim**
4:00 pm	Report Task Force RAP/RAS • AASHTO Recommendations/State DOT Issues • Industry Concerns	**Gallivan**
	Adjourn for the Day	

Day 2 – April 8, 2015

8:00 am	Recycled Materials- Performance Prediction	**Bukowski**
	• RAS & RAP Mixes Fatigue/Fracture Resistance	**Al-Qadi**
	• RAS and/or RAP with Various Recycling Agents	**Mohammad**
9:30 am	Break	
10:00 am	Recycled Materials- Performance Prediction (Cont.)	
	• Mix Evaluation Using Disc-Shaped Compact Tension	**Buttlar**
	• ALF Experiment- Status	**Gibson**
11:30 am	NCHRP 9-49A WMA -Long-Term Field Performance	**Wen**
	Noon - Lunch Break	
1:00 pm	Update on the WMA LTPP Experiment	**Musselman**
1:30 pm	Ground Tire Rubber in Pavements Manual	**Copeland**
2:00 pm	Optimized Mix Design	**Buchanan**
3:00 pm	**Break**	
3:30 pm	Construction Task Group Activities	**Dukatz**
	• Research Needs Statement Status	
	• Asphalt Institute Planned Course on Compaction Issues	
4:30 pm	Action Items and Next Meeting Planning	**Fee/Bukowski**
	Adjourn	

ATTACHMENT B

FHWA Asphalt Mixture & Construction Expert Task Force Members

Chairman: **Frank Fee** Frank Fee, LLC 401 Woodward Road Media, PA 19063 Phone: 610-608-9703 Cell: 610-565-3719 Frank.Fee@verizon.net	Co-chairman: **Ray Bonaquist** Chief Operating Officer Advanced Asphalt Technologies, LLC 40 Commerce Circle Kearneysville, WV 25430 Phone: 681-252-3329 aatt@erols.com
Secretary: **John Bukowski** Asphalt Team Leader FHWA Federal Highway Administration 1200 New Jersey Ave., SE; E75-332 Washington, D.C. 20590 Phone: 202 366-1287 Fax 202-493-2070 John.Bukowski@dot.gov	
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ATTACHMENT C

Task Force Members and Assignments
FHWA Asphalt Mixture & Construction ETG

Task Force Identification:		Members Assigned to Force:
1	Performance Test Review	Mike Anderson (Lead), Ray Bonaquist (Lead); Richard Kim, Elie Hajj, Haleh Azari, Audrey Copeland, Kevin Van Frank, Phil Blankenship, Nam Tran, Raj Dongre, Nelson Gibson, Harold Von Quintus
	T 320; Simple Shear Test	Louay Mohammad, Tom Bennert, Richard Steger, Becky McDaniel
	T 321; Bending Beam Fatigue	Geoff Rowe, Tom Bennert, Phil Blankenship, Bill Criqui, John Harvey, Kieran McGrane, Mike Mamlouk, Richard Steger, Louay Mohammad, Elie Hajj, and Andrew Copper
	T 322; Indirect Tension	Jo Daniels, Becky McDaniels, Rey Roque, Richard Steger
2	WMA Mixture Design	Matt Corrigan (Lead): Louay Mohammah, Charlie Pan (for Reid Kaiser), Gerald Reinke, Kevin Hall, Dave Newcomb, Randy West, Tim Ramirez, Walaa Mogawer, and Jason Lema.
3	Construction Task Group	Erv Dukatz (Lead); Jim Musselman, Kevin Hall, Gerry Huber, Adam Hand, Ron Sines, Audrey Copeland, Tom Harman, and Mark Buncher.
4	AMPT, TP 60: Air Void Tolerance and Sample Preparation Issues	Ramon Bonaquist (Lead); Haleh Azari, Matt Corrigan, Richard Kim, Gerald Reinke, Richard Steger, and Randy West
5	RAP/RAS	Jim Musselman (Lead): Timothy Aschenbrener, Audrey Copeland, John D'Angelo, Lee Gallivan, Danny Gierhart, Gerry Huber, Timothy Ramirez, Ron Sines, Hassan Tabatabaee, Randy West, and Richard Willis
6	LTPP WMA Group	Jim Musselman (Lead); Ramon Bonaquist, Adam Hand, Georgene Geary, Audrey Copeland