FHWA Asphalt Mixture Expert Task Group

Asphalt Mixture Expert Task Group Purpose
The primary objective of this Federal Highway Administration (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 (16 members, 2 contract personnel, and 48 visitors). Attachment A contains the meeting agenda, Attachment B includes a listing of the Mixture Expert Task Group (ETG) members, Attachment C is a listing of the Mixture ETG Task Force members, and Attachment D contains the Preliminary Outline for a Regional Pooled Fund Study on Performance Related Specifications (PRS) for Asphalt Paving Mix.

Members of the FHWA Asphalt Mixture ETG in attendance:

Shane Buchanan, Oldcastle Materials (Chairman)
Ray Bonaquist, Advanced Asphalt Technologies, LLC (Co-Chairman)
Matt Corrigan, FHWA (Secretary)
Howard Anderson, Utah Department of Transportation (DOT)
Rick Bradbury, Maine DOT
Ervin Dukatz, Mathy Construction Company
Kevin Hall, University of Arkansas
Adam Hand, University of Nevada
Gerry Huber, Heritage Research Group
Ross O. Metcalfe, Montana DOT
Louay Mohammad, Louisiana State University
Dave Newcomb, Texas A&M University
Timothy Ramirez, Pennsylvania DOT
Mark Buncher, Asphalt Institute (Liaison)
Nam Tan, National Center for Asphalt Technology (NCAT) (Liaison)
Pamela Marks, Ontario Ministry of Transportation (MTO) (Liaison)

Members of the FHWA Asphalt Mixture ETG not in attendance:

Tom Bennert, Rutgers University
Jo Daniel, University of New Hampshire
Todd Lynn, Thunderhead Testing, LLC
R. Michael Anderson, Asphalt Institute (Liaison)
Audrey Copeland, National Asphalt Pavement Association (NAPA) (Liaison)
Evan Rothblatt, American Association of State Highway and Transportation Officials (AASHTO) (Liaison)
Edward Harrigan, National Cooperative Highway Research Program (NCHRP) (Liaison)

"Friends" of the FHWA Asphalt Mixture ETG in attendance:

David Porter, Payne and Dolan
Stacy Glidden, Payne and Dolan
Andrew Hanz, Mathy Construction
CJ DuBois, DuPont Elvaloy®
Weiguang Zhang, Purdue University
Shenghua Wu, University of Illinois at Urban Champaign
Tim Aschenbrener, FHWA
Dennis Bachman, FHWA - Illinois
Brian Pfeifer, Illinois DOT
Robbie Troxler, Troxler Electronics
David Jones, University of California Pavement Research Center
Todd Arnold, Pine Test Equipment, Inc.
John D'Angelo, D'Angelo Consulting
Ali Regimand, InstroTek, Inc.
Punitu Shivaprasad, Shell Oil Products US
Ashley Buss, Iowa State University
Jason Bausano, Ingevity Corp
Bob Kluttz, Kraton Polymers LLC
Bill Buttlar, University of Missouri – Columbia
Randy West, NCAT
Mark Blow, Asphalt Institute
Salmon Hakimzadeh, Reliable Asphalt Corporation
Chris Williams, Iowa State University
Joseph Podolsky, Iowa State University
Andrea Caruessi, IPC Global – Controls Group
Steven King, IPC Global – Controls Group
Todd Thomas, Colas
Rebecca S. McDaniel, North Central Superpave Center
Lee Gallivan, Consultant
Frank Fee, Frank Fee, LLC
Shihui Shen, Penn State University Altoona
Cassie Castorena, North Carolina State University
Richard Kim, North Carolina State University
Dave Mensching, FHWA
Richard Duval, FHWA
Jim Musselman, Oldcastle Materials
Ron Sines, Oldcastle Materials
Doug Zuberer, Zydex
Khaled Hasiba, Controls Group USA
Mike Hemsley, Paragon Technical Services
Gerald Reinke, MTE Services, Inc.
Kevin VanFrank, CMRTG
Shauna Brorold, Testquip LLC
Tom Brorold, Testquip LLC

Chris Wagner, FHWA
Jack Youtcheff, FHWA
Dan Staebell, Asphalt Pavement Alliance (APA)
Amir Golalipour, Engineering & Software Consultants, Inc.

Meeting Coordinator: Carol Fisher, Amec Foster Wheeler
Meeting Technical Report: Beth Visintine, Amec Foster Wheeler

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DAY 1: Monday, May 1, 2017

1. Call to Order

Shane Buchanan called the meeting to order at 8:02 AM.

2. Welcome and Introductions

Chris Williams welcomed the meeting participants to Ames, Iowa, and Iowa State University.

Matthew Corrigan thanked Williams for hosting the meeting at Iowa State University, welcomed everyone to the meeting, and asked everyone to introduce themselves.

3. Review Agenda, Minutes & Action Items [Matt Corrigan, FHWA]

Corrigan noted that the technical report from the last meeting was distributed to members.

Corrigan stated the Action Items from the September 2016 ETG meeting are included on the agenda for this meeting. The following is a listing and status of the Action Items from the last meeting:

- Action Item #201609-1. Andrew Hanz will present an update on Long-Term Aging of Recycled Asphalt Shingles (RAS) at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-2. Louay Mohammad will report on NCHRP 9-49(A) Warm Mix Asphalt (WMA) Long Term Field Performance at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-3. Richard Kim will report on the status of NCHRP 9-54 Long-Term Aging of Mixes at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-4. Randy West will report on the status of NCHRP 9-55 RAS in WMA at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-5. ETG members are requested to provide comments on AASHTO TP 107 (Cyclic Fatigue – Asphalt Mixture Performance Tester (AMPT)) to David Mensching. Comments will be summarized and either forwarded as a draft provisional standard to the Subcommittee on Materials (SOM) or, if significant comments, discussed further at the next ETG meeting.
  Update: Item is on the agenda.

- Action Item #201609-6. Audrey Copeland will present on NAPA's technical activities at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-7. Shane Buchanan will present on the activities/recommendations of the Balanced Mix Design Task Force at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-8. Kevin Hall and Dave Newcomb will present on the challenges of introducing pavement related subjects into the engineering curriculum.
  Update: Item is on the agenda.

- Action Item #201609-9. Geoff Rowe will lead the preparation and present on proposed practice changes to AASHTO T 321 "Determining the Fatigue Life of Compacted Asphalt Mixtures Subjected to Repeated Flexural Bending" at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-10. Jim Musselman will present on activities of the reclaimed asphalt pavement (RAP)/RAS Task Force at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-11. Erv Dukatz will present on activities of the Task Force on Construction at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-12. Pamela Marks will present on the Ontario Ministry of Transportation's Asphalt Testing Innovations at the next meeting.
  Update: Item is on the agenda.

- Action Item #201609-13. Kevin Hall and Nam Tran will present at the next meeting an update on their effort related to analysis of the asphalt fatigue cracking model in the ME-Design procedure.
  Update: Item is on the agenda.

4. Update: RAP/RAS Task Force [Jim Musselman, Oldcastle Materials]

Presentation Title: *RAP/RAS Team Update*

Summary of Presentation:
Jim Musselman began the presentation by acknowledging the Task Force members and additional support. Musselman stated due to retirements and employment changes the current Task Force team needs a better membership balance from State agencies.

Musselman stated in 2015 the amount of RAS usage in hot mix asphalt (HMA) and WMA was roughly 2 million tons nationwide which equates to about 0.5 percent of the total HMA tonnage. The benefits of RAS presented by Musselman include improved resistance to rutting, reduced

costs for HMA production and conservation of landfill space while the risks of RAS include incomplete blending and decreased resistance to cracking. The two main issues with RAS are the binder quantity and quality – how much of the RAS binder becomes effective binder and how to address the stiffness/brittleness of the RAS binder.

The RAS Task Force recommended that a minimum voids in mineral aggregate (VMA) be raised by 0.1 percent for every 1 percent RAS (by weight of total aggregate) based on the assumption of 70 percent binder availability. To address binder quality, the Task Force recommended to focus on the critical low temperature difference of the binder, ΔTc, where the ΔTc for the blended binder should be greater than or equal to -5.0 ºC for 40-hour pressure aging vessel (PAV) conditioned binders.

Musselman presented the options in the standard, which include 40-hour PAV aging for the binder, loose mix conditioning at 135 ºC for 24 hours for mixture aging, agencies allowed to use a mixture performance test for cracking in lieu of the binder testing for ΔTc, agency's may default to RAS binder replacement (RASBR) less than or equal to 0.10 and agency's may set allowable RAS tiers. Musselman stated the advantages of the standard are it provides a relatively simple approach focused on the end result and it provides agencies a better mechanism to set the limits on RAS usage.

The revised AASHTO PP 78: Standard Practice "Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures" will be published in August 2017.

The future activities of the Task Force include discussing inconsistencies in Table 2 and Table 3 in the AASHTO M 323: Standard Practice "Superpave Volumetric Mix Design" and decide if the percentage of reclaimed asphalt mixture (RAP) should be based on the weight of mixture, on the weight of the aggregate or on the reclaimed asphalt pavement binder ratio (RAPBR). The addition of an option for mixture performance test and/or ΔTc for high RAP mixes needs to be discussed as well as consideration for rejuvenators. The current standard does not provide a primary control sieve for the 4.75 mm mixture.

Musselman stated that although AASHTO PP 78 was improved, it will need to be revised in the future based on the latest emerging research. Musselman ended the presentation by asking for new members to join the Task Force.

ETG Comments, Questions, and Discussion:
Shane Buchanan asked how the RAP standard handled the two tables. Clarification was provided stating that Table 2 is used if an agency elects to use RAP by dry weight, while Table 3 is used if an agency uses percent binder replacement to adjust the binder grade in order to account for the amount of stiffness of the RAP binder.

Chris Williams commented there are lots of recycling agents or "rejuvenators" coming out in the market and that it is best practice to use rejuvenators with recycled materials. Musselman stated the standards will need to be edited to account for recycling agents.

It was asked what type of concerns were received from the RAS industry? Musselman responded the RAS industry was concerned with the 70 percent binder availability used as the basis for the change in VMA. Musselman also stated industry was concerned that ΔTc may restrict their products historically used. However, Musselman pointed out that the standard allows for mixture performance testing to supplement the ΔTc.

Bill Butler asked whether agencies would still be bound to the VMA numbers if performance test were used. Tim Aschenbrener clarified the VMA adjustment is in a different section of the standard than the performance testing so the VMA adjustment was still required. Bill responded it was good to have options out there and that there are a lot of variables, so it is good to have flexibility.

John D'Angelo commented that melting point of RAS can sometimes be higher than the production temperature of asphalt mixtures. Studies regarding diffusion have shown the diffusion of the RAP binder is delayed around one hour but with RAS, this diffusion takes much longer. Although RAS is not a rock, it does not blend very much. This results in a non-blended composite material.

Chris Williams commented the pavement responds to load and that the design with various materials should consider loading. Musselman acknowledged it was a good point and that the engineering properties need to be considered.

Frank Fee commented that another element to consider was time and if the pavement would last longer than a year.

Volunteers for additional Task Force members include:

- Rebecca McDaniel
- Bill Buttlar
- Stacy Glidden
- Howard Anderson
- Sam Cooper
- Andrew Hanz
- Chris Williams
- Salman Hakimzadeh
- Brian Pfeifer
- Nathan Morian

Howard Anderson commented that UtahDOT would consider using RAS in lower lifts. He stated although ΔTc is a great procedure, it may face opposition to implement within the State. Anderson suggested the State needs a percentage of RAP that can be used as they do not have the ability for ΔTc.

Tim Ramirez commented with RAP stockpiles continuously changing, they are creeping from tier 1 to tier 2 when considering recycled asphalt binder replacement (ABR). Ramirez asked for some guidance regarding this issue.

It was asked whether States that have more stringent criteria for grind size could adjust the VMA. Musselman responded States make their adjustments and there is flexibility based on materials, conditions and also warranties.

Ervin Dukatz commented the original mission was to remove the deficiencies with the RAP table and that keeping both tables for ease of use was not correct. Corrigan responded States currently using Table 2 need time to transition to Table 3. With the Standard having both tables, it provided flexibility for people to transition to Table 3 over time.

Buchanan asked whether the Task Force could transition M 323 from using Table 2 to using Table 3. Musselman responded that in next Task Force revision, he does not think that Table 2 will be included.
Musselman noted that the RAS revision to PP 78 was based on the best available information at the time and that it represents a significant improvement and a move in the right direction.

Action Item #201705-1. Jim Musselman solicited additional members of RAP/RAS Task Force. The future focus of the Task Force will be on RAP and AASHTO M 323. Musselman will provide an update at the next ETG meeting.

5. Update: Related NCHRP Projects and Activities [Ed Harrigan, Transportation Research Board]

Presentation Title: *National Cooperative Highway Research Program (NCHRP)*

Summary of Presentation:
Matthew Corrigan made the presentation on behalf of Ed Harrigan. The presentation provided an update on the progress of on-going NCHRP projects.

The 2018 NCHRP project includes:

- Project 9-57A: “Field Validation of Laboratory Tests to Assess Cracking Resistance of Asphalt Mixtures.”

  Newcomb provided a brief update stating that the second phase will be starting this coming fall and will likely include ruggedness testing and cracking validation.

  West asked whether the project would move forward with ruggedness on all projects. Newcomb responded that the ruggedness testing could be completed quickly considering the long amount of time the field validation will require but ultimately the project’s panel membership will decide what tests will be included.

Recently awarded projects include:

- Project 9-52A: “Short-Term Laboratory Conditioning of Asphalt Mixtures: Field Verification” awarded to Texas A&M Transportation Institute. The objective of the project is to verify short-term laboratory conditioning procedure for asphalt mixtures developed in NCHRP Project 9-52 with field data obtained over an extended service period.

Newcomb stated that Project 9-52 was completed two years ago and that this project will follow-up on field sections to try to capture the increase in stiffness with time. To date, about 40 percent of the sites have been visited with the remaining sites targeted for summer 2017.

- Project 9-61: "Short and Long-Term Aging Methods to Accurately Reflect Binder Aging in Different Asphalt Applications" awarded to Advanced Asphalt Technologies, LLC. The objective of the project is to develop practical laboratory aging methods to accurately simulate the short-term (from production to placement) and long-term (in-service) aging of asphalt binders.

  Ray Bonaquist explained the purpose of the project is to improve short-term and long-term binder aging procedures. Bonaquist stated that there are deficiencies with rolling thin film oven (RTFO) and PAV with improvements for each and that aging should be calibrated to field data with calibration for both short-term and long-term procedures. The project is currently in the planning phase with a detailed work plan expected in August 2017.

- Project 20-07/Task 400: "Effect of Elevation on Rolling Thin Film Oven Aging of Asphalt Binders" awarded to Advanced Asphalt Technologies, LLC. The objective of the project is to develop a standard method for adjusting RTFO conditioning times based on laboratory elevation above sea level.

  Bonaquist stated the project is using data collected from AASHTO re:source and Western Cooperative test group. Bonaquist stated it was clear there is an elevation effect on aging where stiffness of the aged binder decreases with increasing elevation. The project is investigating if there is a way to address this based on changing the aging time as a function of elevation.

- Project 20-44(01): "Workshop on Increasing WMA Implementation by Leveraging the State-of-the-Knowledge" awarded to Myers McCarthy Consulting Engineers, LLC. The objectives of the project are to identify the barriers to implementation of WMA specifications by the State Departments of Transportation (DOTs) and to establish performance measures for WMA implementation nationwide.

  This project was initiated by demand of State DOTs with the emphasis on implementing NCHRP project results, findings, and recommendations. A workshop is scheduled for May 8-9, 2017 in Irvine, CA to discuss issues and understand why some States are not using WMA and the barriers they are facing. There will be a documentation report after the workshop.

Projects in negotiation include:

- Project 9-62: "Quality Assurance and Specifications for In-Place Recycled Pavements Constructed Using Asphalt-Based Recycling Agents."
- Project 20-07/Task 406: "Development of a Framework for Balanced Asphalt Mixture Design."

- Project 9-56A: “Identifying Influences on and Minimizing the Variability of Ignition Furnace Correction Factors-Phase II.”

The projects nearing completion include:

- Project 9-54: “Long-term Aging of Asphalt Mixtures for Performance Testing and Prediction.”

  Findings of the project propose a conditioning protocol with an aging temperature no greater than 95 ºC. The project is on the current meeting agenda to be discussed.

Recent NCHRP publications include:

- NCHRP Research Report 837, Performance-Related Specifications for Emulsified Asphaltic Binders Used in Preservation Surface Treatments.
- NCHRP Synthesis 495, Use of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles in Asphalt Mixtures.

Spring 2017 Publications

- NCHRP Research Report 847, Variability of Ignition Furnace Correction Factors
- NCHRP Research Report 843, Long-Term Field Performance of Warm Mix Asphalt Technologies

Problem statements for FY 2019 are needed and due to NCHRP by October 15, 2017. Problem statements may be submitted by State DOTs, AASHTO Committees, and FHWA. Project 20-07 Problem Statements accepted from the Standing Committee on Highways (SCOH) Subcommittees at any time with two selections per year. Corrigan stated this was a potential way to have ETG identified research needs addressed; membership should be proactive in generating and drafting research needs statements for submission. Corrigan commented the ETG typically works through the AASHTO Subcommittee on Materials (SOM) through Oak Metcalfe, MTDOT and SOM Tech Section 2d chairman.

<u>ETG Comments, Questions, and Discussion:</u>
Regarding oven conditioning, Dave Anderson commented many people provide incorrect barometric data as it has been corrected to sea level. The barometric pressure is not reported consistently between laboratories.

Dukatz commented to find barometric pressure; the pressure density takes into effect the altitude while some report pressure adjusted to sea level. Bonaquist responded the data sets have a mixture of the two data types. Due to the elevation effect, binders are not passing the criteria (2.2 kPa) at higher elevations but would at lower temperatures.

Bob Kluttz asked if the RTFO and the mix plant are both at 6,000 ft. elevation, whether a correction was desired? Bonaquist responded it is a performance specification and there is a desire to include some correction for between laboratory comparisons; it would be another step in the AASHTO re:source process. John D’Angelo commented in some states have laboratories located at different elevations than the rest of the state and that issue needs to be addressed.

Buchanan commented the States that they work in have different definitions for WMA and that a unified voice at the workshop would be helpful as some of the fears associated with not using WMA are unfounded.

Musselman asked what was the goal of Project 20-44(01) and if it was for States to develop specifications? Corrigan stated there was a perception by AASHTO member State CEO's that WMA was not being utilized to the fullest extent considering the amount of completed WMA NCHRP projects. Although there was an acceleration of WMA usage since 2009, usage has flattened out over the past couple of years. The workshop is to assess the remaining barriers to implement and advance WMA and what can be done to remove the barriers.

6. NCHRP 9-49A Long Term Field Performance of WMA [Shihui Shen, Pennsylvania State University]

Presentation Title: *NCHRP 9-49A Project Long-Term Field Performance of Warm Mix Asphalt Technologies NCHRP Report 843*

Summary of Presentation:
Shen stated the project was initiated in 2011. At that time, the use of WMA was rapidly growing in the US and throughout the world, given the many benefits of using WMA. Many research projects were also on-going, mostly focused on laboratory test and short-term performance. Some agencies were skeptical about the long-term performance of WMA, as compared to HMA.

The research objectives of the project were to investigate the long-term field performance of WMA as compared to its control HMA (transverse cracking, wheel-path longitudinal cracking, rutting and moisture damage), 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 focus of the presentation was on the first research objective.

Since the sample size and project section were the most important steps in the project, this was done in consultation with statisticians and practical considerations in order to select 28 projects throughout the country in four climate zones. Of these projects, 22 projects were in-service pavements.

There was a HMA control at each project and several WMA categories (organic, chemical and foaming) at the same site. Therefore, the projects shared the same construction quality, climate, and traffic with the major difference being the material.

Shen provided the project distribution as summarized below:

- WMA type – 12 organic, 17 chemical, 18 foaming
- Climate zone – 6 dry freeze, 10 wet freeze, 4 dry no-freeze, 9 wet no-freeze
- Service year – 11 (year 4, 5) 10 (year 5, 7) 7 (year 7, 9)
- Pavement type – 20 flexible, 8 Portland cement concrete (PCC) or cement stabilized base

- Traffic – 18 less than 3 million Equivalent Single Axle Loads (ESALs), 10 greater than or equal to 3 million ESALs
- Use of anti-stripping – 12 yes, 12 no, 4 N/A
- Use of RAP – 14 yes, 10 no, 4 N/A

The research approach for the selection of WMA candidate projects included laboratory characterization and field characterization. The laboratory characterization included volumetrics (aggregate gradation, asphalt content (AC), maximum specific gravity (G_{mm}) and specific gravity (G_{mb})), field cores and extracted binders. The field characterization included field core (plant mix), distress survey (transverse cracking, wheel-path longitudinal cracking, and rutting), and falling weight deflectometer (FWD) testing.

Manual distress surveys were conducted following the Long-Term Pavement Program (LTPP) protocol. Transverse cracking characterization was quantified using three randomly selected research sections 200 feet in length. The quantified transverse cracks in the sections were averaged. Cores were taken at non-traffic sites for use in material calculation and to verify how the pavement was cracking (thermal or reflective cracking) and for cracking test. Longitudinal cracking was quantified in the wheelpath measured two to four feet away from the shoulder or centerline. Field cores indicated that the cracking was top-down. Rutting was measured in both wheelpaths using a straight edge. After data collection, the data analysis consisted of field performance comparison, identification of significant determinants, and development of performance predictive models.

The first round of field transverse cracking was measured in 2011 and 2012. At that time, 14 of the 28 projects had cracked and the performance of the HMA and WMA was similar (29 out of 35 pairs). Projects in the wet climate had more transverse cracking; however, this could be attributed to climate (moisture), traffic, structure or materials. The first round of field performance comparison among WMA technologies showed that all technologies behaved similarly in transverse cracking and that most pavements began to show cracking at year 4. The effect of pavement age on performance showed that at 4 years, the binder high temperature increased and could be related to inferior cracking performance.

The second round of field transverse cracking was measured in 2014 and 2015. At that time, 22 projects showed transverse cracking with most of these projects in the wet climate zone. As a result, moisture may be a consideration for transverse cracking. HMA and WMA again showed comparable behavior (31 out of 39 pairs). The effect of pavement age on performance showed that cracking increased at year 4 and 8. The new projects all cracked prior to year 4. The comparison among WMA technologies showed that the organic WMA starts to show more cracks than chemical and foaming.

The first round of field wheel-path longitudinal cracking was measured in 2011 and 2012. At the time, 8 of the 28 projects had cracked and the performance of the HMA and WMA was similar (39 out of 41 pairs). All projects that showed cracking were in the wet climate. Comparison among WMA technologies showed that all technologies behaved similarly in wheel-path longitudinal cracking. The effect of pavement age showed that cracking begins to increase at year 4.

The second round of field wheel-path longitudinal cracking was measured in 2014 and 2015 and showed that some cracks did develop in the dry freeze zone but more cracking was measured in the wet climates. The performance of HMA and WMA was comparable (39 of 44 pairs). Comparison among WMA technologies showed that organic starts to show more cracks than chemical and foaming. The effect of pavement age showed cracking beginning around year 3 and significant increase in cracking length in years 6 and 7.

The rutting field performance comparison showed the rut depth was less than $1/16^{th}$ of an inch for the first round. Shen presented the second round of survey results for comparison where 23 out of 28 projects showed some degree of rutting. The comparison between HMA and WMA was similar (39 out of 43 pairs). Colorado and Washington showed more rutting where studded tires are used. Pavement age showed no effect on rutting for the first three years and then two projects showed high rut depths. More differences in rut depth occurred after 6 years. Comparison among WMA technologies was similar.

Moisture susceptibility field performance showed no moisture damage for both HMA and WMA pavements which was consistent with NCRHP 9-49 findings. Field cores used for the Hamburg Wheel Track Test showed some pavements with moisture sensitivity potential which was not shown yet in the field. Most of these projects that show the stripping inflection point (SIP) potential did not have anti-stripping agent while most of the projects with anti-stripping agent did not have an issue with moisture.

Shen next presented the relationship between rutting and cracking performance by climate zone. For the dry freeze zone, rutting is more dominant than cracking and possibly could be attributed to studded tires. The dry non-freeze zone was non-conclusive because there were only two data points. Cracking was dominant for the wet freeze zone while the wet non-freeze zone showed both cracking and rutting.

Shen presented the following findings for transverse cracking:

- Transverse cracks were found to initiate from the top surface of the pavement, but often overlapped with existing transverse cracks in the asphalt layer.
    - Transverse cracking could be a combination of thermal and reflective cracking.
- Transverse cracking performance between HMA and WMA.
    - Comparable for the majority of HMA and WMA pavements.
    - Mostly seen in pavements with four or more years of age.
- Transverse cracking performance among WMAs.
    - Short-term: comparable for the three WMA technologies.
    - Longer term: chemical and foaming appear to be comparable or better than organic.

Shen presented the following findings for wheel-path longitudinal cracking:

- Cracks were found to initiate from the surface of the pavement.
    - May be indicative of top-down fatigue cracking.
- Performance comparison between HMA and WMA.
    - Comparable for the majority of HMA and WMA pavements.

    - Cracks start to develop mostly at age of 3-4 years; more cracking is seen with 6+ years.
- Performance among WMAs.
    - Short-term: comparable for the three WMA technologies.
    - Longer term: chemical and foaming appear to have comparable or better performance than organic.

Shen presented the following findings for rutting and moisture susceptibility:

- Rutting performance between HMA and WMA pavements and among WMA technologies is mainly comparable.
- Field rut depth starts to build up as early as 3 years; and becomes more differentiable (more than 0.1") with 6 or more years of service.
- Based on field investigation, no moisture-related distress was found in both HMA and WMA pavements.
- Based on laboratory HWT test results, most of mixes without an anti-stripping agent exhibited SIPs.
    - The use of anti-stripping agent may be beneficial overall for both HMA and WMA mixtures.

The overall findings presented were that the distress distribution appears to be climate related. Future research may include the effect of moisture on cracking.

ETG Comments, Questions, and Discussion:
D'Angelo asked what was considered organic WMA. Shen responded mostly Sasobit.
Kevin Hall commented that there could be more factors affecting performance than climate, such as traffic and pavement structure. Shen responded that there were some high traffic projects in the dry zones.

Adam Hand asked if the WMA additive provided a similar benefit for any of projects where anti-strip was not used. Shen responded that they did not use anti-strip for WMA.

Gerry Reinke asked whether the projects were truly "warm" based on the decrease in production temperature. Shen stated that they have the production temperatures for the projects.

West asked why it was recommended to use anti-strip agents when there was no stripping seen in the field?. Shen responded that it was not a recommendation but only an indication and it can be beneficial to delay stripping.

7. NCHRP 9-54 Update Long Term Aging of Mixes [Y. Richard Kim, North Carolina State University]

Presentation Title: *NCHRP Project 9-54 Update – Long-term Aging of Asphalt Mixtures for Performance Testing and Prediction*

Summary of Presentation:
The objectives of NCHRP 9-54 are to develop a calibrated and validated procedure to simulate long-term aging of asphalt mixtures for performance testing and prediction, develop an aging model that is more accurate than global aging system (GAS) model and less cumbersome than the Transport model, and to develop calibration functions by investigating the differences in mechanical properties as functions of traffic, climate and moisture. Kim stated the Transport model has multiple inputs that are difficult for agencies to gather. The presentation focused on the long-term aging procedure.

The aging factors investigated included pressure versus oven, compacted specimen versus loose mix and 95 ºC versus 135 ºC (presented at the previous ETG meeting). The proposed long-term aging method that was most promising was oven aging of loose mix at 95 ºC based on specimen integrity (compactability), uniformity of oxidation, efficiency, practicality and versatility, and simulation of physicochemical changes in field aging.

Kim next presented the verification of existing kinetics models using rheological AIP (log G*) and laboratory aged loose mix data. Kim stated for the project, the model switched from chemical related equations to rheology related equations. Petersen and Glasser demonstrated the M value was an important parameter. The k_c and k_f are constants. The M value can be determined from 95 ºC aging. With at least two points, using the M value, aging at other temperatures can be predicted using the kinetics model.

Kim presented the measured and predicted M value for different mixes. The graphs showed the higher the M value, the faster the aging rate and more spread between temperatures while slower aging rates and less spread occur with smaller M values. The M values were calculated based on 95 ºC and then used to predict other temperatures. The predictions appeared good and showed the kinetics model works. This prediction was based on isothermal aging. Verification using non-isothermal history compared G* values at different time and predicted these values using the kinetics model for 16 days, 33 days and 43 days. The error was less than 15 percent. Since 15 percent error in G* is about equivalent to 10 percent E*, this error is considered within acceptable limits.

Kim presented the use of kinetics modeling to find the required duration to match field aging. There are fluctuations in temperatures in the field but not in the laboratory; however, the aging needs to match. The assumption is that short-term aging (STA) condition is similar to field placement. The aging duration is based on the field enhanced integrated climatic model (EICM). The required aging duration to match field aging is independent of binder source/type (i.e., STA G* and M value).

The non-isothermal aging verification was done with accelerated loading facility (ALF)-control and WesTrack-Fine. An exponential relation was observed in non-isothermal laboratory aging trial.

Verification from field cores included FHWA ALF control and FHWA ALF SBS (polymer) modified. The field core G* were matched using the laboratory aging. Since these cores are from

the same climate condition, individual binder characteristics do not affect the aging duration. The required aging duration was 7.7 days and 8 days for the ALF control and ALF-SBS, respectively.

Verification from WMA versus HMA matching the field aging levels (for the same climatic region) in the laboratory showed about the same required duration at 85 ºC with 16.5 days for HMA and 16.1 days for WMA in Manitoba. The NCAT sections showed a larger difference between required aging – 35.6 days versus 31.3 days for HMA and WMA, respectively – but still within 10 percent. This is the amount of aging time required for compacted specimens, but loose mix aging would be less.

The field cores showed the climatic condition of a project is required for determining the required aging duration. Kim next presented aging durations based on climatic data matching 4, 8, and 16 years of field aging. The climatic aging index was developed. The aging duration based on climatic aging index had a slope of 1 with some scatter due to factors such as differing VMA and in-place density at the same locations. The aging duration is determined based on the climatic aging index at years 4, 8, and 16. Kim presented maps showing the required oven aging duration at 95 ºC to matching 4 years, 8 years, and 16 years of field aging in days for the United States. The required laboratory conditioning duration ranged from 1 to 6 days to represent 4 years; 1 to 12 days to represent 8 years; and 2 to 23 days to represent 16 years.

ETG Comments, Questions, and Discussion:
Chris Williams asked if the reaction products of the field versus the laboratory were considered as well as the distribution of molecules. Kim responded they performed Fourier Transform Infrared (FTIR). Williams asked if ultraviolet light was used since biological products are not effectively aged in the oven. Kim responded they are avoiding looking at the surface of the pavement as they are not able to capture the effects at the surface and therefore they are considering the aging at a depth of at least 19 mm with diffusion to deeper depths.

Kluttz commented on the kinetics equation used and the lack of exponents used on both parts similar to fundamental kinetics. Kim responded what was used was coming from many mixes and that although it could be fit with an exponential, Peterson and Glaser suggested the linear model.

Gerry Huber commented the aging at 4, 8, and 16 years was independent from the original materials and asked what the models would predict as the performance grade (PG) of an original PG64-22 after 16 years. Kim responded that is a different study. Huber agreed that it is different but it would be interesting to consider data on RAP based on these aging models. Kim responded currently the map will not provide that information and that it only provides the number of days to get the number of years of aging. Kim acknowledged although they can determine duration, it does not mean that they are determining other material properties.

Jack Youtcheff asked what this represented in the field? Kim responded that this map was for the aging duration required at a depth of 19 mm.

Reinke commented the properties of the binder in the top half inch are strongly related to the pavement performance in 4 to 5 years; and asked why they were targeting 19 mm? Kim

responded PG is based on 20 mm depth and they are using 38-mm cores from the surface. Reinke stated aging at 19 mm is irrelevant to looking at 4 to 6-year performance since the top half inch of the binder correlates to the distress. Kim responded that they are starting at 19 mm and deeper since many variables affect the G*.

Frank Fee commented the issue is with top down cracking. Kim asked if aging at the top of the surface was needed for top down cracking? Kim stated it might be correct based on data at 6 mm deep, but there is more variability. Fee responded they need a timeline for rate of aging. Kim responded M-value provides that as it is a long-term aging procedure of mix to match the field core aging.

Action Item #201705-2. Richard Kim will report on the status of NCHRP 9-54 Long Term Aging of Mixes at the next ETG meeting.

8. NCHRP 9-55 RAS in WMA [Randy West, NCAT]

Presentation Title: *NCHRP 9-55: Recycled Asphalt Shingles in Asphalt Mixtures with Warm Mix Asphalt Technologies*

Summary of Presentation:
West began the presentation by stating that the project team is writing the final report and the project looked at existing field projects that had both field and material characterization data.

The project includes three existing field projects – two in Texas and one in Illinois. The Texas projects have both HMA and WMA while the Illinois project is only WMA with two aggregate types. Low and high severity transverse cracking, low and medium severity longitudinal cracking, and low severity block cracking were observed at 37-47 months.

The project will also consider five new field projects that were constructed between September 2013 and October 2015. The production temperatures for HMA and WMA for the Wisconsin project were only between 3 and 7 degrees different. The Alabama project had issues with low voids in the mixture. The mixture properties were adjusted. The differences were designated “low” and “adjusted” throughout. The North Carolina project used both post-consumer (PC) and manufacturer wastes RAS (MWRAS). The Indiana project used MWRAS. The field performance of these projects showed reflection cracking over unrubblized PCCP at 24 months in Wisconsin, low-severity transverse cracking at 29 months in Alabama, low-severity transverse cracking (no other distress) at 25 and 14 months in Tennessee and North Carolina, respectively, and no cracking or other distresses at 16 months in Indiana.

Laboratory testing was conducted on plant mix, lab compacted material with no additional aging. Recovered binder testing included PG, ΔTc, MSCR and linear amplitude sweep (LAS). Dynamic modulus testing was conducted. Flow Number (FN) and Hamburg Wheel Tracking (HWT) test were conducted for rutting. Cracking tests included Bending-Beam Fatigue (BBF), Energy Ratio, Overlay Tester (OT) (standard Texas procedure), Illinois Flexibility Index Test (I-FIT), Semi-Circular Bending (SCB)-Jc, indirect tensile (IDT) creep.

West presented the percent effective binder content (V_{be}), ΔTc and TxOT results for the five new projects. The V_{be} was measured since raising the VMA requirement in the standard is meant to increase the asphalt content. The Wisconsin project with HMA and Rediset did not pass the TxOT. All of the Alabama projects did not pass the ΔTc or TxOT. The HMA project in Tennessee failed all three tests while the WMA only failed the ΔTc. The HMA with MWRAS failed the percent V_{be} and TxOT; the WMA with MWRAS failed the percent V_{be} and the HMA with PCRAS failed the TxOT in North Carolina. Both the HMA and WMA in Indiana failed all three tests. The WMA with RAS appears to improve the cycles to failure with the TxOT. Only the HMA adjusted air voids in Alabama and the HMA with MWRAS in North Carolina failed the Energy Ratio test. The SCB-Jc interval showed failures for all Wisconsin projects, HMA projects in Alabama, and HMA with MWRAS an WMA with MWRAS and PCRAS in North Carolina. All projects failed the I-FIT test with no values close to the threshold of 8. West stated that this was consistent with testing they have seen from the test track. Using the E* parameters as cracking indicators showed agreement for the ranking of mixes.

The preliminary findings are presented in four areas – production and construction of RAS mixtures, mix design verification, short term field performance and performance tests results. The production and construction of RAS mixtures showed that lower mix production temperatures associated with WMA did not cause plant issues or construction problems for any of the project sites evaluated in this study. Also, similar roller patterns resulted in statistically equivalent as-constructed densities for WMA mixes compared to the corresponding HMA.

The short-term field performance showed the following:

- All projects had less than 5 mm rutting after 2-3 years.
- No project had any evidence of moisture damage.
- Reflection cracking was the most common cracking distress.
- All test sections had similar surface texture depths.
- The use of WMA did not appear to affect density changes under traffic compared to HMA. Density did change over time for most projects.

The mix design verification showed slight differences in the optimum asphalt content for all mixtures. The observed tendency was for verified mixtures to have higher asphalt contents. Critical properties such as the specific gravity of the aggregate tended to have higher verified values (RAS G_{sb} between lab variability).

The performance tests showed the following:

- WMA mixtures tend to have lower E* values than those of corresponding HMA mixtures in most cases.
- FN and HWT results indicate that WMA mixtures are more susceptible to rutting, but still met suggested criteria.
- Most WMA mixtures were slightly more resistant to cracking (TxOT, Illinois Flexibility Index Test (I-FIT), ER and Jc).
- Analysis of IDT creep compliance & strength tests indicate WMA mixtures generally have a small improvement in low temperature cracking.

- E* parameters generally agree with results obtained from laboratory performance tests. Thus, providing an additional tool to evaluate cracking susceptibility.

In general, West presented the following:

- WMA mixtures had better lab results for cracking resistance and were slightly more susceptible to rutting.
- All field sections are performing well which makes it challenging to validate performance test criteria.
- Long term monitoring of field sections is recommended.

ETG Comments, Questions, and Discussion:

Youtcheff asked if there was data on the parent binders? West responded the parent binder data was available and that it was in the report.

D'Angelo asked whether the V_{be} was changing because of the absorption in virgin aggregate? West responded that it was a result of variations in the materials sampled.

Mohammad asked what stress value was used from the structure? West responded that the default value was used.

D'Angelo commented it is possible that too many projections are made off of early aging and that this could significantly skew the results. West responded the LTPP study considered pavements 13 years old and that RAP tended to have higher cracking.

Reinke commented the ΔTc data looked consistent with 5% RAS but that some looked lower. Reinke asked whether the binders used in the mixtures were tested? West responded the individual binder, RAP and RAS binders were characterized individually. The table shown is the recovered binder. Reinke asked if testing for zinc or phosphorous was performed? West responded they were not. Youtcheff offered to perform trace metal testing on the samples if West sent the samples to FHWA.

Mohammad commented the criteria established for I-FIT and TxOT were developed for local conditions.

Dukatz asked how the production temperatures were measured? As the temperature reported by the plant and its accuracy can be an issue. West responded an engineer recorded the production temperatures reported by the plant. West will need to verify but believes it was the discharge temperature. West noted the paving temperature was also recorded.

Chris Williams commented some of the WMA technologies also have a "rejuvenating" effect and these will be more aggressive with hard asphalts. Some WMA are improving the performance. West agreed and asked whether it would be shown by X-Ray Fluorescence (XRF)?

Jim Musselman asked whether additional aging was performed on the recovered binder for the ΔTc testing? The numbers looked too good West responded he did not think it was aged but would need to look into it. West noted the pavements were already in service.

Action Item #201705-3. Randy West will report on the status of NCHRP 9-55 RAS in WMA at the next ETG meeting.

9. NCHRP 9-56 Ignition Furnace Correction Factors [Randy West, NCAT]

Presentation Title: *NCHRP 9-56: Identifying Influences on and Minimizing the Variability of Ignition Furnace Correction Factors*

Summary of Presentation:
West stated a report is available for the first phase. The project objectives are to determine significant factors that affect asphalt and aggregate correction factors (CF) for ignition furnaces considering effect of sharing CFs between units/mixes and to minimize variability in CFs. In addition, the project was to develop guidelines for installation, operation, and maintenance of ignition furnaces.

The project consists of three phases. Phase I includes a literature review, DOT/Industry survey and an experimental plan. Phase II includes conducting the experimental plan including a sensitivity study at NCAT, interlaboratory study and troubleshooting outliers from interlaboratory study. Phases III is the AASHTO practices and Final Report.

The experimental plan included four mixes of 12.5 mm nominal maximum aggregate size (NMAS) and PG 67-22 binder. The aggregates for the four mixes were limestone and granite, limestone and granite with 1 percent lime, and limestone and dolomite. The optimum asphalt content for the first two mixes were both 5.2 percent with an expected CF range of 0.0 – 0.5. The optimum asphalt content was 6.2 percent and 6.1 percent for mixes 3 and 4, respectively. The expected CF range for mixes 3 and 4 ranged from 0.5-1.0 and 1.0-3.0, respectively.

The sensitivity study at the NCAT lab included six factors – oven, test temperature, air flow, sample mass, AC content, and burning profile (Troxler only). The ovens were Thermolyne, Troxler, and Gilson. The test temperatures were 427 ºC and 538 ºC. The air flow levels were 30 percent and 100 percent open. The sample mass levels were 1,500 and 2,000 grams. The AC content levels were optimum AC ±1 percent. The burning profile levels were default, option 1 and option 2. The sensitivity study resulted in a total number of 352 tests.

The experimental plan for the interlaboratory study included – labs, oven brands, multi-labs, number of mixes, test temperature and replicates. There were 18 DOT agencies and five contractors/research labs. There were 17 Thermolyne, 8 Troxler and 3 Gilson ovens. There were five labs with two different oven brands. There were four mixes at their optimum asphalt content. The test temperature was 538 ºC for mixes 1-3 and 482 ºC (mix 4) for convection units (Thermolyne, Gilson); default and option 1 for infrared unit (Troxler). There were three replicates per mix.

The average range of asphalt content CF for mix 1 was 0.11 with a minimum of -0.66 and maximum of 0.62. West noted some outliers due to setting ovens incorrectly. The average range of asphalt content CFs for mix 2 was -0.23 with a minimum of -0.67 and maximum of 0.18. West noted two outliers. The average range of asphalt content CFs for mix 3 was 0.92 with a minimum

of 0.55 and maximum of 1.51. West noted the variability in the results. The average range of asphalt content CFs for mix 4 was 1.25 with a minimum of -1.57 and maximum of 3.58. West noted some outliers in the data.

West presented the precision statistics for the interlaboratory study. The repeatability standard deviations for mixes 1 and 2 were 0.089 and 0.074, respectively. The reproducibility standard deviation for mixes 1 and 2 were 0.131 and 0.111, respectively. The repeatability and reproducibility standard deviations for mix 3 were 0.112 and 0.264, respectively. The repeatability and reproducibility standard deviations for mix 4 were 0.178 and 0.403, respectively. The AASHTO T 308 repeatability and reproducibility standard deviations were 0.196 and 0.330, respectively.

West presented the following conclusions:

- Type of oven and test temperature are the primary factors affecting CFs.
- Conducting test at 800 °F substantially reduced magnitude and standard deviation (σ) of CF factors for asphalt mixtures that do not contain lime.
- Different precision statements may be necessary for aggregates with higher CFs.
    - For mixes 1 and 2 within-lab and between-lab σ similar to AASHTO T 308.
    - For mixes 3 and 4 as CF increased σ also increased.
- Precision statement in AASHTO T 308 applicable only to mixtures with low CF aggregates.
- Although not recommended in AASHTO T 308, sharing CFs among different ignition furnaces appears acceptable for low CF aggregates.
- Amount of lime has to be closely controlled during production otherwise this will affect the CF and result in incorrect AC content.
- Causes of differences in CF during the troubleshooting study were related to wrong equipment settings.

The key product of this research is a Proposed Standard Practice for Installation, Operation, and Maintenance of Ignition Furnaces. Conducting ignition test for RAP materials at 427 ºC may allow more accurate determination of RAP asphalt content which can be difficult since CF is not known. Future work will evaluate the effect of reducing test temperatures for mixes that contain significant recycled materials compared to those with virgin binder and aggregate only.

ETG Comments, Questions, and Discussion:

Adam Hand asked what was the absorption of the dolomite aggregate? Becky McDaniel responded that dolomite was a good aggregate source for Indiana. Gerry Huber responded it is relatively low absorption around 2.6 to 2.9 but it has a magnesium content. Hand explained in Western part of the US, there is a relationship between the correction factor and the water absorption.

Howard Anderson asked whether the hydrated lime was burning off during the ignition test similar to binder and how that could affect the results? Youtcheff stated the lime can come out as sulfate and the higher sulfur lime would cause a larger issue. Huber responded the less lime that

is put in, the closer the correction factor to the real number due to less sulfur. West responded it creates uncertainty in the results as the amount of lime can change during production.

10. Update: BMD Task Force [Shane Buchanan, Oldcastle Materials]

Presentation Title: *Balanced Mix Design (BMD) Task Force Update*

Summary of Presentation:
Buchanan began the presentation by acknowledging the BMD Task Force membership. Buchanan stated a Technical Brief document was submitted to FHWA and it is still in the review process.

A research problem statement (RPS) was prepared by the BMD Task Force in June 2016 and submitted to the AASHTO Subcommittee on Materials (SOM). The BMD statement was the only RPS in the area of asphalt mixtures or binder. Although the RPS ranked very high, it was not advanced forward because the time (60 months) and funding ($1,700,000) were considered too high by the project selection committee.

NCHRP 20-07 Task 406 project, Development of a Framework for Balanced Asphalt Mixture Design and Gap Analysis was approved with funding of $100,000. Buchanan commented this was a low-level substitute for the former problem statement. The Contractor has been selected and the contract is being finalized.

Presentations have been made in Colorado, Florida, Michigan, Montana, Oregon, South Carolina and Vermont to give an overview of BMD and highlight the Task Force efforts. Tom Bennert and Frank Fee are leading an effort for a Regional Pooled Fund Study (Mid Atlantic/Northeast States) on Performance Related Specifications (PRS). Fee stated the objective was to develop a user group of States in a program designed to set up PRS protocols and parameters. There are three resource centers identified – University of New Hampshire, University of Massachusetts Dartmouth, and Rutgers. New York and Pennsylvania have shown interest in this PRS effort and other states have expressed interest. Fee provided the structure for getting a mechanism for a pooled fund contained in attachment D.

An initial training course was conducted by NCAT with others scheduled throughout 2017. NAPA will be holding a “Paving for Performance – Designed to Perform” conference in Atlanta on October 11-13 and will include sessions on BMD and performance specifications. There will be a TRB workshop session sponsored by AFK30 and AFK50 titled Performance/Balance Mixture Design: Implementation Efforts and Success Stories.

There has been significant state funding for research on related activities. Buchanan provided an overview of research in progress from states with a summary as follows:

- Caltrans – PPRC14 SPE 3.33: Simplified Performance Based Specifications for AC Long Life Projects.
- Idaho DOT – Development and Evaluation of Performance Measures to Augment Asphalt Mix Design in Idaho.

- Purdue University/Indiana DOT – SPR-4114: Performance Balanced Mix Design for Indian's Asphalt Pavements.
- Minnesota DOT – Balanced Design of Asphalt Mixtures.
- Texas DOT – Develop Guidelines and Design Program for Hot-Mix Asphalts Containing RAP, RAS, and Other Additives through a Balanced Mix-Design Process.
- Wisconsin DOT – Analysis and Feasibility of Asphalt Pavement Performance-Based Testing Specifications for the Wisconsin Department of Transportation.

Buchanan asked the ETG what the next steps for the Task Force should be?

ETG Comments, Questions, and Discussion:
Mohammad commented another item beneficial to States is to see what obstacles, challenges and limitations States that have implemented BMD faced and how they were overcome in the implementation process.

Buttlar asked what would be gained and what could be relaxed based on the performance tests and if it would allow more wiggle room? Buchanan responded that as approach B identified – having performance without volumetrics is possible since there are still performance requirements.

Huber commented the rutting performance tests are asphalt pavement analyzer (APA) and Hamburg; but for cracking there is still research needed. Huber asked if there was a way to bring information forward through the ETG?. Mohammad commented although there is information in papers and reports, it is better for States to discuss and see the innovation that other States have and disseminating this would be very beneficial.

Buchanan stated that BMD and Performance Related Specifications (PRS) can coexist. Corrigan added there are elements of PRS which are larger long-term goals; and BMD is an element that can be accomplish as part of PRS. Certain facets of the industry have made it seem as if the two are in competition, but PRS and BMD are not in competition; they go hand in hand. The key is bringing an engineering based approach to get performance. Corrigan asked whether there was a more suitable name or title to provide more cohesiveness instead of competition. As a strategy, if the industry is unified with an emphasis on an engineering approach to result in performance it could help advance these concepts and initiatives. Buchanan replied the Task Force will consider changing the name and respond to the ETG.

Buchanan stated it was important to reiterate how BMD came to be as a short–term improvement to performance. Williams responded in order to put the added cost of performance testing, contractors would need incentives and meeting performance criteria should allow flexibility.

Hall commented that a lot of people are pursing BMD and PRS with a simple go/no go test for cracking resistance which may not have any relationship to performance or performance related models for long-term performance.

Newcomb stated the objective of NCHRP extension of Project 9-57 is a follow-on study of potential cracking tests and agrees with what Hall is saying about ensuring they are tied to performance.

Fee responded the issues are on the top four inches of the pavement and when PRS is used the sub structure does not have to be reworked. However, given the existing tools, it does not accomplish what is needed. Hall responded it depends on how you are judging top down cracking and that some cracking tests are meant to maximize cracking resistance. These are empirical relationships based on observed performance. If we want to go forward to more predictive models, should performance be predicted; or preventing bad performance be predicted? Reflection cracking still has a structural component that can be modeled. Mohammad agreed that there needs to be a test that is fundamental and provide properties that are fed into the model; for example Pavement ME.

Musselman expressed his concern with the tempo of development and explained that by starting slowly, states unilaterally begin on their own without collective guidance, and there will be 50 versions of cracking tests; and these variations cause problems. Guidance is needed before there is too much variability for a national standard.

D'Angelo replied recommendations can be provided to States to move things forward and continue to improve, similar to work done with warranties. Fee responded this is the reason they are taking a regional PRS approach and initiating the pooled fund. Marks responded the need for fundamental tests is now; as decisions need to be made so that agencies can start. Marks stated some information that is shared is useful because we do not want to rely on a single person, a single agency, or survey.

Action Item #201705-4. Shane Buchanan will present the activities of the Balanced Mix Design Task Force at the next ETG meeting; including the potential of changing the title to include "performance" and "engineered."

11. Subcommittee on Materials Updates/Comments [Oak Metcalfe, Montana DOT]

Summary of Presentation:
Metcalfe provided the Subcommittee on Materials (SOM) update. Metcalfe is the Chairman of Technical Section 2d.

- AASHTO T 321 "Test for Determining the Fatigue Life of Compacted Asphalt Mixtures Subjected to Repeated Flexural Bending" passed the full ballot without negatives and some editorial comments.
- AASHTO M 323 "Superpave Volumetric Mix Design" was passed.
- R 35 "Superpave Volumetric Design for Asphalt Mixtures" revised to improve consistency with AASHTO T 283. AASHTO T 324 "Hamburg Wheel-Tack Testing of Compacted Hot Mix asphalt (HMA)" was added as an option for moisture susceptibility.
- AASHTO PP 78 "Design Consideration When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures" was accepted without negatives and minor editorial comments.

All asphalt publications will be published in August 2017.

On the Technical Section ballot, the name change for AASHTO TP 124 “Determining the Fracture Potential of Asphalt Mixtures Using Semicircular Bend Geometry (SCB) at Intermediate Temperature” was approved. There were substantial technical and editorial comments on the standard and it was returned to Illinois. Changes to the standard will be distributed for the Technical Section ballot prior to the annual SOM meeting.

The Executive Committee did not feel the size and scope of the BMD RPS was appropriate for NCHRP and they did not want to use all the research money for one project although the BMD RPS was the highest rated. A NCHRP 20-07 project was awarded for BMD.

The SOM ballot reconfirmed AASHTO M 325 “Standard Specification for Stone Matrix Asphalt (SMA)” and AASHTO R 46 “Standard Practice for Designing Stone Matrix Asphalt (SMA).” There is a Task Force investigating SMA and the potential for allowing other types of fibers in SMA.

AASHTO R 62 “Standard Practice for Developing Dynamic Modulus Master Curves for Asphalt Mixtures” was reconfirmed.

The following provisional standards were moved forward:

- PP 60 “Standard Practice for Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)” (AASHTO R 83).
- PP 61 “Standard Practice for Developing Dynamic Modulus Master Curves for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)” (AASHTO R 84).
- TP 79 “Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Asphalt Mixtures Using the Asphalt Mixture Performance Tester (AMPT)” (AASHTO T 378).

The changes to AASHTO TP 107 “Standard Method of Test for Determining the Damage Characteristic Curve of Asphalt Mixtures from Direct Tension Cyclic Fatigue Tests” were discussed at the Technical Section’s mid-year webinar and passed the Technical Section ballot. The changes will be discussed further at the full SOM ballot in the fall.

The only major comment for AASHTO PP 78 “Design Consideration When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures” was the desire to see the RAP/RAS Task Force continue to harmonize the effort between RAP and RAS and applying ΔT_c to RAP.

Technical Section 2d has a webinar scheduled for first the part of June regarding the Moisture Induced Stress Tester (MIST) method for moisture sensitivity which will be a proposed provisional standard.

Allan Meyers, from Kentucky, is the Technical Section 2c chair. Technical Section 2c did not have a lot of updates. AASHTO T 324 Task Force is continuing to meet and discuss changes based on the research report that Mohammad authored as there are some major issues to deal with such as sinusoidal travel, waveform, etc.

ETG Comments, Questions, and Discussion:
Corrigan explained he is no longer the vice-chair of Technical Section 2c, nor Tim Aschenbrener as vice-chair of Technical-Section 5c; as FHWA will no longer be serving in a vice-chair role. FHWA will continue to be engaged and provide technical support to AASHTO SOM efforts moving forward.

A presentation on NCHRP 20-07 Task 382 "Longer Pavement Life from Increased In-Place Density of Asphalt Pavements" will be scheduled for the annual meeting and will be published later in 2017.

NCAT's New Methods on Mix Design for Cold Recycled Asphalt and Foaming Asphalt will be addressed on conference calls in June or at the annual meeting.

12. Update: AASHTO TP 107 Direct Tension Cyclic Fatigue [David Mensching, FHWA]

Presentation Title: *Update: AASHTO TP 107 AMPT Cyclic Fatigue*

Summary of Presentation:
The AMPT fundamental tests include stress and strain modeling, "bulk testing" and are compatible with Pavement ME or FlexPave™. The FHWA PRS initiative includes the use of fundamental tests to capture variance between as-designed and as-built acceptance quality characteristics (AQCs), the AMPT used in performance-engineered mixture design (PEMD), structural response modeling, and performance volumetric relationships used in construction. The performance testing is currently proposed for use only in the design phase.

Mensching presented the performance-engineered mixture design fundamentals such as how targets are expressed in terms of distress and pavements, life, and how stresses, strains, and corresponding material properties are used with a structural response model with many temperature/loading conditions represented. In addition, Mensching presented the index-based performance-engineered mixture design as go/no-go (correlation based), measuring engineering properties that are empirical, and not used with structural response model while representing a few temperature/loading conditions.

The benefits of PRS involve long-term pavement performance predicted from fundamental engineering properties and incentives and disincentives justified through reduction or increase in pavement life that allows the contractor to be more innovative and more competitive. The challenges with PRS include testing efficiency and simplicity, standardization of test methods, verifying performance prediction models, performance volumetric relationships (PVR) and using the same principles and methods between mix design and PRS.

Mensching presented the revisions to AASHTO TP 107 that were submitted to the AASHTO SOM Technical Section 2d. These include adding the failure criterion, simplifying language, making the specification AMPT-specific, removal of spreadsheet derivation, new strain selection guidance, and small-specimen appendix. Standardization of test methods are needed for small specimens and standards are being drafted for AASHTO consideration.

The purpose of the field validation of AMPT cyclic fatigue was then presented, which is to develop laboratory-to-field transfer functions using pavement prediction software (FlexMAT™ and FlexPAVE™) with volumetrics included.

Mensching presented the FlexMAT™ input tab that has buttons to input samples for dynamic modulus and fatigue specimens to generate master curves and continuum damage cyclic fatigue modeling terms. The FlexPAVE™ graphical user interface was designed similar to Pavement ME and files can be imported from FlexMAT™. FlexPAVE™ provides damage control whether the pavement structure is going to be top down or bottom up susceptible. The plot of distress versus time over design life is similar to Pavement ME.

One of the challenges of PRS is the PVRs. A database was developed at Turner Fairbank Highway Research Center (TFHRC) with expansion underway in shadow projects in order to provide agency and contractor guidance for planning purposes. The initial PVR database has relative rather than absolute distress and is applicable for a particular structure and traffic. A design catalog option can be generated with FlexPAVE™.

It was then mentioned that the AMPT cyclic fatigue process requires about 1 to 2 days for testing and 1 to 2 hours for analysis using FlexMAT™ and FlexPAVE™ which results in about one week per mixture when specimen preparation is included.

Mensching presented the advantages of the AMPT cyclic fatigue as having standard sample preparation procedure, being AASHTOWare Pavement ME compatible, having FlexMAT™ and FlexPAVE™ available for ease of analysis, and predicting performance and material behavior across a wide range of loading and temperature conditions.

AMPT implementation efforts included a Transportation Pooled Fund Study (TPF (5)-178); test standard development, improvement and revision; instructional videos and TechBriefs; PRS shadow implementation; Mobile Asphalt Testing Trailer (MATT) projects/training; and user groups at TRB and regional meetings. The AMPT user groups are moving more towards a regional focus. There is a webinar scheduled on July 25, 2017 at 1 pm EST and interested participants should email Mensching. DOTs interested in additional shadow PRS projects should contact Richard Duval, FHWA.

Mensching then presented the Asphalt Technology Guidance Program (ATGP) goals, which are to advance performance, advance quality assurance, and advance innovation. The program focus areas provide support to national initiatives such as increased pavement density, increased RAP/RAS usage, understanding GTR testing, mixture performance testing and the AMPT, stone matrix asphalt, binder performance testing and long-term aging; equipment development and refinement of the AMPT, and binder performance testing; development of new QA concepts for HMA.

Mensching presented the solutions to agency needs through project-specific work plans including material characterization, mix design replication and testing, mix production testing, performance prediction, and training and demonstration.

ETG Comments, Questions, and Discussion:
Hall asked what was being used for the base and subgrade models. Kim responded the Pavement ME models and EICM were being used; the NCHRP models will be implemented when available.

Hall asked if FlexMAT™ and FlexPAVE™ would replace the Pavement ME. Mensching replied that their goal was to maximize investment and to identify the best tools. Mensching noted that they were not actively looking to replace Pavement ME.

Buchanan asked if there was potential to shorten the time for a mix design and how much shorter? Mensching replied that they are trying to reduce the amount of material processing, the number of replicate specimens, and that using small geometry specimens is significantly reducing the preparation and testing time

Corrigan commented that the initial strain conditions for AMPT cyclic fatigue based on dynamic modulus generated from the MATT for unusual mixtures such as high recycle content or rubber modified, will further help to reduce the number of specimens required to achieve a series of targeted strain conditions for testing. Guidance is being added to the standard to reduce the time and materials required for various mixtures types.

Hall asked how it was envisioned that DOTs would change their procedures since this is for a single mix design and structure? Whether there would be a typical design and if the contractor may change the structural design? Mensching responded it was not expected for the contractors to change the structure; emphasis on optimizing the mixture. Agencies could catalog potential structures and the contractor could produce the mixtures. Hall asked why there was a separate system rather than improve the current Pavement ME. Mensching responded that FlexMAT™ and FlexPAVE™ could supplement and enhance Pavement ME if AASHTO adopts.

D'Angelo commented that FlexMAT™ and FlexPAVE™ are likely the next steps in the future since Pavement ME currently has limitations. Hall agreed but asked whether Pavement ME would then be abandoned or improved?

Kim commented investment made for Pavement ME will be useful in FlexPAVE™ by tying mix design to structural design. Corrigan responded that they are actively engaged with AASHTO and consider stakeholders ideas and concerns. Corrigan continued that with the AASHTO reorganization and merging of the SOM with the Joint Technical Committee on Pavements, there is more cross-over in pavements and they will engage each on the topic to determine what is viable.

Dukatz asked if there are plans to provide guidance regarding whether this test is appropriate based on the size of the project or not? Mensching responded the shadow projects will provide some indication. Dukatz asked about the sensitivity of aggregate properties to this procedure? Mensching responded the most sensitive areas will be identified through ruggedness testing.

13. Cyclic Fatigue Failure Criterion based on DR Parameter [Y. Richard Kim, North Carolina State University]

Presentation Title: *D^R Failure Criterion for Cracking of Asphalt Concrete*

Summary of Presentation:
Kim began the presentation by explaining that although the Cumulative Dissipated Energy and N_f was a good concept, a better property is needed to represent damage only. The ratio of change in dissipated energy does not remove viscoelasticity. The Dissipated Pseudo Strain Energy (DPSE) removed the effect of viscoelasticity, was a fracture based criterion and G^R failure criterion. The G^R failure criterion is an energy based parameter versus the number of cycles to failure in log-log scale produces a unique linear relationship. This criterion is sensitive to test variability. However, a model that is dependent on one mode of loading or one temperature requires many loadings and temperatures. Fatigue testing in the laboratory are accelerated tests that increase the strain more than what occurs in the pavement. Therefore, the energy produced in the pavement is much lower than generated in the laboratory, so extrapolation is necessary. If a test is not repeatable, extrapolation could result in erroneous results.

The D^R failure criterion -i.e., the average reduction in pseudo stiffness up to failure, uses the arithmetic scale. Although extrapolation is still necessary, it is less sensitive to noise in the data. This is independent of mode of loading, temperature, and loading amplitude. The linear relationship passes through the origin. Theoretically only one specimen is required, but three are recommended.

Kim presented the D^R for PRS mixtures which showed a nice relationship with R^2 values over 0.99. The D^R is the slope of the relationship and is a function of mixture type. The higher the D^R, the better the mixture. As a mixture is aged, the D^R is lower. The crumb rubber terminal blend (CRTB) performed similar to the polymer (SBS) in the ALF mixtures.

The comparison of the D^R for NCAT section versus the percent cracking area showed issues. The D^R cannot be used as an index property. D^R is a good failure criteria, but it cannot be an index property.

The D^R and G^R based criterion can be entered into FlexPAVE™ 1.0. D^R is not in the most recent version of AASHTO TP 107. FlexMAT™ data can be imported into FlexPAVE™. FlexPAVE™ provided simulation produces damage contour using a 3D moving load simulation. The NCAT test track damage contours showed the open graded friction course (OGFC) had a higher concentration of cracking at the top. A comparison of field measurements (percent cracking area) to the FlexPAVE™ simulation of percent damage area will be used to create a transfer function.

Performance varies depending on the pavement structure. Although D^R as an index property is not good, when including the entire pavement structure in the analysis, there is a nice relationship between the percent cracking measured and the percent damage predicted using the FHWA ALF.

A FlexPAVE™ Simulation of the KEC Test Road with various structures was conducted. The G^R simulation of the full depth pavement performance (thicker AC) showed worse performance than the aggregate base pavement. It would be expected that a thicker AC pavement would have lower damage. The D^R simulation shows the correct performance trend: the aggregate base thickness increases whereas damage decreases.
Kim next presented the effect of extrapolation. The G^R approach with full depth AC, there was a bulb of damage. Extrapolation of the base material was exaggerating the material performance. With G^R, more samples are needed as it is more prone to variation due to test variability compared to D^R. The sensitivity of G^R in log-log scale causes this large damage to be predicted.

Kim explained it was not only important to tie mix design to structural design, but to also have an index property that is based on the same scientific principle. Kim presented the S_{app} as a cracking index property. The S_{app} is determined from measurements from the TP 107 test procedure at the reference temperature. The apparent damage capacity is the amount of damage the material can tolerate until the material stiffness reaches the average stiffness value. A S_{app} value greater than 8 is the preliminary critical value.

The relationship between field cracking and S_{app} value for ALF mixtures showed a reduction in S_{app} for poorer cracking performance. For mixtures with the same VMA and binder content, an increase in air voids reduces S_{app}. As binder is increased, the S_{app} value increased. A comparison of S_{app} and percent cracking area for NCAT data showed a nice correlation.

A proposed change to TP 107 include recommending three tests, fatigue testing at one strain level (closed-form solution is available for the prediction of N_f under different strain levels) and inclusion of D^R and S_{app} in the specification.

ETG Comments, Questions, and Discussion:
Nam Tran asked if it was possible to convert G^R to D^R. Kim responded that it is possible through FlexMAT™.

West asked with a layer structure with multiple mixtures per structure, whether each layer was being tested. Kim responded this was the biggest difference with Pavement ME. Kim commented for fatigue cracking, the bottom layer coefficient is what matters. With FlexPAVE™, the layer information is input. Kim stated for a forensic investigation for NCDOT, the field performance was matched 80% by FlexPAVE™ by entering layer by layer properties. By looking at individual layer properties, pavement performance can be predicted.

Kluttz asked whether the test could compare equal moduli since it was single stress, strain and temperature. Kim responded it could be performed with equal modulus and that D^R would be at that temperature to enter into FlexMAT™.

14. Proposed Small Specimen Geometry Specifications for Specimen Fabrication, AMPT Dynamic Modulus, and AMPT Cyclic Fatigue Tests [Cassie Castorena, North Carolina State University]

Presentation Title: *Proposed Small Specimen Geometry Specifications for Specimen Fabrication, AMPT Dynamic Modulus, and AMPT Cyclic Fatigue*

Summary of Presentation:
Small specimen geometry was initially proposed to enable performance testing of as-built pavement layers since many pavement layers are not thick enough to extract a standard 100-mm diameter specimen vertically through the pavement. Two 38-mm diameter specimens can be extracted per lift horizontally from a 6-inch core. The 38-mm diameter specimens are 100-mm long. For thin layers, a 25-mm prism specimen 100-mm in length can be used when a 39-mm diameter specimen cannot be extracted. Small specimen geometry enables field core testing and improves the efficiency of laboratory specimen fabrication. For large specimens, six gyratory specimens are required, for small specimens, only two gyratory specimens produce eight small test specimens.

The NCHRP IDEA project objectives are to evaluate the effects of specimen geometry on dynamic modulus and direct tension fatigue tests using mixtures with various NMAS values and to optimize the laboratory fabrication of small specimens extracted from gyratory-compacted specimens.

The experimental plan included plant-produced loose mixtures with various NMAS, asphalt binder and RAP content. Dynamic modulus and cyclic fatigue testing were considered. It was later discovered that dynamic modulus testing at 54 ºC when using small specimens was not appropriate. Smaller specimens only require 1 hour of platen curing time since less epoxy is required versus the 16-hours platen curing time required for large specimens. Large specimen fabrication followed the standard procedures for large specimen testing, consisting of 100-mm diameter specimens with 150-mm height for dynamic modulus and 130-mm height for cyclic fatigue. Small specimens were extracted from the inner 100-mm diameter of Superpave gyratory compactor (SGC) samples. Initially, three small specimens were extracted per gyratory but four small specimens can be extracted with acceptable air void uniformity. Horizontal coring from SGC is a challenge since 110-mm height is the minimum height to use with standard LVDTs.

The comparison of the dynamic modulus and specimen geometry showed excellent agreement between the dynamic moduli values of large and small specimens at intermediate and high reduced frequency (i.e., low and intermediate temperature). At high temperatures, the small specimens consistently exhibited dynamic moduli higher than the large specimens and therefore, it was recommended to avoid testing at 54 ºC.

There was good agreement between the damage characteristic curve and failure criteria amongst large and small specimens. Specimen geometry is comparable. All plots were on a single line and were not geometry dependent.

The material level difference effect was considered within a structure to predict pavement performance. FlexPAVE™ was used to compute the percent fatigue damage area and showed no significant difference in performance predictions.

The effect of coring direction showed the difference in dynamic modulus and fatigue was negligible. All of the horizontally extracted specimens subjected to cyclic fatigue testing in the AMPT experienced end failures due to air void gradient within the gyratory samples. Therefore, vertical coring is preferred.

Results of the air void variability analysis showed charging the center of the gyratory compaction mold reduced air void variability. Four cores were extracted from two gyratory specimens each and all eight specimens were tested in AMPT. Three of the 32 (one 12.5 NMAS and two 19.0 NMAS) specimens experienced end failures.

Specimen-to-specimen variability showed no bias with center pouring method but the 25-mm mix had more variability in air void content and specimen-to-specimen variability increased.

Castorena presented the results as follows:

- Small specimen testing provides equivalent dynamic modulus test results to large specimen testing at low and intermediate temperatures.
    - Do not recommend testing at 54°C.
- Small specimen testing provides equivalent cyclic fatigue test results to large specimen testing.
- Anisotropy in gyratory-compacted samples does not affect dynamic modulus or cyclic fatigue test results.
- Horizontal coring in laboratory specimen fabrication should be avoided because it leads to end failure in cyclic fatigue tests.
- The recommended procedure for laboratory fabrication of small specimens is the vertical coring of four specimens from the inner 100-mm diameter of gyratory-compacted samples.

The proposed specification includes fabrication following AASHTO PP 60 and extraction of small specimens, AMPT Dynamic Modulus testing conducted following AASHTO TP 79 and AMPT Cyclic Fatigue Testing conducted following AASHTO TP 107.

Castorena asked if there were suggestions for facilitating charging the center of the mold? D'Angelo responded when dumping the mix into the mold, larger aggregates are pushed to the side and a finer mix results in the middle. D'Angelo suggested placing the mix in the mold versus dumping the mix in the center of the mold.

For AMPT cyclic fatigue, Castorena asked if it would be better to require testing of three or four specimens? Buchanan asked what her experience showed? Castorena responded two specimens are enough and there are no problems with three specimens.

Castorena asked whether the air void tolerance of ±0.5 percent should be adopted from the large specimen testing or to increase the air void tolerance to ±0.7 percent? Corrigan responded the air

void tolerance should be prompted based on results of ruggedness testing. D'Angelo commented that it might be difficult to achieve that [0.5 percent] air void tolerance with a smaller specimen. Kim responded that 0.7 percent tolerance might be okay, but a full sensitivity study has not been completed.

ETG Comments, Questions, and Discussion:
Hall asked whether it is randomized which specimens are used when there are four specimens? Castorena responded all fatigue specimens are from the same gyratory specimen.

Mohammad asked what strain level was applied? Castorena replied that with dynamic modulus, the peak to peak strain was 50 to 75 and that fatigue testing was higher. The test is performed by controlling the movement of the crosshead and therefore the strain varies. Controlling the specimen strain is more difficult.
Tram asked if small specimens have been used with high RAP and long-term aged specimens? Castorena responded RAP was not included in the IDEA project.

Mensching commented that he has conducted small specimen testing with RAP and RAS on FHWA ALF mixtures and there was one mixture that was brittle which was complicated.

Glidden asked how four specimens were extracted? Castorena responded they have developed a template to best align the specimen to extract the specimens. Reinke asked whether it would be better to use two gyratory specimens and extract two test specimens? Castorena responded three specimens can be extracted easily. They have not had an issue extracting four specimens and do not think that it would generate a better specimen.

Kim commented that in the draft specification, the design template is included. Kim also commented they invited five DOTs to a workshop to demonstrate the laboratory procedures and they did not have any problems with the procedures. Kim noted it could be changed to extract two specimens out of two gyratory specimens.

Hall asked what aging protocol was used. Castorena responded short-term aging of 4 hours at 135 ºC.

It was noted the CoreLok procedures were used for determining the small specimen air voids.

Action Item #201705-5. Richard Kim, Cassie Castorena, and Dave Mensching to work with Matthew Corrigan on the draft of small scale specimen specification for distribution to the ETG for comment.

Corrigan adjourned the meeting at 4:28 PM.

DAY 2: Tuesday, May 2, 2017

15. Call to Order

Buchanan called the meeting to order at 7:58 AM.

16. Update: Analysis of the Fatigue Cracking Model in the ME-Design Procedure [Kevin Hall, University of Arkansas and Nam Tran, NCAT]

Presentation Title: *Cracking: Future Directions (?)*

Summary of Presentation:
Hall began the presentation by stating that he was going to recap the current status of Pavement-ME Design and present curious philosophies, key questions and possible directions for the future. Pavement-ME predicts four types of cracking – bottom-up, top-down, transverse and reflection cracking. For Pavement-ME Build 2.3, the bottom-up and top-down cracking uses fatigue strength from flexural beam fatigue test. The transverse and reflection cracking use indirect tensile strength and indirect tensile creep compliance.

Hall presented a summary of Pavement-ME cracking. There are no changes or enhancements or anything planned for the short-term for bottom-up cracking. There are no changes to date for top-down cracking but changes are anticipated from NCHRP 1-52. There are no changes to date for transverse cracking but the need for changes has been identified for the long-term. Major enhancements for reflection cracking were included in version 2.2 of Pavement-ME where regression was replaced with ME.

Hall surveyed the room asking how long until work is done on a new pavement. The response ranged from 5 to 20 years. Hall presented the first curious philosophy as the design approach in the MEPDG focuses on managing the failure of the pavement rather than seeking to avoid failure. Hall asked the first key question of, in the context of bottom-up fatigue cracking, is it desired to continue to predict the extent of fatigue cracking, or attempt to prevent fatigue cracking?

Hall asked whether preventing bottom-up fatigue cracking should be a goal? Hall stated that perpetual pavement design within Pavement ME should be improved. Hall also recommended the endurance limit predictive equation from NCHRP 9-44 should be refined and incorporated for all analyses. Improved guidance in the MEPDG Manual regarding perpetual pavements is needed including mix type selection for layers within a perpetual pavement cross-section and material properties for layers within the cross-section.

Dukatz commented that he liked the theory and asked whether each layer would be designed so that the first maintenance cycle of the first layer is more than 20 years. Hall responded that the decision is up to the designer. However, Hall cautioned that although the design life is 20 years, that does not mean that nothing needs to be done to the pavement for 20 years as maintenance and preservation activities will be needed. Hall stated that MEPDG is a structural design procedure and if done this way could be possible to only require maintenance and preservation.

Hall stated the MEPDG is not a performance prediction tool and that when a prediction does not meet specifications, the material properties or pavement structure is changed through an iterative process. Klutz commented that this was way more complex.

Newcomb commented many pavements are over-designed because as traffic volume increases, thickness increases but that a point of no return on investment is reached. This method would prevent that from happening and reduces the effect of the traffic prediction accuracy.

Hall presented the next question as is it important and/or desirable to model all forms of load-related cracking using the same general approach and/or mechanistic basis? Currently, reflection cracking uses fracture and top-down uses regression, but is possibly moving to fracture and bottom-up uses bending/flexure.

Hall recommended a common basis for cracking models. For this, a fracture-based bottom-up fatigue cracking model would need to be developed and implemented. A fracture-based model form similar to that used for reflection cracking is anticipated for top-down. Any new fatigue cracking models should be compatible with the concepts of perpetual pavement design. Hall recommended linking the model forms for structural design to the cracking-related material performance measures generated for asphalt mixture design.

Hall presented the second curious philosophy as when pursuing new technologies for pavements and mixtures, researchers are strongly encouraged to simplify the implementation product and in many cases, seek to engineer the design processes to the point where it does not require an engineer to perform the design. Hall presented the next question as is it important and/or desirable to integrate, more fully, asphalt mixture characterization between the processes for asphalt mixture design and flexible pavement structural design? For example, should performance-related tests used for asphalt mixture design yield material properties which are also used in structural design models? One potential way to accomplish this is through visco-elastic continuum damage (VECD) and Simplified Visco Elastic Continuum Damage (S-VECD). Hall recommended streamlining laboratory testing and data analysis procedures for S-VECD in the context of asphalt mixture design and to produce user-friendly software which would allow a typical mixture design laboratory to complete an S-VECD based design. The structural pavement design procedures contained in the layered visco-elastic continuum damage (LVECD) program should be refined and expanded. Hall also recommended supporting FHWA PRS efforts with FlexMAT™, FlexPAVE™ and PASSFlex™.

Buncher commented that structural design is performed first followed by mix design; and asked under the current process, how does this help because material properties are needed for the structural design, but the structural design is done first. Hall responded for performance related specifications, that would be the process. Hall stated some assumptions will need to be made at the structural design and then quality characteristics will need to be measured to tie back to the assumptions. Another possibility would be to take the as-built properties and check that the structural design is acceptable. Hall commented that possibly during the structural design there is a catalog of material properties. Buncher commented the contractor will have to make a mix design that meets the criteria used in the structural design. Hall responded if the two (i.e.

assumptions from structural design and mix design properties) were not the same, what then would be the effect on the pavement? This is the goal of PRS.

Kluttz commented that this change will be a challenge for administrators and upper management to accept. Hall responded this would require a large education effort and recognize that it would require buy-in throughout the agency to support a change.

ETG Comments, Questions, and Discussion:
Huber commented that standardizing perpetual pavement within Pavement-ME is a matter of directing Pavement-ME in that direction. Huber stated although pavements are designed for 20-years, it is conservative and more likely to have 50-years of life. Huber stated that it is not about being more conservative but evaluating pavements the way they are designed and considering perpetual pavements.

It was noted that the PAVEMENT ME rutting model will be improved in the January 2018 release. The current rutting model was over predicting rutting in the unbound material. Hall responded that for mixes in Arkansas, a go/no go for mixes regarding rutting was implemented. Mixtures where rutting was not expected were predicted as having rutting with the previous model.

In response to the second question, Buncher stated the only advantage of using the same approach is if it is more accurate or if it allows less data on the materials to be collected. Buncher asked if that was the case? Hall responded he would defer the accuracy to the modelers and it would depend on the form of the model. Hall stated the reason for asking questions is, if every load related model was on the same basis, and then material characterization in the laboratory could be directed to that basis. If all models were on the same basis, then it could be possible to more directly characterize the material and not have an intermediate model.

D'Angelo commented flexural beam is an empirical test that uses a transfer function to relate to linear elastic theory. For fracture basis, the separation of material is considered. D'Angelo commented there is a big difference between the two but suggested to move away from the empirical test.

Buchanan asked what percentage of mill and overlay and deep mill add structural capacity? Hall responded if structural capacity is added, then structural design is required. Hall added, it is an overlay design issue and that the type of cracking on the existing pavement needs to be considered and whether there could be reflection cracking. However, if the overlay is for preservation, then ME design is not required.

17. NAPA's Technical Activities [Dan Staebell, Asphalt Pavement Alliance]

Presentation Title: *Got Asphalt?*

Summary of Presentation:
The Asphalt Pavement Alliance (APA) is a partnership of the Asphalt Institute, National Asphalt Pavement Association and the State Asphalt Pavement Associations. APA was formed 10 years

ago to promote the increased use of asphalt. APA's mission is to establish asphalt pavements as the preferred choice for quality, performance and the environment. This message is arranged through a council consisting of research and technology, market research and communications and deployment activities. Under research, there is a pavement economics committee that consists of six task groups: best quality and competitiveness, environmental sustainability, legislative, pavement type selection, pavement design, pavement preservation and private sector markets and local roads. The pavement economics committee has three focus areas – technology and innovation, environmental sustainability and pavement preservation.

The Research Project Summary provides a recap for industry on pavement design, sustainability and preservation and performance. The report shows that the initial service life values used for life cycle cost analysis (LCCA) do not adequately represent actual pavement age of AC pavements at time of first rehab and initial service life most used in LCCA is between 10-15 years and 20 to 25 years for PCC pavements. Rehabilitation occurs on AC pavements well before reaching unacceptable levels and AC pavements are more likely to have good ride quality prior to rehab.

Green Codes and LCA are affecting product selection decisions and the asphalt industry is working to dispel myths and promote science. The Emerald Eco Label quantifies potential environmental impacts of an asphalt mixture and rate a pavement's sustainability.

Thinlays can be as thin as 5/8 inch or greater as surface conditions necessitate. A 1-inch thinlay provides structural benefits. Innovations in thinlays for pavement preservation include fine graded polymer thin overlays, smaller NMAS mixes and perpetual pavements through preservation. Resources include a thinlays position paper, SHRP R26 Guidelines for Preservation of High Traffic Volume Roads and NCHRP Synthesis 464, Thin Asphalt Concrete Overlays.

ETG Comments, Questions, and Discussion:
None

18. Ontario Ministry of Transportation's Asphalt Testing Innovations [Pamela Marks, Ontario Ministry of Transportation]

Presentation Title: *Innovative Testing of Ontario's Asphalt Materials*

Summary of Presentation:
Marks began the presentation by providing background of the Ontario Ministry of Transportation (MTO). The MTO was 100% Superpave mix design by 2005 which has mitigated rutting but cracking is still a concern. The MTO is establishing mix performance testing for design and acceptance of placed mix remains a goal.

The MTO conducts moisture sensitivity testing by assessing stripping by Static Immersion Test which determines the stripping susceptibility of the different components of an asphalt mix. Aggregates are blended with asphalt cement and the blended material is submerged in distilled water at 49 ºC for 24 hours. The stripping susceptibility of the asphalt mix is assessed visually based on the percentage of the retained coating on the aggregate. Consistency between the

people conducting the test is important. The percent coating of various samples can be compared to determine what aggregate, AC, and anti-stripping treatment (AST) combination, provides better moisture resistance. The minimum satisfactory value for this test is 65 percent retained coating. Three alternative products were approved as an alternate to hydrated lime after the static immersion test showed the percent retained coating was as good or better as hydrated lime.

The Tensile Strength Ratio (TSR) determines the change in tensile strength resulting from moisture conditioning followed by a freeze-thaw cycle of compacted asphalt mixtures. The test is used during mix design to determine susceptibility of an asphalt mix to moisture damage. However, in some cases, it is insufficient and an anti-strip agent is specified to minimize risk of stripping.

The MIST is an alternative moisture conditioning process to the TSR's freeze/thaw conditioning. MIST conditioning time is over 10 times less than the TSR's and MIST can be used to evaluate specimens based on sample swelling by comparing the bulk relative density prior and after MIST conditioning. The moisture sensitivity test results showed the sample with the lowest retained coating, also had the lowest TSR, MIST-TSR and highest swelling value. Alternately, the diabase (a non-stripping aggregate) had greatest retained coating without AST, the highest TSR, MIST-TSR and lowest swelling.

The Hamburg Wheel Tracking (HWT) test is used to evaluate mixes made with various antistripping additives, evaluate specialty mixes (e.g., fiber reinforced HMA) and to investigate premature pavement failure. The MTO has not used the HWT test to evaluate mixes before they are used in production or to evaluate mix during production. The MTO uses an AMPT for dynamic modulus, flow number, S-VECD and Texas Overlay testing. The MTO is purchasing a Dynamic Testing System (DTS-30) that can perform dynamic modulus, flow number, S-VECD, Texas Overlay, four-point bending, SCB, Disk-shaped compact tension (DCT), IDT creep compliance and strength, resilient modulus and Thermal Stress Restrained Specimen Test (TSRST). The MTO has just acquired a bitumen bond strength (BBS) test that can measure the moisture resistance of the asphalt-aggregate interface for different combinations of materials.

The MTO plans more testing with MIST and BBS as well as embarking on a large mix testing program mainly involving SCB, DTC, IDT and HWT. The TMO is also looking at enhancing the recovery process when evaluating production mixes as they currently use solvents and run RTFO after recovery. The MTO is considering proposals to establish a digital image process that measures the risk of stripping by Static Immersion.

Marks next present the MTO asphalt cement test innovations such as ash content test, extended bending Beam Rheometer (ExBBR) test, XRF, and FTIR Spectroscopy. The MTO implemented the ash content test in 2008 to prevent over-modification with re-refined engine oil bottoms (REOB). There was good correlation between ash content and estimated REOB content as well as between 5-year pavement cracking and ash content. The ExBBR determines if the AC meets the low temperature performance grade after a physical hardening process that occurs with extended conditioning at cool temperatures. The ExBBR determines low temperature grade over 72 hours versus the 1 hour for standard grading. The MTO developed a multivariate regression formula to predict the 72 hour ExBBR test based on 1 and 24 hour properties using over 330

ExBBR tests. The predicted m-value and S can be used to estimate ExBBR low temperature limiting grade that could be useful for quality control purposes. The MTO has limited ΔTc date from BBR/ExBBR testing but is beginning to consider. The estimated REOB content versus ΔTc showed poor correlation. The XRF detects the elemental content of a sample and is used by MTO to identify over-modification of REOB in asphalt cement. The elemental intensity peaks obtained are all relative to other elements found, so calibration curves are required for each element in a material to be quantified. The four key elements and levels detected in a REOB sample are Calcium (10,000 ppm), zinc (3,000 ppm), molybdenum (300 ppm) and copper (100 ppm). The MTO created calibration curves from base asphalt cement samples with varying percentages of REOB. A linear regression curve was created for each element. FTIR detects the infrared energy absorbed in a sample. Comparison of FTIR spectra of an unknown sample to a standard sample can be used to spot modifications made to the unknown sample. The FTIR also provided information on the molecular bond and functional groups of modifications that are made to a material. The MTO has found a unique FTIR absorbance peak corresponding to REOB near wavenumber 1229 cm^{-1} believed to correspond to polyisobutylene, an additive used in engine oil. MTO is estimating the percent REOB in AC with XRF. The FTIR peak and XRF percent REOB showed agreement. The correlation between five-year pavement cracking performance and XRF estimated REOB content was 0.87.

Marks concluded the presentation by stating the MTO's focus has been on AC testing, however:

- MTO has a long history using HWT for investigations and new mixes.
- The use of swelling after MIST conditioning is promising and warrants further investigation.
- Expect to start evaluating various crack predicting mix test in 2017.
- Establishing a mix test for cracking, will be Ontario's first step toward testing production mix for acceptance and will provide contractors with a tool to use a balanced mix design.

ETG Comments, Questions, and Discussion:

D'Angelo asked how the failure number for the MIST swell test was set at 4. Marks responded that it was not set, but for this particular sample, it is known to be a failure. Marks stated this is not the value that is used as a threshold.

Reinke commented that the ExBBR correlation to the -5.0 ΔTc is based on 40-hour PAV and that the data shown was with 20-hour PAV. Marks agreed that MTO does not do 40-hour PAV and that either double PAV is needed or using a quarter of the material for the PAV. Marks commented that the ExBBR without double PAV appears to be similar to the BBR with double PAV. Reinke responded that they have seen that with a limited number of samples.

Amir Golalipour asked how many base binders were used to develop the relationship between the 1 hour and 72-hour relationship? Golalipour stated the relationship is very dependent on base binder and crude source and that the relationship for one crude source may not be true for another crude source. Marks stated Ontario is confident in the relationship but did not recollect the number of sources. Marks explained that the MOT requires all grades to have the ExBBR and this helps the regression equations.

19. Challenges of Introducing Pavement Related Subjects into the Engineering Curriculum [Kevin Hall, University of Arkansas and Dave Newcomb, Texas A&M Transportation Institute]

Presentation Title: *University-Based Asphalt Materials and Flexible Pavements Education: Developing a Roadmap and Action Plan*

Summary of Presentation:
Hall began the presentation by explaining the difficulty of incorporating pavement related material in the civil engineering curriculum as many states are mandating lower credit hours for a BSCE. With the general core education and State mandated core and the number of credit hours required decreasing, there is nowhere for pavement courses to be added. ASCE has published statement 465 which states that a Master's degree is required in order to practice civil engineering with a license. However, this was revised to state the need to attain a body of knowledge beyond a bachelor's degree. However, it appears that ASCE is unaccompanied in this thought. Hall stated that another curriculum constraint was ABET as the program must be accredited but the civil engineering program criteria limits the technical areas as only four are required. Hall stated that if pavements were to be one of the main focus areas, it needs to be defined. In addition, laboratories are required in two technical areas which are usually geotechnical and concrete. Concrete is often the default construction material as it relates to structures as well. Hall stated that there is a lack of qualified faculty with a background in pavements and often times the research mission is constraining as the primary metric for professors is the amount of money funded through research and the number of journal publications. Hall also stated that it is difficult to include an elective pavement course due to required teaching loads of other courses. Resources such as textbooks, instructional materials and laboratory space and equipment are also an issue.

Mohammad commented that one way to accommodate the need is through offering courses through technical design or analytical electives. Hall responded they must be more creative. Williams commented that laboratory courses also indirectly affect curriculum as support for teaching assistants and laboratories are being cut. Williams stated they are being constrained by funding support that is impacting the knowledge.

Williams also commented the concrete industry provides their technical reference to students for free and it is a workbook education based references. The asphalt industry does not have any supportive educational references with work problems for students. Williams recommended coming together and creating an education accompaniment to MS-2 or NAPA documents. Buncher commented it has been the practice of the concrete industry for some time and that the AI foundation has programs to develop strategic research and internship program. There are also discussions about the need for complementary manuals for the universities. Williams stated they have used Blackboard in his department where students can download the manuals and to only access the material while enrolled. Dukatz commented that at his teaching college where the professors were professional engineers, he gained a strong knowledge of the basics and that this is key for students before getting to a pavement class. It was commented that each state has a technician training program and that could be a good resource for questions and examples for pavement classes.

Hall asked what the body of knowledge (BOK) for flexible pavement engineering should be and the differences between the minimum exposure, content for an emphasis in flexible pavements and minimum content for pavement/materials base MS and PhD? The general pavement life-cycle includes design, materials, construction, maintenance and preservation and rehabilitation with associated topics of sustainability, pavement management and airports. The required BOK becomes complicated.

Williams commented that it would be beneficial to come together to provide required classes and that it has been done in the transportation group. Hall responded there are models for this where universities transparently share materials, etc. Williams commented they also need to promote opportunities to younger students since most professors do not get contact until junior year. Hall responded it is up to the group to generate the excitement and to do so at least in the materials course in the sophomore year.

Hall presented the potential path forward to include professor training, instructional materials and laboratory resources. Hall explained that NAPA provides resources for participant training and AI also has training. Hall stated that industry needs to support this initiative for program chairs and that there is a need for partnerships. Hall stated sharing classes through universities would also be a potential but need to figure out the administration aspect. Hall recommended the establishment of a Task Force to develop a plan and to coordinate with the Academy of Pavement Scientists and Engineers (APSE). APSE is an international group where Membership requires a PhD and to be part of a university. Hall recommended that the group coordinate with APSE in order to accomplish things in concert. Tran asked if this was only for professors. Hall responded that it is for pavement academics.

Hall stated that the ETG could possibly establish a repository for funding, updating, oversight, and publicity and establish a Task Force. Williams stated he would share the documents that are expected of interns for their formal internship program with the state association. Newcomb suggested contacting John Epps for his insights. Ultimately, Newcomb stated to have influence over a lifetime, there needs to be funding for professorships for pavements. Buncher agreed there should be a national group to address these issues. Buncher stated the industry has the guides, manuals, specifications, etc., but it is a matter of packaging the materials to make it easier for pavement professors to deliver to the students.

Action Item #201705-6. Individuals interested in joining the education outreach effort should inform Kevin Hall. Hall will provide goals and outcomes of the effort at future ETG meetings.

ETG Comments, Questions, and Discussion:
Buchanan asked what was the charge for the group? Newcomb responded the first thing should be to define the body of knowledge so that there is a clear path forward. Corrigan cautioned within the context of the ETG and other regulatory requirements, the charge cannot include funding discussions or recommendations. Corrigan recommended efforts avoid funding.

The education outreach effort is comprised of the following members:

- Kevin Hall – University of Arkansas
- Dave Newcomb – TTI/Texas A&M
- Rebecca McDaniel – North Central Superpave Center / Purdue
- Louay Mohammed – LSU / LTRC
- Mark Blow – Asphalt Institute
- Erv Dukatz – Mathy Construction (WI)
- Stacy Glidden – Payne and Dolan
- Adam Hand – University of Nevada – Reno
- Frank Fee – Frank Fee LLC
- Shane Buchanan – Oldcastle Materials

20. FHWA ALF Update [Jack Youtcheff, FHWA]

Presentation Title: *Update for the FHWA ALF Research Activities*

Summary of Presentation:
Youtcheff presented an update for the FHWA ALF research activities. The first project presented was on the high RAP and RAS with 20 and 40 percent binder replacement with WMA accelerated pavement test. The purpose of this project was to advance use of recycled asphalt in flexible pavement infrastructure and to develop and deploy a framework for proper use and evaluation of recycled asphalt in asphalt mixtures. The objective of the project was to quantify cracking resistance of high RAP/RAS mixtures that consider the use of lower temperature production with WMA and to investigate limitations and provide recommendations for combining the two technologies. The experiment was built in 2013 with two binder grades, RAP/RAS, two WMA technologies and three ABR contents. The loading conditions included 14,200 lbf at a speed of 11 mph, and was conducted at 20 ºC isothermal. Cracking measurements are taken by individually tracing cracks with a planimeter. The WMA tended to perform better in many cases. Healing of the asphalt cracks was observed during the summer.

The mixture field sample testing used the small-geometry specimens for Dynamic Modulus, Fatigue and Monotonic Direct Tension testing all done using the AMPT. The air void content of the field size for both small geometry and full size cores were comparable. Field core sampling and testing has been done each year since 2013 to 2016 including binder extraction and testing and data analysis.

The extracted binder testing included DSR fatigue using the linear amplitude sweep test (LAST), BBR ΔTc, and double notched tension for cracking strain tolerance. Youtcheff presented the ΔTc increase after 2 years for the ALF lanes. The lanes with RAS mixture had higher ΔTc than other mixtures with values of almost -5 and also less than -8 versus all other lanes being greater than -3. The next steps include performing a second test at aged conditions for lanes 3, 4, 5, and 8 with data analysis, post-mortem evaluations and reporting and documentation.

The second project presented by Youtcheff was the effect of in-place density and aggregate base geosynthetic reinforcement on the asphalt pavement density. The premise of the project is that

the compaction of AC mixtures is critical to achieving optimal pavement performance. The quality and strength of the substructure (base and subgrade) have great influence of pavement performance. The objectives of the project are investigation of AC compaction and its impact on performance of pavements built with and without geosynthetic base reinforcement. The experiment had one AC mixture, four lanes with different AC compaction (high – greater than 92 percent, medium 90-92 percent and low – less than 90 percent), two structures per lane (unreinforced and reinforced with a standard BS-1200) and the performance measures were cracking and rutting. The geosynthetic was place at the midpoint of the new crushed aggregate base. The distribution of the air voids of field cores was variable with averages ranging from 7.1 to 11.9 percent with standard deviations ranging from 0.7 to 1.3. There was some improvement in air voids by trimming the CoreLok.

The proposed testing included cracking with a loading temperature of 20 ºC, terminal state of total cracking length was greater than 1,000 inches, and all lanes were to be tested at least twice for fatigue cracking, one at one reinforced base site and one at one geosynthetic reinforced base site. Two lanes will have one extra fatigue test at aged conditions.

The construction was completed in October 2016. The phase 1 fatigue testing will be conducted in May and June 2017 and Winter 2017 through Spring 2018. The rutting testing will be conducted in late summer through early winter 2017. Phase 2 fatigue testing will be conducted in late winter 2018 through early summer 2018. Phase 3 fatigue testing will be conducted in fall 2018 through spring 2019.

The laboratory performance testing will include dynamic modulus, fatigue (AASHTO TP 107), monotonic direct tension, and flow number plus stress sweep rutting. All testing will be completed using the AMPT. The loose mix dynamic modulus testing showed that dynamic modulus increases with compaction level. The loose mix flow number testing showed higher deformation for 11 percent air voids versus 9 percent air voids.

Youtcheff presented the proposed rutting testing with a terminal state of 0.5 inches of total rut. Youtcheff asked the group whether it would be better to do static loading at a lower temperature (45 ºC) or use a variable tiered temperature (25,000 passes at 40 ºC, 25,000 passes at 50 ºC, repeat until terminal state reached)?

ETG Comments, Questions, and Discussion:
Huber asked if the anticipated failure mechanism would be rutting at the surface caused by the aggregate base or hot mix? Youtcheff responded that with the high air voids, the aggregate base would punch through. Huber responded if most failures are due to aggregate base, it may not make a large difference. It was asked if testing for both temperatures could be performed and compared? Youtcheff responded that the main concern was with the 11 percent air voids and collecting valid information. More people in the room, by a show of hands, favored the fixed option of temperature loading.

Glidden asked what was the goal of the variable temperature? Youtcheff responded it was to ensure that it does not result in an immediate failure.

D'Angelo recommended making a laboratory sample and use the HWT with no water to perform the test with 9 percent air voids and see if there is a difference.

Buncher asked what were the original ΔTc of the binders; and the change in ΔT_c over the two-year period presented? Youtcheff responded it was less than 5 degrees and there was not a large effect of REOB.

Action Item #201705-7. Jack Youtcheff will send correspondence to the ETG soliciting questions on rutting and temperature for the ALF project.

21. Update: Construction Task Force [Ervin Dukatz, Mathy Construction]

Presentation Title: *Rapid Asphalt Production/Construction Feedback – PCF: Part 3 – e-Circular*

Summary of Presentation:
Dukatz presented the Construction Task Force update with emphasis on the e-Circular. Dukatz mentioned the Task Force has grown. Members of the Task Force are listed in attachment C. Production/Construction feedback (PCF) are controls and devices designed to provide rapid feedback to the user to improve the density and hence the performance of asphalt pavements. Dukatz emphasized density as key and that for each additional percent of density, the pavement life increases 10 percent. The PCF areas of concern are design, materials, specifications, construction, aggregate moisture, asphalt sampling and compaction.

Dukatz explained that mix design is considering pavement thickness, aggregate structure (fine gradation, coarse gradation, gap graded) and the effects these have on structure. Areas of concern for the density specification include pavement thickness, subgrade (drainage, soft spots, repairs and pavement condition for overlays). Another area of concern is whether the density specification accounts for best practices and impediments to implementation. Dukatz stated planning and discussion is needed.

Dukatz presented rolling density meter (RDM) data for density, speed, and temperature. The plots showed the differences that can occur based on interpretation of the data. In section one of the plots, there is good density, proper roller speed and temperature of the mat. In section 2, the density is reduced. There was second roller added to section 2 and the speed of compaction was reduced, which should have increased density. However, there was also a decrease in temperature. Dukatz asked how to take the information from the analysis phase to use during construction to meet the construction goal?

The Task Force has created an outline for the first draft of the e-Circular including executive summary, introduction, and mix design. The executive summary will be key and targeted towards directors, owners and executives. The next steps are to review the Utah Density Specification, review the FHWA Density Initiative projects and develop an outline of compaction improvement. Dukatz presented a roadmap for compaction improvement that considered both pre-construction and construction. Following this roadmap will result in good density. The Task Force will then develop an e-Circular over that next 9-12 months.

Presentation Title: *Utah DOT HMA In-Place Density Specification*

Summary of Presentation:
Utah looked at the definitions contained in the specification based on training from AI, FHWA and their own experience. The definition for longitudinal joint is any new asphalt lift abutting an existing paving lift, exceeding 200 feet in length and excluding intersections. This includes joints created by echelon paving and new asphalt placed against a milled asphalt edge. The definition of overband is an 8-inch protective asphalt coating sealing the longitudinal joint of final riding surface, as proposed by the contractor and approved by the engineer. Thin overlay pavement is defined as an overlay where the sum of the thickness of the HMA lifts is less than two inches. Production day is defined as a 24-hour period in which HMA is being placed. A lot is the number of tons of HMA placed in a production day.
Anderson presented some of the specification highlights such as:

- Both mat and longitudinal joint density
- Thin lifts treated separately
- Density based on cores and G_{mm}
- Joint layout plan 10 days prior to paving
- Lot equal to one day's paving needs a minimum of four samples
- Targets and limits
- Percent within limits/pay factor

H. Anderson stated the density specification is 93 percent of rice specific gravity. The incentive/disincentive for density break even when percent within limits (PWL) is 88 to 91 percent. The in-place density of the mat is based on cores taken with two contract days of paving 1-ft from the edge. Density is based on the G_{mm} of the lot. The longitudinal joint in-place density is based on cores taken with two contract days of paving using G_{mm} of mat averages. The joint edges (3 inches confined or 6 inches unconfined) may be removed with payment. Ten cores per day in the mat and at least four cores in the longitudinal joint are used.

Buchanan asked how many contractors use the 6 inches on unconfined? H. Anderson responded they did not have any projects yet but some contractors are changing the mix design based on this specification.

H. Anderson presented the specification limits. For the mat, the target is 93.5 percent with lower and upper limits of 91.5 and 97.5 percent, respectively. The longitudinal joint target is 91.5 percent with lower and upper limits of 89.5 and 97.5 percent, respectively. The incentive/disincentive is based on a tier structure with three tiers for a bonus including gradation and asphalt content. However, if the density falls below 88 percent, the bonus for asphalt content and gradation is nullified. H. Anderson stated that they do not reject the mat based on longitudinal joint material quality but that as much as $5/ton can be deducted for longitudinal joint density and if the longitudinal joint density is below, the entire mat is deducted. If the result is a remove and replace, the material stays in place with a 35 percent penalty.

Next, Adam Hand presented his past employment contractor perspective. Hand commented that Utah's specification was always achievable but needed some improvement. Hand stated normally there were not many bonuses in Utah, but there were good quality projects. Hand stated

the specification was easily understood and it forces paving planning. The association with the Utah Asphalt Paving Association in the State was good and that UDOT listened to industry. In addition, UDOT includes dispute resolution, identifying problematic data and revisions. There are three potential avenues if merit is found by UDOT – test and calculation procedure review, validation testing as appropriate, and third party testing as appropriate.

ETG Comments, Questions, and Discussion:
Metcalfe asked if Utah's specification was available online. Anderson stated yes.

Of the 10 states that participated in the intelligent compaction study, Minnesota is the only state to have a specification and it is available online.

Corrigan commented there are a lot of resources for these topics published by other entities and asked how the e-Circular will repackage this information to consolidate it and to highlight what and where people need to focus? Corrigan asked how this was advancing the industry? Dukatz responded they have discussed this as a Task Force. The Task Force feels basic steps are being ignored and that distribution of the e-Circular can connect these resources and bring the basics to the forefront. Distribution and implementation is two-fold. First, have a writer/editor produce the Executive Summary so owners and managers will read it and implement it. Dukatz stated there can be a lot of benefit without a high cost by reorganizing how the information is distributed. From the e-Circular, a presentation can be developed to distribute to local agencies and pavement associations. Corrigan asked how the Task Force can emphasize and highlight these issues to make an immediate impact? Newcomb responded best practices can get lost in verbiage and the research community can overwhelm the ideal. Newcomb suggested by simplifying the best practices to what is important and having bullet points in terms of implementing best practices would be beneficial. The bullet points would then be substantiated with references to the other work. The document can highlight how to get the most out of the investment in a relatively simple form.

Hall commented that one of the biggest obstacles is agencies do not look at the best practices if itis not presumed to be a problem. Since many agencies will not believe they have a problem, the message needs to be this can improve the performance, save money and provide long lasting pavements. It was commented the ride specification will take precedence and it is critical to generate enthusiasm to promote density. Dukatz responded it is likely that where you have the best densities, the ride will also be improved.

H. Anderson commented from a DOT perspective, density may not be on the radar and the focus is often on safety and maintenance of traffic. Density is not an issue for top management. Dukatz responded the executive summary is very important for senior management and that this can be tied to safety and traffic flow.

The e-Circular will be a readable document that shows the interconnection and new technologies.

Hall commented that there are professionals (not engineers) that can communicate the points better and they should develop the document. Dukatz agreed and stated they needed to develop the bullet points.

Buncher commented that AI has a workshop on the topic. Dukatz responded that they will provide links in the e-Circular for items completed by AI, NAPA, and others.

Discussion based on the compaction improvement presented by Dukatz resulted in the following outline for the e-Circular topics:

- Site Investigation
  - Underlying support
  - Surface condition
  - Moisture conditions assessed
  - Proof rolling
  - Expansion of site conditions on either side of road alignment
  - Pre-construction meeting
- Pavement design
  - Mix type selection
  - Lift thickness (NMAS based on lift thickness)
  - Milling depth with respect to scab
  - Base repairs (prior to milling in PA)
- Mix design issues
  - Gradation
  - Binder
  - Compactability
  - Temperature ranges for mix and compaction required
- Balanced Production (NAPA has a good resource on this)
  - Plant production
  - Truck scheduling
- Environmental monitoring
  - Wind speed
  - Air Temperature
  - Base temperature/moisture
  - Existing water table at time of construction (could be tied to site investigation)
- Paving Practices
  - Segregation
  - Stop-start
  - Truck bump
  - Temperature
  - Monitor paver set-up
  - Proper use of material transfer devices.
  - Paver preparation for use with material transfer (i.e., insert on the hopper)
  - Proper maintenance and cleaning of pavers
  - Use of tack coat
- Compaction
  - Rolling pattern
  - Roller position

    - Roller coverage
    - Number of rollers
    - Types of rollers
    - Roller settings (i.e., amplitude, frequency, impact per foot)
- Paving Monitoring
    - Temperature
    - In-place density
    - QC/QA
    - Real-Time feedback
    - GPS on rollers (coverage maps)
- Adjustments
    - Evaluate
    - Feedback

Action Item #201705-8. Erv Dukatz will provide a detailed outline of the e-Circular in advance of next ETG meeting.

22. Update: Construction Task Force – Pavement Density Initiative [Tim Aschenbrener, FHWA]

Presentation Title: *Enhanced Durability Through Increased In-Place Pavement Density*

Summary of Presentation:
Aschenbrener presented the overall objective of the pavement density demonstration project as ultimately achieving increased in-place asphalt pavement density that results in the highest asphalt pavement performance. The demonstration project was a partnership between the FHWA and NAPA. An FHWA sponsored NCAT Report 16-02 published in 2016 showed that a 1 percent decrease in air voids was estimated to improve fatigue performance by 8.2 to 43.8 percent; improve the rutting resistance by 7.3 to 66.3 percent and extend the service life by (conservatively) 10 percent.

The project support included compaction workshops that provided comprehensive formal training and field project support through pre-paving meeting attendance and advice and on-site technical advice. Eighteen states participated in the workshop only while 10 states had a demonstration project, two of which also had the FHWA Mobile Asphalt Testing Trailer onsite for assistance and mixture performance testing.

Achieving increase in-place density was broken into five groupings – percent density requirement, optimum asphalt content, consistency, best practices and new technology. The AI conducted a specification mining effort that showed acceptance is determined by simple average and PWL. For simple average, most states had 92 percent as the minimum but there were states using 90 and 91 percent. For PWL, the lower specification limit was 92 but there were State using 91 percent as the lower limit.

Jim Musselman commented the lower specification limit can be misleading to highlight as those limits are not the targeted density. For example, if the target was 93.5 percent, with a tolerance of 2.5 percent, the lower limit would be 91 percent. Musselman stated this should be differentiated that the specification limit is not a target and for PWL the target is higher. Aschenbrener agreed the lower specification limit is not the target.

Aschenbrener presented a success story for PWL using NYSDOT case study. The comparison of 2015 data to the previous 13-year average showed improvement over time. The PWL had specification limits of 92 and 97 with an average of 94.5.

For selecting optimum asphalt content, changes were made to the AASHTO Standards by most States. These changes included mix design adjustments including gyrations, air voids, and VMA. States used engineering adjustment to make mix design changes to increase the asphalt content. The FHWA Tech Brief “Superpave Mix Design and Gyratory Compaction Levels” evaluated the effects of changes to gyratory levels and is recommended reading.

Consistency is important for achieving density. This includes temperature of the mix, roller speed, etc. By focusing on consistency, States were able to reduce the standard deviation below 1 versus an average of about 1.5.

Best practices can be used by the contractor and by the State in terms of writing specifications. Meeting with five equipment manufacturers for feedback on other best practices resulted in the following suggestions: roller settings, vibration frequency versus roller speed, amplitude, vibrating screed, mat temperature, and paver speed. The percent density test sections showed field densities are much better for 7 out of the 10 States. The density improvement from the control section showed over 1 percent density improvement in most States. The change from the control could be misleadingly low because the control construction was often better than normal due to the amount of scrutiny on the projects. The incentives help the contractors see what is important in the State.

One State did a cost/benefit of best practices which considered what the cost was to get the improved density. The benefit of 10 percent increase well outweighed the cost of 1 percent density increase through additional rollers, WMA additive, NMAS aggregates and AVR to 3 percent with binder.

Three states used new technology including RDM to measure density from dielectric constant and thermal temperature scanner (IR Scan) to monitor paver speed and temperature. In the final report, States emphasized the troubleshooting ability of this equipment; when the process is not in control and causes density to become variable.

Increased in-place density can be achieved. Test sections had increased % theoretical maximum density (TMD) from the control in 9 out of 10 States and this was more than 1 percent from the control in 8 out of 10 States. Density greater than 94 percent TMD was achieved in 7 out of 10 States. As a result, 7 of the 10 States are changing their specifications.

The next steps include the SHA's summary reports for the 10 projects with a potential for follow-up on field performance. FHWA's best practices communication through a summary document, Tech Brief and additional workshops. The extended field experiment is soliciting Phase 2 involvement until May 19, 2017.

ETG Comments, Questions, and Discussion:
Buncher asked of the seven states changing their specifications, what was the typical change? Aschenbrener responded it is State dependent based on what each State found during the project but the most common change was to increase the specification limit. Some States had a very low specification limit and others were not using G_{mm} as the reference. Some States are trying to increase the amount of asphalt in the mix.

Fee asked if any of the demonstration projects included WMA. Aschenbrener responded that six States included WMA and that one State used it as a variable to try to get higher density. However, that State was unable to achieve higher density with WMA.

West commented that on NCAT projects where they took cores independently of acceptance, it was alarming that over half of those project had density below 91 percent. West stated that a lot of projects are not being compacted well and agencies are not always receiving what they think they are receiving. West commented States realized that increasing the asphalt content consistently achieved higher density. One of the States sent cores used for density measurements to NCAT for flexibility testing. It was expected that higher density would result in better flexibility. However, this was not observed. A laboratory study was done to investigate this and higher density again did not result in better flexibility. West wanted to make people aware that they did not see the effect expected. Huber commented additional information is needed. Huber predicted the energy to failure would increase but the slope would be steeper and that would result in a lower flexibility index.

Corrigan commented performance and the models need to be linked. Density performance needs to be considered within the overall QA system such as PWL statistical evaluation, sampling, payment, and their associated risk analysis. The components of the system make a framework for performance and it is too often not considered a system.

Buncher commented there is not a density specification for many projects such as lower volume roads; and it is a matter of raising the bar or actually having a bar. The AI study presented by Phil Blankenship only considered pavements with the highest traffic level. Buncher stated there are many projects and specifications without a density requirement.

Ron Sines commented on the NYDOT specification stating that the incentive portion of the specification did not begin until within 60 percent of the specified band since the benefit is not realized until density is in the higher portion. Aschenbrener asked if it was more of a quadratic incentive once the density was higher. Sines responded that it was not that complex but that a pay factor was assigned for each band.

23. Action Items

Action Items:

Action Item #201705-1. Jim Musselman solicited additional members of RAP/RAS Task Force. The future focus of the Task Force will be on RAP and AASHTO M 323. Musselman will provide update at the next ETG meeting.

Action Item #201705-2. Richard Kim will report on the status of NCHRP 9-54 Long Term Aging of Mixes at the next ETG meeting.

Action Item #201705-3. Randy West will report on the status of NCHRP 9-55 RAS in WMA at the next ETG meeting.

Action Item #201705-4. Shane Buchanan will present the activities of the Balanced Mix Design Task Force at the next ETG meeting; including the potential of changing the title to include “performance” and “engineered.”

Action Item #201705-5. Richard Kim, Cassie Castorena, and Dave Mensching to work with Matthew Corrigan on the draft of small scale specimen specification for distribution to the ETG for comment.

Action Item #201705-6. Individuals interested in joining the education outreach effort should inform Kevin Hall. Hall will provide goals and outcomes of the effort at future ETG meetings.

Action Item #201705-7. Jack Youtcheff will send correspondence to the ETG soliciting questions on rutting and temperature for the ALF project.

Action Item #201705-8. Erv Dukatz will provide a detailed outline of the e-Circular in advance of next ETG meeting.

24. Next Meeting Location and Date

The next meeting date will be coordinated with the Asphalt Binder ETG. Members were asked to consider the week of September 11, 2017 and September 18, 2017 with the preferred date being the week of September 18, 2017.

Corrigan announced the Mixture ETG meeting will be moving back to a 1.5-day duration meeting as a result of travel and budgetary considerations. The meeting had previously been extended from 1.5 days to 2 days after the sunset of both the WMA and RAP technical working groups. This will also make travel for meetings easier; with meetings occurring Tuesday through Thursday with travel on Monday, Wednesday, and Friday; not requiring weekend travel.

25. Meeting Adjournment

Corrigan thanked all attendees for their participation during the ETG and attending the meeting; and thanked Chris Williams and Iowa State University for hosting the meeting. The meeting was adjourned at 3:30 PM.

ATTACHMENT A – AGENDA

Asphalt Mixture & Construction Expert Task Group
Ames, IA
May 1-2, 2017
Meeting Agenda – Final Draft

Day 1 – May 1, 2017

8:00 am	Welcome and Introductions	**Buchanan/Bonaquist**
8:15 am	Review Agenda, Minutes & Action Items	**Corrigan**
8:30 am	Update: RAP/RAS Task Force	**Musselman**
9:00 am	Update: Related NCHRP Project and Activities	**Harrigan**
9:30 am	**Break**	
10:00 am	Update: Ongoing NCHRP Project and Activities	
	• 9-49A Long Term Field Performance of WMA	**S. Shen**
	• 9-54 Update Long Term Aging of Mixes	**Kim**
	• 9-55 RAS in WMA	**West**
	• 9-56 Ignition Furnace Correction Factors	**West**
Noon	**Lunch Break**	
1:00 pm	Update: BMD Task Group	**Buchanan**
2:00 pm	Subcommittee on Materials Updates/Comments	**Metcalfe**
2:30 pm	**Break**	
3:00 pm	AMPT Performance Testing and Analysis	
	Update: AASHTO TP107 Direct Tension Cyclic Fatigue	**Mensching**
	Cyclic Fatigue Failure Criterion based on DR Parameter	**Y. R. Kim**
	Proposed Small Specimen Geometry Specifications for Specimen Fabrication, AMPT Dynamic Modulus, and AMPT Cyclic Fatigue Test	**Castorena**
5:00 pm	**Adjourn for the Day**	

Day 2 – May 2, 2017

8:00 am	Update: Analysis of the fatigue cracking model in the ME-Design procedure	**Hall/Tram**
9:00 am	NAPA's Technical Activities	**Copeland**
9:30 am	Ontario Ministry of Transportation's Asphalt Testing Innovations	**Marks**
10:00 am	**Break**	
10:30 am	Challenges of Introducing Pavement Related Subjects Into the Engineering Curriculum	**Hall/Newcomb**
11:30 am	FHWA ALF Update	**Youtcheff**
Noon - Lunch Break		
1:00 pm	Update: Construction Task Force	**Dukatz**
2:00 pm	**Break**	
2:30 pm	Update: Construction Task Force – Pavement Density Initiative	**Aschenbrener**
3:00 pm	Action Items and Next Meeting Planning	**Corrigan**
3:30 pm	**Adjourn – Safe Travels!**	

ATTACHMENT B – ETG MEMBER LIST

FHWA Asphalt Mixture & Construction Expert Task Group Members

Chairman: **Shane Buchanan** Asphalt Performance Manager Old Castle Materials 133 Sheffield Lane Birmingham, AL 35242 Cell: 205-873-3316 Shane.Buchanan@oldcastlematerials.com	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: **Matthew Corrigan, P.E.** Asphalt Pavement Engineer U.S. DOT - Federal Highway Administration 1200 New Jersey Ave., SE HIAP, E73-465 Washington, D.C. 20590 Phone: 202 366-1549 matthew.corrigan@dot.gov	
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ATTACHMENT C – TASK FORCE MEMBERS AND ASSIGNMENTS

Task Force Members and Assignments

	Task Force Identification	Members Assigned to Force
3	Construction Task Group	Erv Dukatz (Lead); Jim Musselman, Kevin Hall, Gerry Huber, Adam Hand, Ron Sines, Audrey Copeland, Tom Harman, and Mark Buncher
5	RAP/RAS	Jim Musselman (Lead): Timothy Aschenbrener, Audrey Copeland, John D'Angelo, Lee Gallivan, Danny Gierhart, Gerry Huber, Tanya Nash, Timothy Ramirez, Ron Sines, Hassan Tabatabaee, Randy West, Richard Willis, Rebecca McDaniel, Bill Butler, Stacy Glidden, Howard Anderson, Sam Cooper, Andrew Hanz, Chris Williams, Salman Hakimzadeh, Brian Pfeifer, and Nathan Morian.
7	Balanced Mix Design	Shane Buchanan (Chair), Kevin Hall (Co-Chair): Dave Newcomb, John Haddock, Louay Mohammad, Brian Pfeifer, Bryan Engstrom, Charlie Pan, Curt Turgeon, Derek Nener-Plante, Eliana Carlson, Howard Anderson, Oak Metcalfe, Robert Lee, Steven Hefel, Frank Fee, John D'Angelo, Lee Gallivan, Richard Duval, Tim Aschenbrener, Andrew Hanz, Chris Abadie, Erv Dukatz, Gerry Huber, Anne Holt, and Rand West

ATTACHMENT D – Preliminary Outline for a Regional Pooled Fund Study on Performance Related Specifications (PRS) for Asphalt Paving Mix (Subject to Change)

DRAFT
NEAUPG Region
(Draft - 04/17)

Concept – Asphalt pavement performance can be improved with the use of Performance Related Specifications (PRS). By employing this approach of asphalt mix design and construction practices, significant improvement in asphalt pavement service life can be obtained. The tests, procedures and practices must be implementable and administered on an agency wide basis. The tests will generally be empirical and require local calibration to actual field performance. Calibration by each agency will include the selection of tests to develop pass/fail criteria, which are appropriate for their needs. To the extent possible, these tests should be based on current agency practices, which include pavement thickness design and climate. Where possible, agencies will strive for regional uniformity in the specification provisions.

Initial Evaluation:

1. Establish meetings to determine the perspective of the State Materials Engineers and the contracting industry on this concept.
2. If the meetings are positive, the appropriate resource providers will initiate discussion on joining a Pooled Fund Study.

Pooled Fund Approach:

1. A pooled fund contract will be established with all the Resource Centers and administered by the host State.
2. Each State will have the capability to establish a specific Work Plan and corresponding budget to accomplish their goals. They will then contribute the appropriate amount to the pooled fund.
3. Each State will work with a selected Primary Resource Center to conduct their program. However, shadow testing (e.g. other similar cracking tests, etc.) may be run by other Resource Centers for enhanced data collection.
4. The overall goal would be to have the data from all the Resource Centers available to all participants.

Program:

The following Universities are recommended to become Regional Resource Centers and provide the Principal Investigator (PI) for the technical management and lab support for the overall program: (other support can be added as appropriate)

1. UNH – PI - Professor Jo Daniel
2. UMASS – Dartmouth – PI- Professor Walla Mogawer
3. Rutgers Univ. – PI -Tom Bennert
4. Penn State Univ. – PI - Mansour Solaimanian
5. VATRC – PI – Stacey Diefenderfer

It is intended that the program will be subdivided such that each PI will primarily support a regional State. Initial suggestions are as follows:

UNH – ME, NH, VT
UMASS – MA, CT, RI
Rutgers – NJ, DE, NY, PA
Penn State Univ. – PA
VATRC – MD, VA

Our assumption is that the asphalt mixes of primary concern will be surface mixes over structurally sound bases and will be used for rehabilitation / maintenance. Therefore, the structural design of the pavement will not normally be a part of this approach. (However, if requested, full pavement design services could be provided, under a special arrangement) The primary effort will be to provide a surface mix that resists rutting and cracking over an extended pavement life. Since we will be working with individual States, climate will already be established for the PG binder selection.

Approach: (PI's would be expected to maintain a close team cooperation and dialogue throughout this project – sharing lab specific testing and information concerning their projects at lease quarterly.)

1. Each PI will meet with their respective State representatives and develop a needs and expectations statement. This may include requesting data from the State's pavement management data base or other sources on pavement performance. From this, an outline of objectives for the agency will be developed. The PI will then develop a work plan and budget to meet the objectives. This will need to be reviewed and accepted by the agency.

The PI will maintain an active dialogue with the agency for exchanging input and information throughout the program.

2. The PI will finalize a work plan to evaluate various tests and protocols to test a representative cross section of the State's asphalt mixes. The selected tests and protocols should be prioritized based on their ability to consistently and accurately capture the relevant property, their ease of implementation, time to run, and cost.
3. The PI will initially recommend appropriate tests and protocols to use for establishing the empirical relationships for good and poor performing mixes. Using these tests, they will then recommend performance criteria based on field samples of known performance.
4. When approved by the State, develop a work plan to validate the PRS on field projects. This would include the mix design and plan for field evaluation on various field projects to validate the PRS.

Additional considerations:

1. Develop a needs assessment for the infrastructure needed for the mix design (normally- Contractor) and acceptance (normally- State) testing.
2. Recommend a lab mix aging protocol that is appropriate for the specific mix and application conditions that relates to local long term field performance.
2. Developing final QC and Acceptance testing protocols.
3. Develop field (including in-place pavement) acceptance criteria.
4. Develop provisions for technical training.